GVC IMPACTS ON ARGENTINA'S CARBON EMISSIONS: DECOMPOSITION ANALYSIS

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Manuscript received 15 June 2025; accepted 14 November 2025.

ABSTRACT

This paper examines the environmental impact of Argentina's participation in Global Value Chains (GVCs) from 1995 to 2020, focusing on carbon emissions. Using decompsition analysis and fixed-effects regression, we find that GVC participation increases emissions, primarily due to economic expansion (scale effect), especially through backward linkages. However, improvements in energy efficiency and shifts toward less carbon-intensive sectors partly mitigate this effect. Emissions are concentrated in agriculture and manufacturing, while services have minimal impact. Instrumental variable checks confirm robustness. This study recommends promoting green technologies, stricter regulations, and international cooperation to align GVC participation with sustainability goals in developing economies.
Keywords: Global Value Chains, carbon emissions, Argentina, decomposition effect, sustainable development.
JEL **Classification:** F13, F18, O13, Q56.

http://dx.doi.org/10.22201/fe.01851667p.2026.335.91840

IMPACTOS DE LAS CADENAS GLOBALES DE VALOR (CGV) EN LAS EMISIONES DE CARBONO DE ARGENTINA: ANÁLISIS DE DESCOMPOSICIÓN

RESUMEN

Este artículo examina el impacto ambiental de la participación de Argentina en las cadenas globales de valor (CGV) entre 1995 y 2020, con énfasis en las emisiones de carbono. Utilizando análisis de descomposición y regresión con efectos fijos, se concluye que dicha participación aumenta las emisiones, principalmente por la expansión económica (efecto escala), en especial a través de los eslabonamientos hacia atrás. No obstante, las mejoras en eficiencia energética y los cambios hacia sectores menos intensivos en carbono atenúan parcialmente este efecto. Las emisiones se concentran en la agricultura y la manufactura, mientras que los servicios tienen un impacto mínimo. Se recomienda promover tecnologías verdes, normativas más estrictas y cooperación internacional para alinear CGV y sostenibilidad.
Palabras clave: cadenas globales de valor, emisiones de carbono, Argentina, efecto de descomposición, desarrollo sostenible.
Clasificación JEL: F13, F18, O13, Q56.

1. INTRODUCTION

The rapid expansion of Global Value Chains (GVCs) has fundamentally reshaped international trade, production, and environmental dynamics. As countries increasingly specialize in specific stages of production rather than entire industries, GVCs have facilitated economic growth, technological diffusion, and industrial upgrading (Gereffi, Humphrey, and Sturgeon 2005). However, this integration has also raised critical concerns about its environmental consequences, particularly in developing economies where regulatory frameworks and sustainable practices may lag economic ambitions (Copeland and Taylor, 2003). The environmental implications of GVC participation remain a contested issue in academic and policy circles, with some scholars arguing that GVCs exacerbate pollution through increased industrial activity and transportation emissions, while others highlight their potential to transfer cleaner technologies and promote sustainable production methods.

Argentina, a resource-rich economy with strong agricultural and manufacturing sectors, presents a compelling case for examining the environmental impacts of GVC participation. The country's economy is integrated into GVCs, particularly in sectors such as agribusiness, mining, and automotive manufacturing, which are often associated with significant environmental externalities. While GVCs offer opportunities for economic diversification and technological spillovers, they may also contribute to rising pollution levels, particularly carbon emissions, through heightened production demands, energy-intensive processes, and cross-border transportation (Wang, Wan, and Wang 2019). The pollution haven hypothesis suggests that multinational firms may relocate pollution-intensive production stages to countries with weaker environmental regulations, further aggravating ecological degradation in developing nations like Argentina (Copeland and Taylor, 2003). This raises pressing questions about whether Argentina's participation in GVCs reinforces unsustainable production patterns or provides pathways toward greener industrial practices.

Empirical evidence on the relationship between GVCs and environmental outcomes reveals a complex duality. On one hand, deeper participation in GVCs can lead to higher carbon footprints due to expanded industrial output, fossil fuel dependency in export-oriented sectors, and emissions from global logistics networks (Wang, Rickman, and Yu, 2022; Su *et al.*, 2023; Bhayana and Nag, 2024). On the other hand, GVCs can serve as conduits for environmental progress by facilitating the adoption of advanced technologies, stricter environmental standards imposed by lead firms, and knowledge spillovers that promote green innovation (Fei et al., 2020; Jin *et al.*, 2022). For Argentina, the net effect of GVC participation on pollution remains underexplored, despite the country's growing role in global supply chains and its vulnerability to climate change impacts. Argentina's carbon emissions are driven largely by agriculture —particularly methane emissions from livestock— as well as energy production and industrial activity, making it a pivotal case for analyzing the environmental trade-offs of GVC participation (Zhang *et al.*, 2021; Shi *et al.*, 2022).

This paper investigates how Argentina's GVC participation influences environmental pollution, with a focus on carbon emissions as a key indicator of ecological sustainability. This paper seeks to determine whether deeper GVC participation exacerbates or mitigates pollution levels, which sectors contribute most to emissions within GVCs, and how policy interventions could leverage GVCs to promote sustainable industrial practices. By employing empirical analysis of Argentina's trade and emissions data, this research contributes to the broader debate on sustainable GVCs and offers evidence-based policy recommendations for aligning economic growth with environmental resilience. The findings are particularly relevant for developing economies striving to balance GVC participation with climate commitments under the Paris Agreement and the Sustainable Development Goals (SDGs).

2. LITERATURE REVIEW

The nexus between GVC participation and environmental pollution constitutes a nuanced and multidimensional debate within academic literature. Scholarly perspectives diverge significantly regarding whether GVC participation ultimately alleviates or exacerbates environmental degradation, with empirical evidence supporting both positions.

A substantial body of research identifies potential environmental benefits arising from GVC participation. Fei *et al.* (2020) and Jin *et al.* (2022) demonstrate how GVCs can serve as conduits for technological innovation and efficiency gains, facilitating the adoption of cleaner production methods across borders. This technological diffusion effect is particularly pronounced when considering the transfer of advanced environmental technologies from developed to developing economies (Hu *et al.*, 2021). Some studies, including Zhang *et al.* (2021) have documented measurable reductions in carbon emissions attributable to structural transformations within GVC participation. Wang, Wan, and Wang (2019) further advanced this discussion by identifying an inverted U-shaped relationship between GVC participation and carbon emissions, suggesting that while initial integration may increase pollution, deeper engagement eventually yields environmental improvements through enhanced energy efficiency. Methodologically, scholars like Meng, Yan, and Yu (2022) have employed multi-region input-output models to analyze the environmental impacts of value-added trade.

Conversely, the pollution haven hypothesis, originally formulated by Copeland and Taylor (2003), presents an interesting counter-narrative.

This theoretical framework posits that GVCs facilitate the geographic redistribution of pollutive industries toward jurisdictions with weaker environmental regulations. Empirical validations of this hypothesis abound, with Bhayana and Nag (2024) documenting increased carbon intensity in developing countries engaged in GVCs, while Markusen and Maskus (2001) traced patterns of carbon leakage across regulatory regimes. Liu *et al.* (2018) and Su *et al.* (2023) provide compelling evidence that developing nations frequently absorb environmentally detrimental production segments, resulting in net increases in global emissions. Fei *et al.* (2020) and Jin *et al.* (2022) offer specific cases where GVC expansion correlated with rising carbon emissions in China and other developing economies dominated by low-tech industries.

The empirical record reveals considerable complexity in this relationship. Wang, Rickman, and Yu (2022) demonstrated pollution increases in developing countries through GVC channels, while Zhang *et al.* (2021) noted persistent energy consumption challenges despite emission intensity improvements. Shi *et al.* (2022) introduced further nuance by demonstrating how carbon intensity outcomes vary significantly based on participation mode (forward versus backward linkage) in Belt and Road Initiative countries. The concept of "low-end lock-in" developed by Liu *et al.* (2018) and Jin *et al.* (2022) illustrates how peripheral GVC positioning can perpetuate energy inefficiency, though upward mobility within value chains may yield environmental benefits.

The pollution harbor effect presents another critical dimension. This phenomenon describes how developed economies externalize emission-intensive production stages to developing nations through trade networks, effectively redistributing environmental burdens (Fell and Maniloff, 2018; Kan *et al.*, 2019). Liu *et al.* (2018), Fei *et al.* (2020) and Su *et al.* (2023) demonstrate how technological disparities can exacerbate this effect, resulting in higher global emissions.

Latin America's experience provides particularly salient insights. Adebayo *et al.* (2021) traced how regional economic growth and energy demands have amplified environmental pressures, while Koengkan *et al.* (2019) identified countervailing opportunities through renewable technology transfer. Recent empirical contributions further illuminate how the region's structural position within global value chains shapes environmental outcomes. Sanguinet (2021) demonstrates that Latin

American economies tend to integrate into GVCs through primary and resource-based industries, a pattern reinforced by bilateral trade agreements and characterized by uneven geographical specialization. This integration deepens the environmental burden associated with extractive and low-value-added sectors. Complementing this perspective, Sanguinet, Azzoni, and Alvim (2022) show that CO_2 emissions embedded in value chains across Brazil, Chile, Colombia, and Mexico are disproportionately concentrated in resource-based industries, creating interregional dependencies that limit the capacity for emission reduction. Together, these studies indicate that Latin America's mode of GVC participation, anchored in commodities and resource-intensive activities, generates complex trade-offs between economic development and environmental sustainability.

For Argentina, emerging empirical evidence highlights both the environmental constraints and institutional dynamics that condition the country's participation in global value chains. Okere *et al.* (2021) find that industrial restructuring and financial development have the potential to reduce long-term carbon emissions, whereas fossil fuel dependence, economic growth, and public expenditure exacerbate environmental pressures. These results underscore the structural challenges of Argentina's production matrix, which remains heavily reliant on carbon-intensive activities. In a related vein, Zamorano and Vital da Costa (2025) reveal clear patterns of ecologically unequal exchange in Argentina's trade with major partners, showing that the country bears a disproportionate share of environmental burdens while capturing limited economic gains. Basso (2024) adds an institutional and political dimension, illustrating how coalitions around land use, deforestation, and primary production shape the national climate agenda and constrain mitigation efforts. Taken together, these studies suggest that Argentina's environmental performance within GVCs is shaped not only by technological and structural factors but also by political economy dynamics that reinforce the dominance of primary sectors and limit the country's capacity for sustainable upgrading.

The cumulative evidence suggests that the environmental consequences of GVC participation resist simplistic characterization, varying substantially according to national context, sectoral characteristics, and position within GVCs. This complexity underscores the need for nuanced policy approaches that recognize both the risks and opportunities presented by GVC participation.

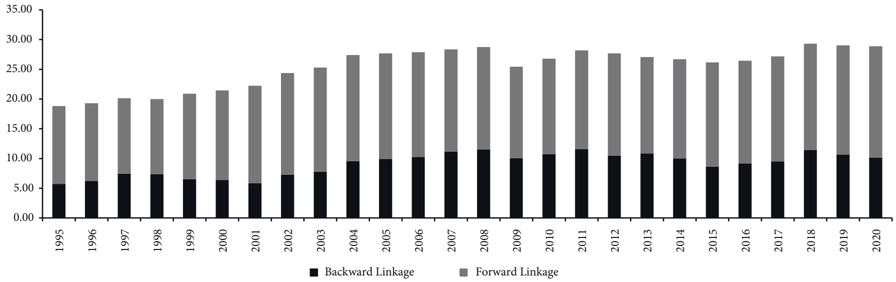
3. STYLIZED FACTS

3.1. GVC participation in Argentina

The relationship between a country's level of economic development and its participation in GVCs plays a main role in shaping its environmental outcomes. Empirical evidence suggests that developed economies tend to exhibit stronger forward GVC linkages, reflecting their dominant position in final-stage production, innovation, and branding (World Bank, 2019). In contrast, countries engaged in low-value-added manufacturing —such as basic commodity processing— often display weaker forward participation, as their exports (*e.g.*, raw materials or garments) are less likely to be used as intermediate inputs in downstream production. However, as economies transition toward advanced manufacturing and knowledge-intensive services, their forward GVC participation tends to increase, potentially altering their environmental footprint.

In Argentina's case, GVC participation over the past 25 years (1995-2020) has been characterized by consistently higher forward linkages compared to backward linkages, as illustrated in Figure 1. This suggests that Argentina's role in GVCs has been more pronounced in the processing and export of intermediate or finished goods rather than in importing

Figure 1. Argentina GVC participation, 1995-2020



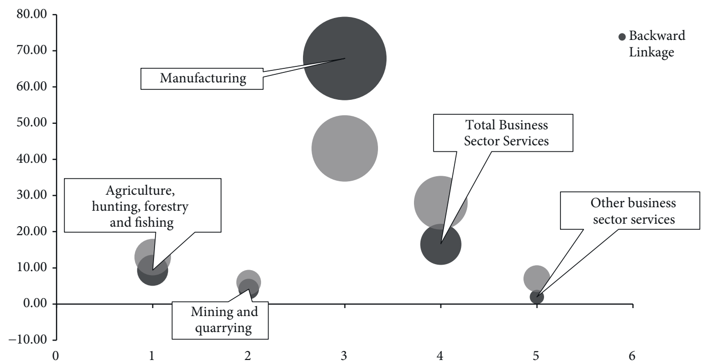
Source: Authors' elaboration based on OECD-WTO TiVA 2023 (Organisation for Economic Co-operation and Development-World Trade Organization).

foreign inputs for domestic production. Meanwhile, backward linkages —which measure the reliance on imported intermediate goods— have remained relatively stable, indicating a steady supply chain environment without major disruptions.

Figure 2 represents the breakdown by industry's weight in 2020. GVC participation reveals a manufacturing-dominated backward linkage (67.86%) contrasting with more diversified forward connections. While manufacturing represents 43% of forward linkages, agriculture (13%) and business services (28%) show stronger forward integration than backward (9.33% and 16.51% respectively). The near-absent participation in electricity/waste sectors (0.2% backward, 0% forward) highlights environmental modernization gaps, whereas mining maintains balanced participation (4.14% backward, 6% forward). This structure suggests Argentina primarily imports manufacturing inputs while exporting both commodities and professional services, with business services showing stronger outward integration (28%) than domestic reliance (16.51%).

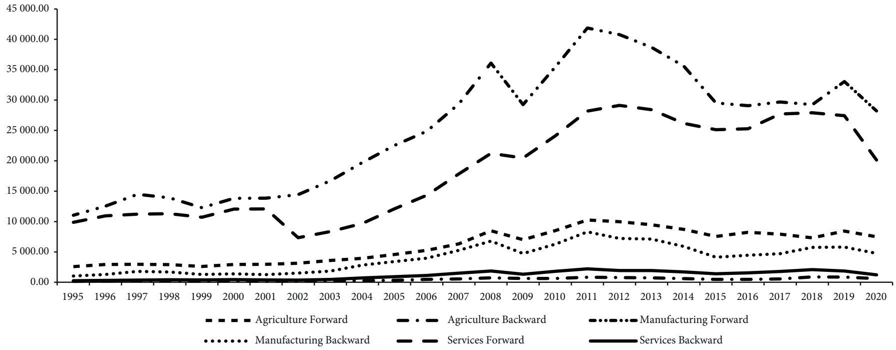
Figure 3 illustrates Argentina's evolving GVC participation across key sectors over 25 years. The agricultural sector shows diverging trends - declining backward linkages suggest reduced reliance on foreign inputs, while rising forward linkages indicate growing integration of Argentine agricultural products into GVCs, likely reflecting successful value-added strategies. The services sector demonstrates stable backward linkages with a slight domestication trend, coupled with steadily increasing forward

Figure 2. Argentina backward and forward linkage, 2020



Source: Authors' elaboration based on OECD TiVA 2023.

Figure 3. GVC **participation by sectors over time (US dollar millions)**



Source: Authors' elaboration based on OECD TiVA 2023.

participation, signaling growing international competitiveness. For manufacturing, cyclical backward linkages reveal fluctuating import dependence, while forward linkages show Argentina's intermittent but strengthening role as a supplier of manufactured goods within GVCs. Notably, the converging manufacturing trends suggest Argentina is gradually balancing its position as both an importer and exporter of industrial goods into GVCs.

3.2. Carbon emissions in Argentina

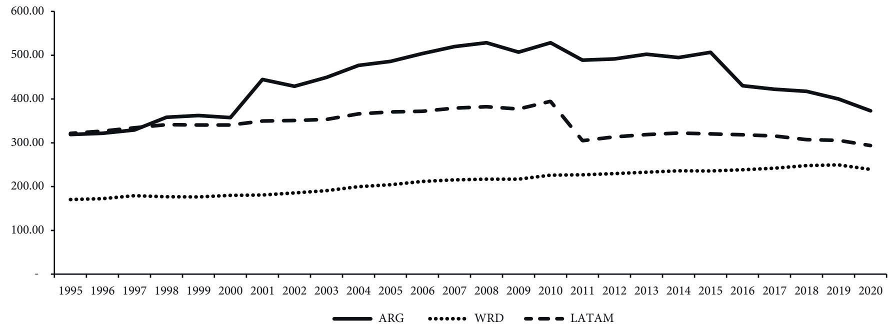
While global emissions remain heavily concentrated, with the five largest emitters[1] accounting for 55% of total emissions (65% when including Brazil and Japan) and G20 nations generating 78% according to UN data, recent years have seen notable pollution reductions due to COVID-19 containment measures —including China's 25% carbon decrease according to the World Meteorological Organization[2] and Italy's 10% nitrogen dioxide[3] decline according to the Copernicus Atmospheric Monitoring

[1] China, United States, India, Russia and Indonesia, respectively.
[2] See for more details: https://wmo.int/media/news/economic-slowdown-result-of-covid-no-substitute-climate-action
[3] Nitrogen dioxide is the main air pollutant.

Service of the European Union[4]. Figure 4 shows Latin America's relatively modest 8% contribution to global carbon emissions (293 billion tons in 2020), with Argentina's emission trajectory showing distinct phases: Steady growth from 1990 peaking around 2008, followed by gradual decline. This reduction aligns with Argentina's climate commitments under the Paris Agreement (ratified through Law 27270 in 2016), marking its formal engagement in global climate action despite regional emission disparities. The post-2011 stabilization of Latin America's emissions and Argentina's downward trend suggest emerging progress in decoupling economic activity from environmental impact in the region. However, we can see that the emissions of Argentina are quite high related to the Latin American and World average.

Figure 5 tracks Argentina's sectoral carbon emissions from 1995 to 2020, revealing that electricity/heat production consistently generated the highest emissions, peaking around 2009-2011 before declining post-2011, suggesting energy efficiency improvements or cleaner energy adoption. The 2020 breakdown shows electricity/heat production remained the dominant source (35%), followed by transport (20%), land use change/

Figure 4. Carbon Emissions by Argentina, Latin American countries[5] and World[6]



Source: Authors' elaboration based on Climate Watch Database.

4 See for more details: https://atmosphere.copernicus.eu/copernicus-confirms-reduction-no2-levels-over-northern-italy-lockdown

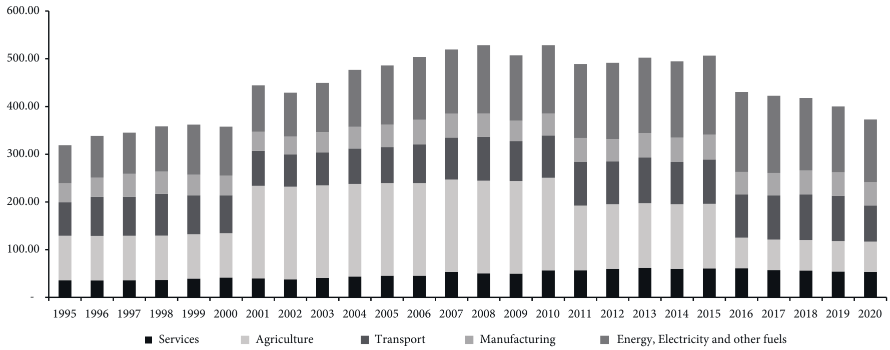
5 Latin American countries average.

6 World countries average.

forestry (17%), buildings/services (14%), manufacturing/construction (13%), highlighting how energy generation and transportation continue to drive Argentina's carbon footprint despite recent reductions in the power sector's emissions.

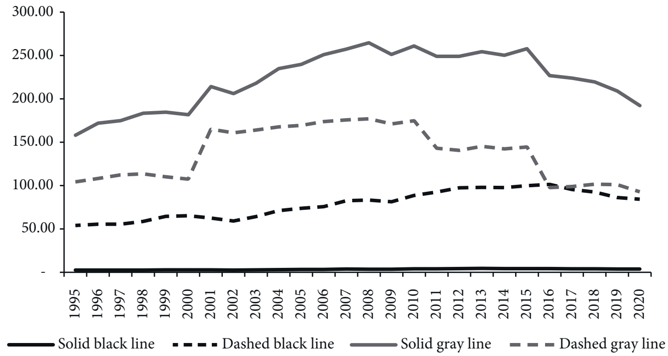
Figure 6 illustrates Argentina's pollution trends from 1995 to 2020, categorized by environmental impact: Dashed gray line (most harmful), solid gray line (moderately harmful), dashed black line (lower impact), and solid black line (renewable/minimal impact).

Figure 5. Carbon Emission by industry in Argentina



Source: Authors' elaboration based on Climate Watch Database.

Figure 6. Carbon emission by pollution level in Argentina, 1995-2020



Source: Authors' elaboration based on Climate Watch Database.

The solid gray line, representing the highest pollution levels, rose steadily from 1995, peaked during 2008-2013, and declined post-2014. The dashed gray line remained relatively stable with minor fluctuations and a slight reduction after 2014, while the dashed black line grew until 2013 before decreasing. The solid black line, reflecting renewable energy or negligible pollution, stayed consistently low throughout the period, showing minimal variation. These trends suggest a gradual shift toward less harmful pollutants in recent years, though industrial and energy-related emissions (solid gray/dashed gray) remain dominant.

Argentina's pollution and carbon emission patterns reveal critical challenges tied to energy production, transportation, and land use, with electricity/heat generation and transport being the largest contributors. The sectoral breakdown underscores the need for targeted policies to accelerate renewable energy adoption, improve industrial efficiency, and curb deforestation. While recent declines in high-impact pollutants (solid gray/dashed gray) signal progress, sustained efforts are essential to align with climate goals and transition toward a low-carbon economy. These insights provide an actionable framework for prioritizing mitigation strategies and advancing environmental sustainability.

4. METHODOLOGY

4.1. Theoretical framework

The relationship between international economic integration and environmental outcomes has been widely analyzed through the scale-composition-technique framework developed by Grossman and Krueger (1991) and formalized by Copeland and Taylor (2003). This approach has become the dominant theoretical lens for evaluating how globalization, and, more recently, GVC participation, affects pollution. The framework remains particularly relevant for studying Argentina, where production structure, technological heterogeneity, and institutional constraints shape the environmental implications of GVC participation.

Academic literature widely acknowledges that a country's participation in GVCs, and the resulting environmental consequences, is influenced by its factor endowments, production capabilities, and institutional context (Hochachka, 2023; OECD, 2021). Yet the ecological footprint associated with this participation varies significantly across development levels. Developed economies tend to specialize in knowledge-intensive segments of GVCs, benefitting from technological advantages that reduce emission intensities, even though their consumption-driven production systems continue to exert substantial environmental pressures (Fei *et al.*, 2020; Hu *et al.*, 2021; Jin *et al.*, 2022). In contrast, developing countries often remain concentrated in resource-intensive and low-value-added segments, reinforcing patterns associated with higher pollution levels and environmental degradation (Liu *et al.*, 2018; Su *et al.*, 2023). These structural differences have direct implications for the scale, composition, and technique channels through which GVC participation influences carbon emissions.

Within this framework, the scale effect reflects changes in pollution arising from increased levels of production. Deeper GVC participation can expand output through export growth, foreign demand, and greater use of imported intermediates, increasing emissions unless offset by technological improvements (Grossman and Krueger, 1991).

The composition effect captures the impact of changes in a country's production structure. Comparative advantages, trade agreements, and insertion points in GVCs may shift resources toward either more or less pollution-intensive sectors (Copeland and Taylor, 2003). For economies such as Argentina, where agriculture and resource-based sectors play a dominant role, GVC participation may reinforce environmentally intensive specialization patterns (Sanguinet, 2021).

The technique effect represents changes in emission intensity resulting from technological upgrading, regulatory improvements, or efficiency gains. Participation in GVCs can facilitate technology transfer, adoption of international standards, and modernization of production processes, particularly in manufacturing sectors where lead firms impose environmental requirements.

Following Copeland and Taylor (2003), changes in total emissions P can be expressed as the sum of changes in scale, composition, and technique:

$$d\ln P = d\ln S + d\ln C + d\ln T \quad [1]$$

This compact expression provides the conceptual foundation for the empirical strategy. The present study operationalizes these effects using three widely adopted proxies: Gross Domestic Product (GDP) per capita for the scale effect, the capital-labor ratio for the composition effect, and energy intensity for the technique effect. These indicators capture the key mechanisms emphasized in theoretical literature and are consistent with empirical applications in trade and environmental economics (Liu *et al.*, 2018; Fei *et al.*, 2020).

For transparency and completeness, the full mathematical derivation of the decomposition, including the assumptions underlying production structure, factor accumulation, and emission functions, is provided in Appendix A. Relocating these derivations to the appendix streamlines the theoretical exposition while preserving the analytical foundation that motivates the empirical specification.

4.2. Hypothesis development

The relationship between GVC participation and carbon emissions is complex and multifaceted, the pollution haven hypothesis posits that trade liberalization encourages pollution-intensive industries to relocate from developed countries with stringent environmental regulations to developing countries with more lenient policies. Studies support this view, highlighting increased environmental degradation in developing nations due to trade openness (Copeland and Taylor, 2003; Markusen and Maskus, 2001). Other research, such as Meng, Yan, and Yu (2022), Su *et al.* (2023) and Bhayana and Nag (2024), further illustrates how trade networks amplify carbon emissions in production-heavy economies. Participation in GVCs has been linked to reductions in carbon and SO2[7] emissions through access to green technologies and cleaner production methods (Fei *et al.*, 2020; Hu *et al.*, 2021; Wang, Rickman, and Yu, 2022; Jin *et al.*, 2022). Liu *et al.* (2018) attributed 35% of energy efficiency gains to increased GVC positions, while Wang, Wan, and Wang (2019) highlighted the role of R&D investments in mitigating emissions in low-GVC participation countries. Advanced technologies transferred

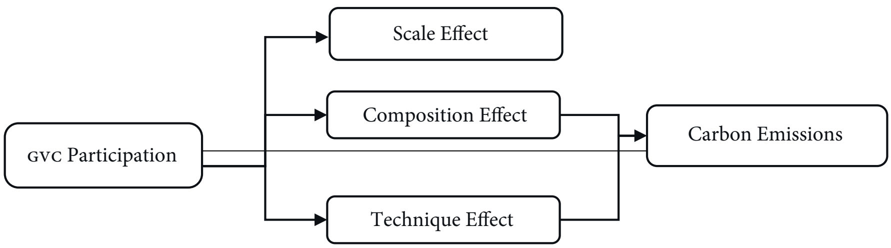
7 Sulphur dioxide (SO2) is a colourless, toxic gas with a sharp, irritating smell, similar to burning matches. It is primarily produced by the combustion of sulphur-containing fuels, such as coal and oil.

from upstream to downstream supply chain actors also encourage cleaner production and improved environmental performance (Shi *et al.*, 2022).

The trade-environment model developed by Copeland and Taylor (2003) provides a foundational framework for studying the environmental effects of international trade as it was explained in the previous section[8]. Although this model was primarily designed to examine inter-industry trade impacts, it can be extended to analyse the environmental implications of GVC participation through three key mechanisms: Scale effect, composition effect, and technology effect.

Figure 7 illustrates the anticipated overall effects of GVC participation on carbon emissions. The scale effect is always linked to increased pollution levels (positive sign). The composition effect has mixed outcomes, influenced by the capital intensity of economic growth. Specifically, if higher capital intensity aligns with more pollution-heavy industries, an increase in composition will lead to more pollution; otherwise, the effect will be negative. The technique effect, which reflects improvements in production methods, typically reduces emissions per unit of output, resulting in a negative slope across all income levels. Consequently, the net impact of economic growth depends on the relative weights of the scale, composition, and technique effects, and could be either positive or negative.

Figure 7. Decomposition of environmental impacts into scale, composition and technique effects



Source: Constructed by the authors.

[8] The scale, composition, and technique effects framework explain how trade and GVC participation influence environmental outcomes.

This role of GVC participation contributes to mitigate the carbon emissions underscoring the importance of contextual factors, such as industry composition, regulatory frameworks, and technology adoption, in shaping environmental outcomes. Based on this analysis, the following hypotheses are proposed:

H1: GVC participation is positively associated with carbon emissions.
H2: Scale effect plays a significant mediating role between GVC participation and carbon emissions.
H3: Composition effect plays a significant mediating role between GVC participation and carbon emissions.
H4: Technical effect plays a significant mediating role between GVC participation and carbon emissions.

4.3. Model

In this paper, the two fixed effects in Ordinary Least Squares (OLS) regression technique will be applied to analyze the relationship between environmental factors and GVC participation. OLS assumes a linear relationship between variables and seeks to minimize the sum of squared differences between observed and predicted values, providing insight into the strength and direction of the impact of various factors on environmental performance. By using this method, it aims to identify significant drivers of environmental outcomes within Argentina's participation in GVCs. Based on this, an environmental model is established:

$$\ln P_{it} = \beta_0 + \beta_1 \ln GVCP_{it} + \beta_2 \ln S_{it} + \beta_3 \ln T_{it} + \beta_4 \ln C_{it} + \beta_5 X_{it} + \vartheta_i + \delta_t + \varepsilon_{it} \quad [2]$$

In this model, P signifies carbon emissions within the economy. $GVCP$ represents overall GVC participation and its sectoral breakdown, including forward and backward GVC components. The variable S, denoting scale effect, is proxied by real GDP per capita, T represents the technique effect employed by energy intensity of the GDP, and C stands for the composition effect represented by capital-labor ratio. Ln represents the variables in Log, X represents the control variables, ϑ is industry fixed-effects, δ is time fixed-effects and ε error term. Finally, *i* denotes the different industries and t the years.

There exists a high probability that enterprises involved in downstream processes within GVCs exert distinct environmental impacts compared to those engaged in upstream activities. To delineate the differential effects on environmental outcomes attributed to forward GVC linkages versus backward GVC linkages[9], the GVCs are disaggregated. Subsequently, the analysis employs both backward (*bw*) and forward (*fw*) components as separate independent variables within a similarly structured econometric model. This approach allows for a nuanced understanding of how different stages of *GVCP* contribute to environmental degradation or improvements, providing insights into the scale, composition, and technique effects across various sectors.

$$\begin{aligned} \ln P_{it} &= \beta_0 + \beta_1 \ln bw_{it} + \beta_2 \ln S_{it} + \beta_3 \ln T_{it} \\ &\quad + \beta_4 \ln C_{it} + \beta_5 X_{it} + \vartheta_i + \delta_t + \varepsilon_{it} \end{aligned} \qquad [3]$$

and

$$\begin{aligned} \ln P_{it} &= \beta_0 + \beta_1 \ln fw_{it} + \beta_2 \ln S_{it} + \beta_3 \ln T_{it} \\ &\quad + \beta_4 \ln C_{it} + \beta_5 X_{it} + \vartheta_i + \delta_t + \varepsilon_{it} \end{aligned} \qquad [4]$$

While these proxies are widely used in literature, each presents potential measurement limitations. GDP per capita may overestimate the scale effect if part of economic activity occurs in low emission sectors

[9] The indicators of forward and backward participation used in this section follow the OECD-WTO TiVA methodology. Backward GVC participation measures the share of foreign value added embodied in a country's exports, capturing the extent to which domestic production depends on imported intermediate inputs. Forward GVC participation, by contrast, represents the domestic value added that is incorporated into other countries' exports, reflecting the contribution of national industries to foreign production processes. Both indicators are constructed using international input-output tables that trace value-added flows across industries and countries. The decomposition allows distinguishing whether Argentina integrates into global value chains primarily as an importer of intermediates or as a supplier of domestic value added to foreign production networks. All values presented in this section are derived from the TiVA 2023 release, ensuring international comparability and consistency across sectors and years.

and may underestimate it when informal or non-reported emissions are significant. The capital-labor ratio, although effective in capturing structural shifts, may not fully reflect sector-specific technological heterogeneity or differences in emission intensity unrelated to factor proportions. Energy intensity, in turn, captures broad improvements in efficiency but cannot differentiate between technological upgrades and short-term fluctuations in energy prices or consumption patterns.

To address these concerns, alternative measures, such as sectoral emission intensities, total factor productivity, or indices of technological sophistication, were considered. However, these indicators are not consistently available throughout the full period and industry disaggregation is required for analysis. The selected proxies offer the best balance between theoretical relevance, empirical consistency, and data availability for Argentina between 1995 and 2020.

4.4. Data

Based on the three decomposition effects, we use Argentina's industrial regional panel data and pollution emission data to investigate the impact of GVC participation on the environment from 1995 to 2020. In terms of the selection of pollutant emissions, the data of carbon dioxide (CO2) were collected from the Climate Watch Database. This paper utilizes a dataset from the OECD-WTO TiVA within their 45 industries (see Table A1). The OECD-WTO TiVA Database covers 64 economies —including all OECD countries, EU member states and the G20, 16 manufacturing sectors and 14 service sectors are covered.

The empirical model operationalizes the scale, composition, and technique effects following standard approaches in the environmental economics and GVC literature. First, GDP per capita value over the years is used as a proxy for the scale effect, reflecting changes in overall economic activity and production volume. This proxy is widely employed in trade-environment studies, including Wang, Wan, and Wang (2019), Su *et al.* (2023) and Bhayana and Nag (2024), because carbon emissions typically increase with higher economic output unless counteracted by strong environmental regulation or technological improvements.

Second, the capital-labour ratio is used as a proxy for the composition effect, capturing structural changes toward more capital-intensive or resource-intensive production. Previous studies (Shi *et al.*, 2022; Hu *et al.*, 2021) rely on this measure because economies with higher capital intensity tend to specialize in manufacturing, heavy industry, or extractive activities that differ substantially in their emission profiles. Although the composition effect can be measured through sectoral shares, the capital-labour ratio provides a consistent and continuous indicator across industries and years, enabling econometric identification in panel data.

Third, the technique effect is approximated through energy intensity, measured as energy use per unit of GDP. This proxy is consistent with research highlighting improvements in energy efficiency, through cleaner technologies, better machinery, and stricter environmental standards, reduce emissions even when economic output expands (Fei *et al.*, 2020; Jin *et al.*, 2022; Liu *et al.*, 2018). Energy intensity is therefore a suitable aggregate indicator of technological upgrading in production processes.

To prevent bias from omitting variables, a set of control variables is included in our econometric model. These controls encompass inflation, the openness rate, foreign direct investment, imports and exports.

The GDP per capita, capital-labor ratio, energy intensity, inflation, openness rate, and foreign direct investment used in this model were collected from the World Development Indicators. Imports and exports were collected from UN COMTRADE. The results of descriptive statistics are presented in Table 1.

Table 1. Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Ln *CO2*	1,170	14.883	1.031	12.206	16.981
Ln *GVCP*	1,170	5.973	1.806	0.000	10.012
Ln *Scale*	1,170	1.312	0.705	–1.347	3.047
Ln *Technique*	1,170	13.543	3.489	5.447	22.509
Ln *Composition*	1,170	6.173	0.658	4.268	7.162
Ln *Openess*	1,170	1.803	0.190	1.454	2.137
Ln *Exports*	1,170	10.697	0.447	9.955	11.326
Ln *Imports*	1,170	10.525	0.549	9.103	11.217
Ln *Inflation*	1,170	2.255	1.671	–2.995	3.895
Ln *FDI*	1,170	0.698	0.516	–0.544	2.135

5. RESULTS

5.1. Main findings

Table 2 represents the two fixed effect regression results. The relationship between carbon emissions and GVC participation that includes the sum of backward and forward index is positive and significant. A 1% increase in GVC participation increases CO2 by 0.009% in Argentina.

Table 2. Main results

Variables	Ln *CO2*	Ln *CO2*	Ln *CO2*	Ln *CO2*	Ln *CO2*	Ln *CO2*
Ln *GVCP*	0.003***	0.009***				
	(0.014)	(0.014)				
Ln *GVCP Bw*			0.013***	0.017***		
			(0.014)	(0.013)		
Ln *GVCP Fw*					0.001***	0.007***
					(0.014)	(0.014)
Ln *Scale*		0.270***		0.271***		0.269***
		(0.000)		(0.038)		(0.038)
Ln *Technique*		–0.022***		–0.021***		–0.022***
		(0.038)		(0.050)		(0.005)
Ln *Composition*		–0.001***		–0.001***		–0.001***
		(0.005)		(0.001)		(0.001)
Ln *Openness*	–0.001**	–0.001***	–0.008***	–0.002***	–0.001***	–0.001***
	(0.074)	(0.075)	(0.074)	(0.076)	(0.074)	(0.075)
Ln *Exports*	0.044	0.159	0.142**	0.151***	0.157**	0.159***
	(0.044)	(0.054)	(0.067)	(0.075)	(0.066)	(0.075)
Ln *Imports*	–0.155***	–0.106***	–0.041	–0.115	–0.044	–0.104
	(0.066)	(0.075)	(0.044)	(0.054)	(0.044)	(0.054)
Ln *Inflation*	–0.009***	–0.017***	–0.009***	–0.017***	–0.009***	–0.017***
	(0.008)	(0.009)	(0.008)	(0.009)	(0.008)	(0.009)
Ln *FDI*	0.003***	0.006***	0.002***	0.006***	0.003***	0.006***
	(0.014)	(0.015)	(0.014)	(0.015)	(0.014)	(0.015)
Industries FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,170	1,170	1,170	1,170	1,170	1,170
R-squared	0.195	0.234	0.194	0.233	0.195	0.234
Number of IND	45	45	45	45	45	45

Notes: Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Related to the decomposition effects all are significant, the scale shows a positive relationship with pollution although technique and composition effects have a negative relationship with the dependent variable. The scale results show that the expansion of the economy or the scale effect is associated with an increase in carbon emissions. The impact is significant for all specifications. The result is in line with Copeland and Taylor (2003), Su *et al.* (2023) and Bhayana and Nag (2024). About the composition effect, the results show that an increase in the capital-labor ratio leads to less carbon emissions in Argentina. This result is in line with the findings of Shi *et al.* (2022), but contrast with those who find that the composition effect is positively related to carbon emissions (Hu *et al.*, 2021; Zhang *et al.*, 2021). The results of carbon emissions with respect to energy intensity or technique effect are negative and statistically significant. This suggests that improvement in energy intensity will reduce carbon emissions in Argentina (Fei *et al.*, 2020; Jin *et al.*, 2022). These results support the proposed hypotheses H1, H2, H3 and H4.

Additional analysis shows that backward GVC participation has a positive and statistically significant relationship with carbon emissions in all specifications. Similarly, forward GVC participation also leads to higher carbon emissions (Shi *et al.*, 2022). These results are fully consistent with the theoretical decomposition into scale, composition, and technique effects and confirm the expected signs derived in the conceptual framework.

5.2. Robustness check

The relationship between GVC participation and emissions is subject to potential endogeneity arising from reverse causality and omitted variable bias. Higher emissions may discourage participation in certain value chains due to environmental compliance requirements, while unobserved technological or regulatory factors may simultaneously affect both emissions and GVC participation. To mitigate these concerns, the analysis includes a set of control variables and employs industry and year fixed effects, but these measures alone may be insufficient to isolate causal effects.

To strengthen identification, this study implements an instrumental variable (IV) strategy using two external and plausibly exogenous instruments: 1) tariff rates on intermediate goods and 2) one-period lagged GVC participation. Tariff rates influence the cost and intensity of international production linkages but do not directly affect carbon emissions except through their impact on GVC participation. This follows the argument in Meng, Yan, and Yu (2022), who show that trade policy shocks are valid instruments for GVC participation. The lagged GVC variable captures persistence in value-chain participation while reducing simultaneity bias. The tariff rates on intermediate goods, sourced from the WTO and World Integrated Trade Solution databases, are considered exogenous to carbon emissions because they primarily reflect trade policy measures rather than being directly influenced by a country's environmental performance. This approach not only enhances the robustness and reliability of the findings but also provides deeper insights into the mechanisms driving environmental impacts associated with GVC participation.

Table 3. IV regression results with 2SLS estimation

Variables	(IV): Tariff rates on intermediate goods		(IV): One lag period of *GVCP*	
	Stage I	Stage II	Stage I	Stage II
Ln *GVCP*		0.365*		0.006*
		(0.209)		(0.020)
Ln *GVCP_IV*	0.039***		0.972***	
	(0. 011)		(0.012)	
Ln *Scale*	0.945***	0.212	0.053	0.106*
	(0.118)	(0.197)	(0.069)	(0.058)
Ln *Technique*	–0.028	–0.039	–0.029*	–0.045**
	(0.035)	(0.024)	(0.016)	(0.018)
Ln *Composition*	–0.002***	–0.001***	0.001	–0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
Control variables	Yes	Yes	Yes	Yes
Industries FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Kleibergen-Paap rk LM	11.964		5,957.18	
Cragg-Donald Wald F	409.89		828.49	
Observations	1,170	1,170	1,170	1,170
R-squared	0.161		0.962	

Notes: Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3 presents the results of the Two-Stage Least Squares (2SLS) regression analysis. Diagnostic tests, including the Kleibergen-Paap rk LM and the Cragg-Donald Wald F-statistic, confirm the instruments' validity and strength, with F-values well above the threshold of 10. These results support the main results obtained in Table 2.

5.3. Heterogeneity Analysis

The sectoral analysis reveals heterogeneous environmental effects of GVC participation across agriculture, manufacturing, and services. These differences are closely linked to Argentina's productive structure and its asymmetric integration into global value chains (Shi *et al.*, 2022; Agostino *et al.*, 2023).

Table 4 shows that in the agricultural sector, GVC participation increases carbon emissions, which is consistent with Argentina's specialization in resource-intensive and land-extensive activities. Agriculture remains a core pillar of the export structure, dominated by soy, maize, wheat, and livestock, activities associated with deforestation, methane emissions, fertilizer use, and energy-intensive mechanization. The expansion of backward and forward linkages in agribusiness amplifies production scale and reinforces the country's historical pattern of primary export primarization, generating a strong positive scale effect. Moreover, technological spillovers from GVCs in this sector often emphasize productivity (*e.g.*, higher yields, automated machinery) rather than green innovations, limiting the magnitude of the technique effect. These dynamics help explain why GVC participation leads to higher emissions in agriculture despite potential efficiency gains. In contrast, the manufacturing sector exhibits a negative relationship between GVC participation and carbon emissions, suggesting that GVCs serve as a channel for cleaner production practices and technological upgrading. Manufacturing in Argentina, particularly in automotive, machinery, chemicals, and electronics, relies on imported intermediate inputs and global production standards that tend to incorporate environmental efficiency requirements. Integration into these chains often involves compliance with international norms, adoption of cleaner technologies, and modernization of equipment, thereby reinforcing a strong negative technique effect. Additionally, Argentina's manufacturing base is relatively small compared to the primary sector, which reduces the potential positive scale effect typically associated with industrial expansion. The negative coefficient indicates that participation in manufacturing-related GVC processes may foster environmental upgrading, especially in medium- and high-tech segments that rely on knowledge-intensive inputs. The service sector shows no significant relationship between GVC participation and emissions, which is consistent with its lower direct environmental intensity. Many services integrated into GVCs in Argentina, particularly professional services, logistics, IT, and business services, generate limited direct emissions and often contribute indirectly to efficiency improvements in other sectors. The negligible impact suggests that services function more as facilitators of value-added processes than as polluting activities, confirming patterns observed in other developing economies.

Table 4. Subsample regression results based on sector level

Variables	Agriculture	Manufacturing	Services
	Ln *CO2*	Ln *CO2*	Ln *CO2*
Ln *GVCP*	0.024***	–0.133***	0.006
	(0.019)	(0.025)	(0.005)
Ln *Scale*	0.735***	0.103*	0.059***
	(0.081)	(0.056)	(0.015)
Ln *Technique*	–0.191***	–0.001	–0.012***
	(0.013)	(0.008)	(0.002)
Ln *Composition*	–0.001	–0.001	–0.001***
	(0.001)	(0.000)	(0.000)
Control variables	Yes	Yes	Yes
Industries FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	125	644	312
R-squared	0.865	0.269	0.957
Number of IND	5	25	12

Notes: Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Thus, these sectoral differences highlight that the environmental impact of GVC participation is conditioned by Argentina's structural duality: A high-emission, resource-based agricultural sector contrasted with smaller but technologically dynamic manufacturing industries. Incorporating literature on structural change, technological heterogeneity, and path dependence helps explain why GVC participation may exacerbate emissions in primary sectors while mitigating them in manufacturing. These insights underscore the importance of designing differentiated policies tailored to sector-specific dynamics.

6. CONCLUSIONS AND POLICY IMPLICATIONS

6.1. Conclusions

This research highlights the intricate and often contradictory relationship between Argentina's participation into GVCs and its environmental outcomes, particularly in terms of carbon emissions and pollution. On the one hand, GVC participation has driven economic expansion and increased production, especially in resource-intensive sectors such as agriculture and basic manufacturing. This scale effect has directly contributed to higher levels of pollution and carbon emissions, as these industries rely heavily on energy- and emission-intensive methods to remain competitive in global markets.

However, the environmental impact of GVCs is not unidirectional. The composition and technology effects offer partial mitigation pathways. The composition effect suggests that a shift toward more technology-intensive sectors could reduce pollution, though Argentina's current GVC specialization remains concentrated in low-value-added and high-polluting activities. The technology effect indicates that GVC participation can facilitate the diffusion of cleaner production technologies and improved energy efficiency through knowledge transfer and foreign direct investment. While there is evidence of modest improvements in energy use and technological upgrading, these advances have not been sufficient to counterbalance the overall rise in emissions.

Environmental outcomes also differ across sectors. Pollution increases are most evident in traditional export industries, yet these are also the sectors where targeted technological interventions and policy reforms could yield the most significant gains. The findings underscore that market forces and GVC engagement alone are inadequate for ensuring environmental sustainability. Instead, strategic policy measures, such as stricter environmental regulations, stronger enforcement, and incentives for cleaner production, are essential to unlock the environmental potential of GVC participation.

Ultimately, both analyses converge on a critical insight: Argentina's current model of GVC participation is contributing to environmental degradation, but with the right institutional support and policy frameworks, this trend can be reversed. By actively steering industrial restructuring, promoting green technologies, and regulating carbon emissions in key sectors, Argentina has the opportunity to transform its GVC involvement into a pathway toward environmentally sustainable development.

6.2. Policy implications

The econometric results provide clear evidence that Argentina's participation in GVCs has heterogeneous environmental effects shaped by the scale, technique, and composition channels. Therefore, policy interventions must explicitly target these mechanisms and reflect the sectoral asymmetries observed in the agricultural and manufacturing sectors.

The positive and statistically significant scale effect indicates that economic expansion, particularly in agriculture and resource-based industries, leads to higher carbon emissions. To contain this effect, policies should focus on moderating the environmental intensity of production growth. This includes implementing stricter emission standards for agricultural producers, enforcing land-use regulations, and strengthening monitoring of deforestation and methane emissions. Targeted environmental taxes or carbon pricing mechanisms could reduce the incentive for scale-driven pollution increases, especially in emission-intensive value chains. These instruments directly address the mechanism identified empirically: Growth in production volume is a key driver of rising emissions.

The negative coefficient associated with energy intensity confirms that technological upgrading and improvements in energy efficiency reduce emissions. Therefore, policies promoting cleaner production methods are essential. Expanding subsidies for renewable energy adoption, facilitating access to green technologies, and offering fiscal incentives for energy-efficient machinery can amplify the technique effect identified in the results[10,11]. Programs such as RenovAr should be scaled up to accelerate the diffusion of green technologies across agricultural and manufacturing firms[12]. Encouraging compliance with international environmental certifications (*e.g.*, ISO 14001) would further align domestic production with global sustainability requirements. These measures capitalize on the empirical finding that efficiency improvements are a crucial channel for reducing emissions.

The negative and significant coefficient of the composition effect suggests that shifts toward more capital-intensive or technologically advanced structures can reduce emissions. This highlights the importance of promoting structural transformation away from highly resource-intensive sectors and toward higher-value-added manufacturing and knowledge-intensive services. Policies that support industrial upgrading, such as investment in R&D, technology parks, and sector-specific modernization plans, can reinforce this channel. Additionally, incentives for companies to diversify into cleaner manufacturing segments (*e.g.*, electric vehicles, biotechnology, advanced machinery) could accelerate the transition toward a less carbon-intensive production structure. This aligns with empirical evidence that composition shifts can mitigate environmental pressures.

The sectoral regressions reveal that GVC participation increases emissions in agriculture but reduces them in manufacturing. These divergent impacts require differentiated policy approaches. In agriculture, interventions should focus on sustainable intensification practices, such as precision farming, improved waste management, and methane-reducing feed additives. Support for low-emission technologies and conservation policies can mitigate the scale-driven rise in emissions. In manufacturing, where GVC participation fosters cleaner processes, policies should incentivize further technology adoption, participation into higher segments

[10] See for more details: www.netzerocircle.org/articles/argentinas-burgeoning-renewable-energies-sector

[11] See for more details: https://taxsummaries.pwc.com/argentina/corporate/tax-credits-and-incentives

[12] See for more details: https://www.argusmedia.com/en/news-and-insights/latest-market-news/2525134-argentina-eyes-emissions-trading-system

of GVCs, and compliance with international standards[13]. Strengthening backward linkages to global suppliers of clean technologies can further reinforce the negative effect identified in manufacturing.

Finally, translating these findings into effective environmental governance requires robust institutional frameworks. Strengthening regulatory agencies, improving enforcement capacity, and coordinating policies across ministries are essential to manage the environmental risks of GVC participation. Aligning national policies with global climate commitments, such as the Paris Agreement and EU environmental standards, can also help steer production toward greener trajectories. Institutional stability is crucial to sustain the long-term impacts of the scale, composition, and technique effects identified in the econometric analysis[14]. ◄

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[13] See for more details: https://fund.ar/en/publicacion/trade-challenges-and-opportunities-in-a-world-fighting-climate-change-and-deforestation

[14] See for more details: https://allende.com/en/administrative/new-regulation-for-the-importation-and-exportation-of-recycled-waste-in-argentina-01-03-2025

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APPENDIX A

Environmental upgrading offers pathways to sustainable GVC participation through three mechanisms: 1) process innovations that enhance resource efficiency; 2) product redesign using eco-friendly materials and 3) organizational shifts through sustainability certifications. According to the study from Copeland and Taylor (2003), it defines the pollution equation as:

$$\hat{z} = \hat{S} + \hat{\varphi}_x + \hat{e} \qquad [5]$$

Where $\hat{z} = dz / z$, and so on. And the scale, S, is defined as:

$$S = p^0 x + y \qquad [6]$$

Where p^0 denotes the world relative price of X before any shocks they analyse.

The first component is the scale effect, which quantifies the rise in pollution if the economy expanded proportionally, assuming no changes in the mix of goods produced or the production methods. The second component is the composition effect, which reflects changes in the share of pollution-intensive goods within national output. If the size of the economy and emissions intensities remain unchanged, an increase in the production of polluting goods will lead to higher pollution levels. Lastly, the technique effect captures the impact of improvements in production methods; a decrease in emissions intensity, with all other factors held constant, will reduce pollution.

To analyse the effects of scaling up factor endowments, let the new endowment vector be denoted as (λK, λL) where λ represents the proportional increase in all inputs. Taking the logarithmic concerning λ results in an expression that decomposes the change in pollution into scale, composition, and technique effects:

$$\frac{\frac{dz}{d\lambda}}{z} = \frac{\frac{dx}{d\lambda} + \frac{dy}{d\lambda}}{S} + \frac{\frac{d(x/S)}{d\lambda}}{\varphi_x} + \frac{\frac{de}{d\lambda}}{e} \qquad [7]$$

Here, they make use of equation [6] and assume normalized units where $p^0 = 1$. Then they assume that x and y are homogeneous of degree 1 concerning K and L, which means:

$$\frac{\frac{dx}{d\lambda}+\frac{dy}{d\lambda}}{S}=\frac{x(p,\tau,K,L)+y(p,\tau,K,L)}{x(p,\tau,\lambda K,\lambda L)+y(p,\tau,\lambda K,\lambda L)}=\frac{1}{\lambda}>0 \qquad [8]$$

This result implies that the scale effect is positive because scaling up endowments proportionally increases production scale. This represents a pure scale effect since the composition and technique effects are zero.

To explain further: The linear homogeneity of x and y in endowments ensures that the ratio x/S remains unchanged, which means $d(x/S) = 0$. Thus, the composition effect is zero according to equation [7]. Additionally, since both prices p and technology $\tau$are assumed to be fixed, the emissions intensity e does not change, leading to $de/d\lambda = 0$. As a result, the technique effect is also zero [7]. Therefore, under these assumptions of exogenous pollution taxes and fixed technology, scaling up endowments leads exclusively to a pure scale effect, where:

$$\frac{\frac{dz}{d\lambda}}{z}=\frac{1}{\lambda}>0 \qquad [9]$$

Continuing with the equation [7]. In this case, there is no technique effect because pollution taxes are assumed to remain constant, meaning $de/d\lambda = 0$. First, observe that the ratio $x/S = 1(1+y/x)$. Also, they assume from the Rybczynski theorem that an increase in capital accumulation leads to a decline in the ratio $d(y/x)/d\lambda < 0$ because capital growth causes a contraction in the production of Y (the labour-intensive good) and an expansion in the production of X (the capital-intensive good). Therefore, the composition effect of capital accumulation on pollution is unambiguously positive:

$$\frac{\frac{d(x/S)}{d\lambda}}{\varphi_x}>0 \qquad [10]$$

Finally, to confirm these results, they differentiate logarithmically with respect to λ. The technique effect, they establish from:

$$\frac{de/d\lambda}{e} = -\frac{1}{\lambda} < 0 \quad [11]$$

The technique effect is negative because higher taxes reduce the emission intensity.

APPENDIX B

Table A1. Industry list

N°	TiVA 2022 Codes	Economic activities	ISIC Rev. 4 Divisions
1	A01_02	Agriculture, hunting, forestry	01, 02
2	A03	Fishing and aquaculture	03
3	B05_06	Mining and quarrying, energy producing products	05, 06
4	B07_08	Mining and quarrying, non-energy producing products	07, 08
5	B09	Mining support service activities	09
6	C10T12	Food products, beverages and tobacco	10, 11, 12
7	C13T15	Textiles, textile products, leather and footwear	13, 14, 15
8	C16	Wood and products of wood and cork	16
9	C17_18	Paper products and printing	17, 18
10	C19	Coke and refined petroleum products	19
11	C20	Chemical and chemical products	20
12	C21	Pharmaceuticals, medicinal chemical and botanical products	21
13	C22	Rubber and plastics products	22
14	C23	Other non-metallic mineral products	23
15	C24	Basic metals	24
16	C25	Fabricated metal products	25
17	C26	Computer, electronic and optical equipment	26
18	C27	Electrical equipment	27
19	C28	Machinery and equipment, nec	28
20	C29	Motor vehicles, trailers and semi-trailers	29
21	C30	Other transport equipment	30

Table A1. Industry list (concluded)

N°	TiVA 2022 Codes	Economic activities	ISIC Rev. 4 Divisions
22	C31T33	Manufacturing nec; repair and installation of machinery and equipment	31, 32, 33
23	D	Electricity, gas, steam and air conditioning supply	35
24	E	Water supply; sewerage, waste management and remediation activities	36, 37, 38, 39
25	F	Construction	41, 42, 43
26	G	Wholesale and retail trade; repair of motor vehicles	45, 46, 47
27	H49	Land transport and transport via pipelines	49
28	H50	Water transport	50
29	H51	Air transport	51
30	H52	Warehousing and support activities for transportation	52
31	H53	Postal and courier activities	53
32	I	Accommodation and food service activities	55, 56
33	J58T60	Publishing, audiovisual and broadcasting activities	58, 59, 60
34	J61	Telecommunications	61
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36	K	Financial and insurance activities	64, 65, 66
37	L	Real estate activities	68
38	M	Professional, scientific and technical activities	69 to 75
39	N	Administrative and support services	77 to 82
40	O	Public administration and defence; compulsory social security	84
41	P	Education	85
42	Q	Human health and social work activities	86, 87, 88
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45	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	97, 98

The 2022 edition of the TiVA database introduces new codes to conform to new standard codes for all OECD databases that have an economic activity (ISIC Rev.4) dimension.