

Unpacking France's Emissions Paradox: The Role of FDI

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Abstract

This paper investigates the role of Foreign Direct Investment (FDI) in France's apparent decoupling of economic growth from CO_2 emissions over the past two decades. Despite rising output, domestic emissions have declined, suggesting that offshoring via FDI may partially explain this divergence. Using sectoral FDI data for manufacturing industries over 24 years, we decompose France's FDI-linked emissions into scale, composition, and technique effects. Our analysis shows that the scale effect accounts for 53% of the emissions reduction, the composition effect for 20%, and the technique effect for 27%. We further show that shifts in environmental regulation play a central role in driving these effects, highlighting the importance of international policy coordination.

Keywords: Carbon Leakage, Composition Effect, Emissions Decoupling, Environmental Regulations, Foreign Direct Investment (FDI), Offshoring, Scale Effect, Technique Effect.

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1 Introduction

The relationship between international trade, FDI, and carbon emissions is complex, particularly in the context of increasingly integrated global value chains (GVCs). As production processes become more fragmented across borders, GVCs can simultaneously foster economic efficiency and exacerbate environmental impacts. On the one hand, they facilitate the diffusion of green technologies, encouraging firms to adopt cleaner and more energy-efficient production methods and reduce their environmental footprint. On the other hand, the expansion of GVCs increases transportation-related emissions and may incentivize firms to relocate to regions with weaker environmental regulations, reinforcing the so-called Pollution Haven Effect (Copeland and Taylor, 2000). The paradoxical nature of these effects raises critical questions about how GVCs and FDI shape emissions dynamics, and understanding these interactions is crucial to fully grasping the environmental implications of economic integration.

France, a key player in Europe, offers a compelling case for examining the evolution of FDI and GVCs in relation to emissions dynamics. As one of the world's largest economies, with a GDP of approximately \$3,030.90 billion in 2023, France ranks as the seventh largest economy worldwide. The country is deeply integrated into GVCs, with steadily increasing participation rates over recent decades. According to the OECD trade-in-value-added database, France's participation in GVCs rose from 39.6% in 2000 to a peak of 49.3% in 2018, highlighting a growing economic interdependence. Since 2019, France has also emerged as the leading recipient of FDI in Europe (UNCTAD, 2024). France's involvement in GVCs extends to both upstream and downstream activities. In 2021, the foreign value added to its exports reached approximately 21%, while the domestic value added embedded in foreign exports was approximately 25.5%. The significance of France's integration into GVCs is particularly evident in various sectors. For example, the coke and refined petroleum sector exhibited an impressive 87% participation rate in GVC, with most of its production directed to foreign markets. Similarly, the mining and quarrying sector demonstrated strong GVC integration at 72.8%, with nearly half of its value sourced from abroad. Key manufacturing industries such as basic metals and transport equipment also maintain high GVC involvement, underscoring France's reliance on cross-border production networks.

Despite this growth in production and integration into GVC, France has managed to significantly reduce its domestic greenhouse gas (GHG) emissions (see Figure 1). Between 1970 and 2022, GHG emissions fell by approximately 33%, which some have termed an "emission paradox" (Wiedenhofer et al., 2020; Haberl et al., 2020) given the sustained economic expansion.

This paper explores the dynamics underlying France's emissions paradox to assess the extent to which FDI provides an explanation. By examining the interplay of scale, composition, and technique effects within the context of France's integration into GVCs and its FDI patterns, we

seek to provide an answer to the question of whether the observed reduction in GHG emissions reflects a sustainable transition or is merely an artifact of shifting pollution-intensive activities abroad through FDI.

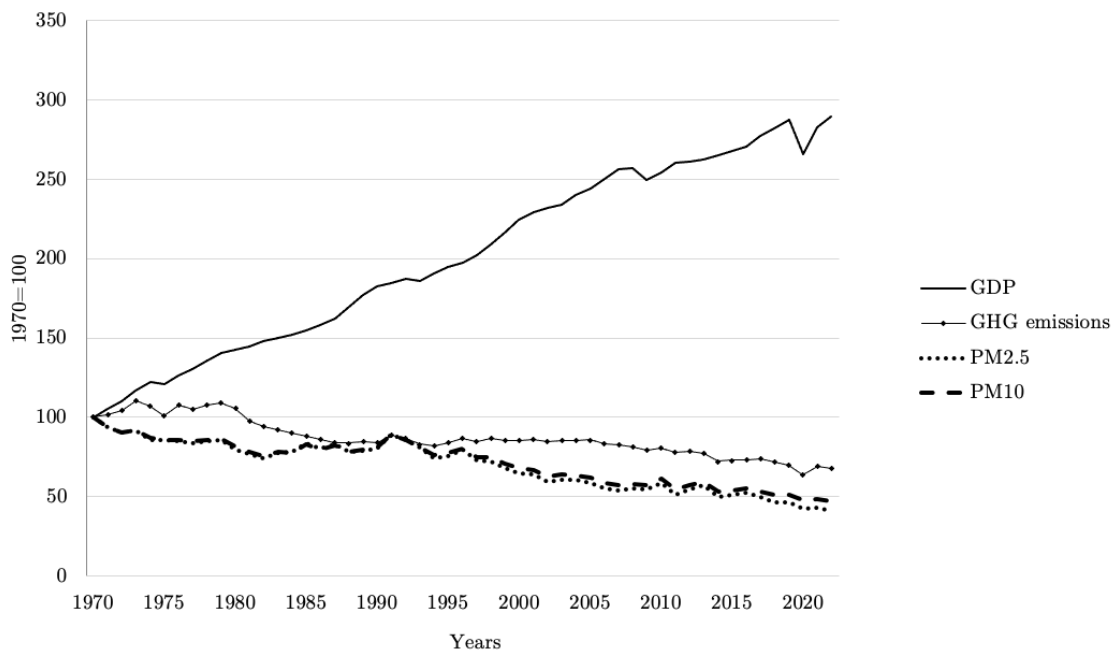


Figure 1: Breaking the Link Between Economic Growth and Emissions in France

These divergent paths challenge the traditional view that economic expansion inherently leads to higher emissions due to increased production. To dissect this phenomenon, scholars have examined the underlying mechanisms through which emissions trends decouple from economic growth. Central to this discussion are the effects of scale, composition, and technique, initially conceptualized by [Grossman and Krueger \(1991\)](#) in their foundational work on the environmental implications of the North American Free Trade Agreement (NAFTA). First, the scale effect refers to the direct relationship between economic output and emissions, consistent with the traditional view, where an increase in production leads to higher emissions, unless offset by other factors. Second, the composition effect refers to changes in the industrial structure of an economy that can influence overall emissions. This effect occurs when the economic focus shifts from pollution-intensive to clean industries or when the former relocate to countries with less stringent environmental regulations ([Copeland and Taylor, 2000](#)). Lastly, the technique effect represents improvements in production processes that reduce emissions per unit of output. This effect emerges through technological advancements, often driven by regulatory pressure and market competition. The technique effect is closely related to the Porter Environmental Hypothesis ([Porter and van der Linde, 1995](#)), which argues that more stringent environmental regulations can promote innovation and the development of environmentally friendly technologies, benefiting both the economy and the environment.

Levinson (2023) investigates pollution embodied in trade to explore whether high-income countries are reducing domestic pollution or simply outsourcing it. His approach involves a multi-step accounting exercise to calculate emission intensities (EI) for each product, enabling the estimation of pollution displacement linked to imports. By quantifying how much pollution would have been generated had these products been manufactured domestically, he sheds some light on the complexities of carbon leakage in global trade.

This paper makes four main contributions to the above-mentioned literature. First, we focus specifically on outward FDI rather than imports to isolate the offshoring effect. Second, we incorporate country-specific emissions data to capture the composition effect, moving beyond the assumption of uniform emission intensities across all countries. Third, we disentangle the technique effect, by using time-specific emissions data. Finally, we test whether environmental regulations are a relevant factor in explaining the changes in emissions embodied in FDI using a simple empirical model.

The main results show that offshoring has played a significant role in reducing emissions within France, while potentially increasing emissions abroad. We identify the occurrence of a technique effect, which is slightly more pronounced than the composition effect, indicating that technological changes and innovation play a crucial role in driving emission reductions, highlighting the importance of technological progress in sustainable production practices. Finally, we show that environmental regulations are important drivers of carbon leakage and technique effect.

The paper is organized as follows. Section 2 provides descriptive statistics and stylized facts on French FDI. In Section 3, we present our version of Levinson’s carbon leakage indicator, adapting his approach to reflect the specific context of outward FDI. Section 4 outlined the main findings disentangling scale, composition and technique effects, while Section 5 presents the estimations of the empirical model. Finally, Section 6 concludes with a summary of the main findings and some policy recommendations.

2 Globalization and FDI Dynamics: The French Case

The globalization that took off in the late 20th century has significantly reshaped the global economic landscape. Liberalization of trade policies, coupled with advancements in transportation and communication technologies, have accelerated the movement of goods, services and capital across borders (Baldwin, 2016). While multilateral trade liberalization has played a key role in this process, regional integration has also gained momentum, driven by geographic and economic proximity (Krugman, 1991), formal agreements (Baldwin, 1997), and the domino effect (Baldwin, 1997), where economic interdependence and competitive pressures push external countries to seek

entry into established trade blocs. As a result, major regional economic blocs have emerged, including the Southern Common Market (MERCOSUR), the Association of Southeast Asian Nations (ASEAN), and most notably, the European Union (EU). One of the most significant milestones in European integration was the establishment of the Schengen Area (1995), which eliminated internal border controls and facilitated economic exchanges between member states. This deeper integration has also accelerated the internationalization of production and has promoted the expansion of GVCs within the EU. Companies increasingly fragment production across multiple countries, leveraging each member state's comparative advantages. This has led to greater specialization, with Germany excelling in high-tech manufacturing, Italy and Spain in textiles, and France in the aerospace and luxury goods industries.

In addition to these regional advantages, the search for additional opportunities often takes firms beyond Europe, where other factors come into play. Non-EU markets, such as China and India, offer considerable advantages in terms of labor cost and flexible regulatory environments. These countries often have less stringent environmental regulations, which reduces the overall cost of production (Copeland and Taylor, 2000). FDI plays a critical role in this expansion, enabling firms to establish operations abroad or form strategic partnerships that deepen their global reach and enhance their competitive advantage in these emerging markets.

2.1 Trends in French FDI over Time and across Sectors

France, as a key player in the global economy, has not been exempt from these trends. The country has seen a significant increase in its involvement in both inbound and outbound FDI over the past few decades, as illustrated in Figure 2. From 1990 to 2023, outbound FDI increased by a factor of 13, while inbound FDI is now nine times larger than it was at the beginning of the period. French multinational firms have increasingly sought to expand their operations abroad, taking advantage of international markets and production opportunities. At the same time, France has become an attractive destination for foreign investment, benefiting from its central position within the European Union and its advanced industrial base. Although the gap between outward and inward FDI has increased over time, France has maintained its position as the leading recipient of FDI, as confirmed in the 2023 report on trade and development (UNCTAD, 2024).

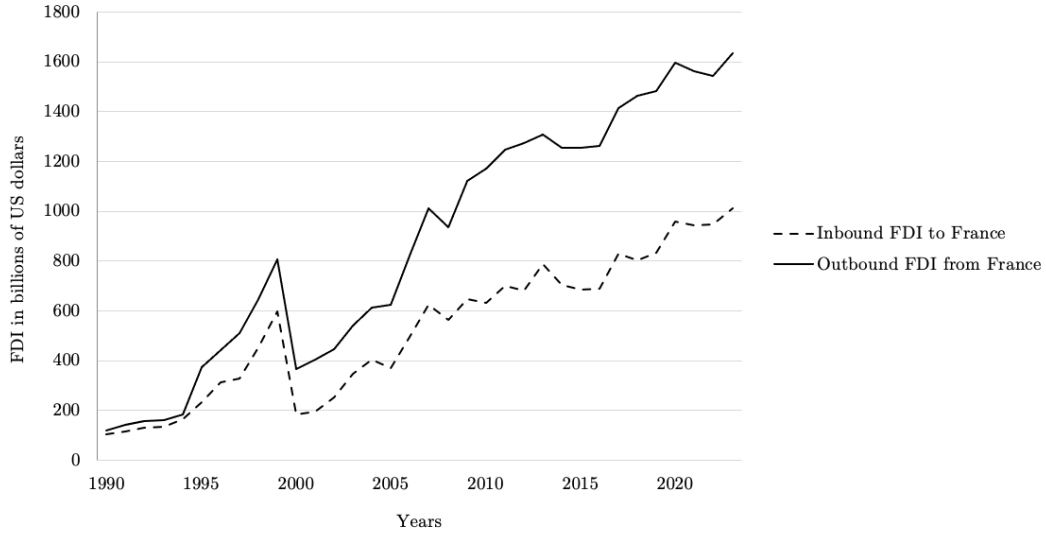


Figure 2: FDI Stocks from and to France

Breaking down French FDI by sector in 2023, we observe that manufacturing accounts for the largest share of both inward and outward flows (see Fig. 3). Within the manufacturing sector, certain industries dominate the distribution (see Fig. 4). Outward FDI is particularly concentrated in food products, textiles and apparel, chemicals, pharmaceuticals and transport equipment, whereas inward FDI is more evenly spread across food products, chemicals, and pharmaceuticals.

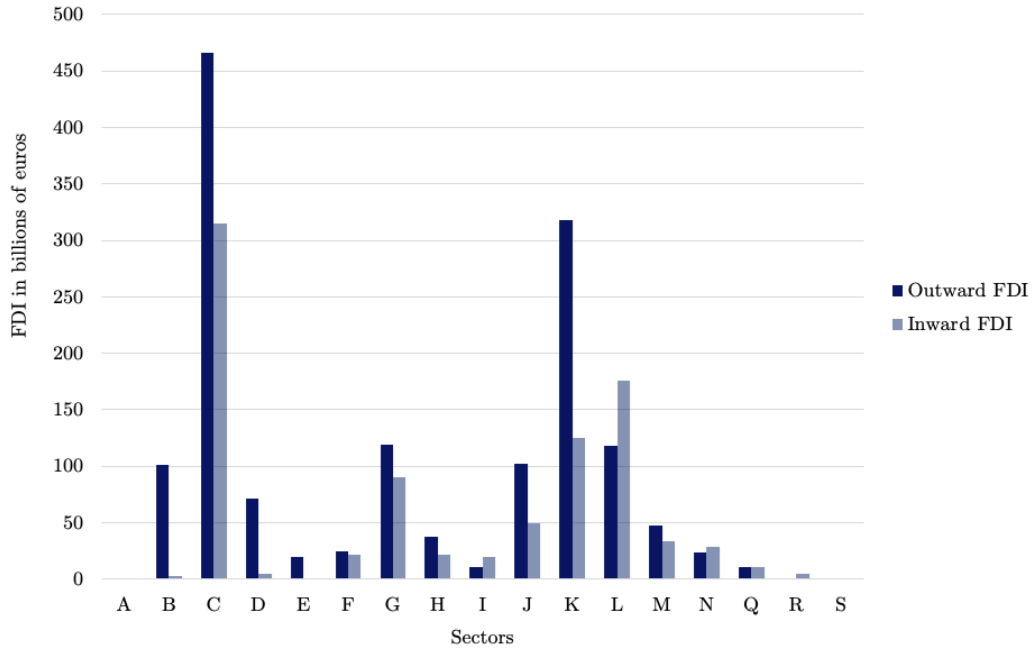


Figure 3: Inward and Outward FDI Flows across Sectors in 2023

Note: A: Agriculture, Forestry, Fishing; B: Mining, Quarrying; C: Manufacturing; D: Electricity, Gas, Steam, Air Supply; E: Water Supply, Sewerage, Waste Management, Remediation Activities; F: Construction; G: Wholesale, Retail Trade, Repair of Motor Vehicles, Motorcycles; H: Transportation, Storage; I: Accommodation, Food Service Activities; J: Information, Communication; K: Financial, Insurance Activities; L: Real Estate Activities; M: Professional, Scientific, Technical Activities; N: Administrative, Support Service Activities; Q: Human Health, Social Work Activities; R: Arts, Entertainment, Recreation; S: Other Service Activities.

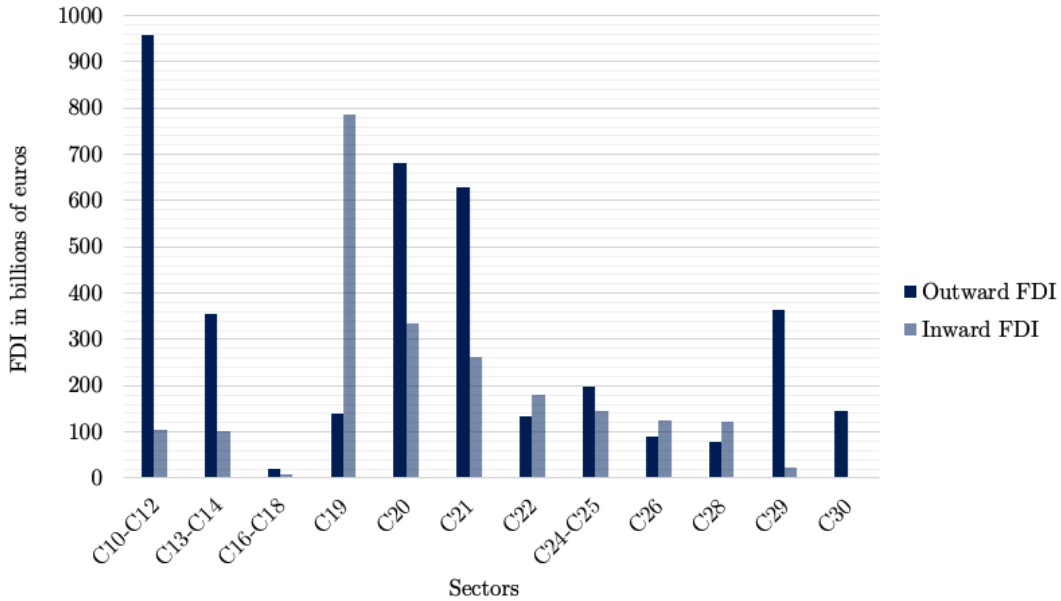


Figure 4: Inward and Outward FDI Flows in 2023. Manufacturing Industries

Note: C10-C12: Food, Beverages and Tobacco; C13-C14: Textiles; C16-C18: Wood, Paper and Printing; C19: Coke and Refined Petroleum; C20: Chemicals; C21 : Pharmaceuticals; C22: Rubber and Plastics; C24-C25: Basic and Fabricated Metals; C26: Electronics and Optical Products; C28: Machinery and Equipment; C29: Motor Vehicles; C30: Other Transport Equipment.

When analyzing emissions data, the figures shown in Table 1 highlight a notable overlap between the most polluting sectors and those most frequently relocated. Specifically, among the top five polluting sectors, three (Food, Beverages and Tobacco; Textiles; and Chemicals) are also highly prone to relocation (see column (1) of Table 1). Also, the data suggest that the outsourcing of polluting activities is not a recent trend. As early as 2000, the average share of direct emissions (i.e., emissions produced within France) across manufacturing sectors stood at only 18%. The relocation of pollution-heavy stages of production appears to be a structural feature of the French economy. This trend has only deepened over time: the share of direct emissions has continued to decline (see column (4)), while indirect emissions associated with imported inputs have increased. For instance, in the textile sector, the share of direct emissions dropped from 29% in 2000 to just 7% in 2015 (columns (2)–(3)). This shift reflects France’s growing integration into GVCs, where production is increasingly fragmented, and the most environmentally damaging stages are often offshored. The data could suggest a strategic reorientation toward cleaner segments of production, such as assembly, branding, and research and development, while more pollution-intensive activities are relocated abroad.

Table 1: French Emissions Data and Shares of Direct Emissions for 2000 and 2015

	(1)	(2)	(3)	(4)
Activity Code	Total Emissions per 1000 Units (2015)	Share of Direct Emissions (2000)	Share of Direct Emissions (2015)	Difference
C10, C11, C12	3.14	9%	7%	-2%
C13, C14	1.86	29%	7%	-22%
C16, C17, C18	1.20	24%	14%	-9%
C19	8.09	31%	27%	-4%
C20	1.99	31%	31%	0%
C22	1.41	20%	13%	-7%
C24, C25	2.63	29%	33%	+4%
C26	1.17	17%	16%	-1%
C28	1.56	6%	3%	-3%
C29	1.71	6%	3%	-3%
C30	1.47	6%	4%	-2%

Note: CO₂ emissions from [De Melo and Solleder \(2023\)](#). C10-C12: Food, Beverages and Tobacco; C13-C14: Textiles; C16-C18: Wood, Paper and Printing; C19: Coke and Refined Petroleum; C20: Chemicals; C22: Rubber and Plastics; C24-C25: Basic and Fabricated Metals; C26: Electronics and Optical Products; C28: Machinery and Equipment; C29: Motor Vehicles; C30: Other Transport Equipment.

2.2 Destinations of French FDI

French outward FDI displayed a broad geographical distribution in 2023, with substantial flows directed toward both advanced and emerging markets, as shown in Figure 5. The Netherlands stood out as the leading recipient of French FDI, attracting a remarkable 228,809 million euros, closely followed by the United States with 224,823 million euros. Other European destinations, such as the UK, Belgium, Germany, Spain and Italy, also played an important role, highlighting the relevance of established markets within the continent. Beyond Europe, emerging economies are increasingly capturing French investments, particularly China, Brazil, and India, reflecting a strategic focus on high-growth regions. This shift is a relatively recent phenomenon, as can be seen when comparing French outward FDI figures in 2000 and 2023 for the top 25 recipient countries in Figure 6. In Africa, countries such as Morocco, Angola, and South Africa are also becoming recipients of 2023 French FDI, emphasizing the continent's growing role as a target for French firms.

French FDI outward in billions of euros  0 114 229

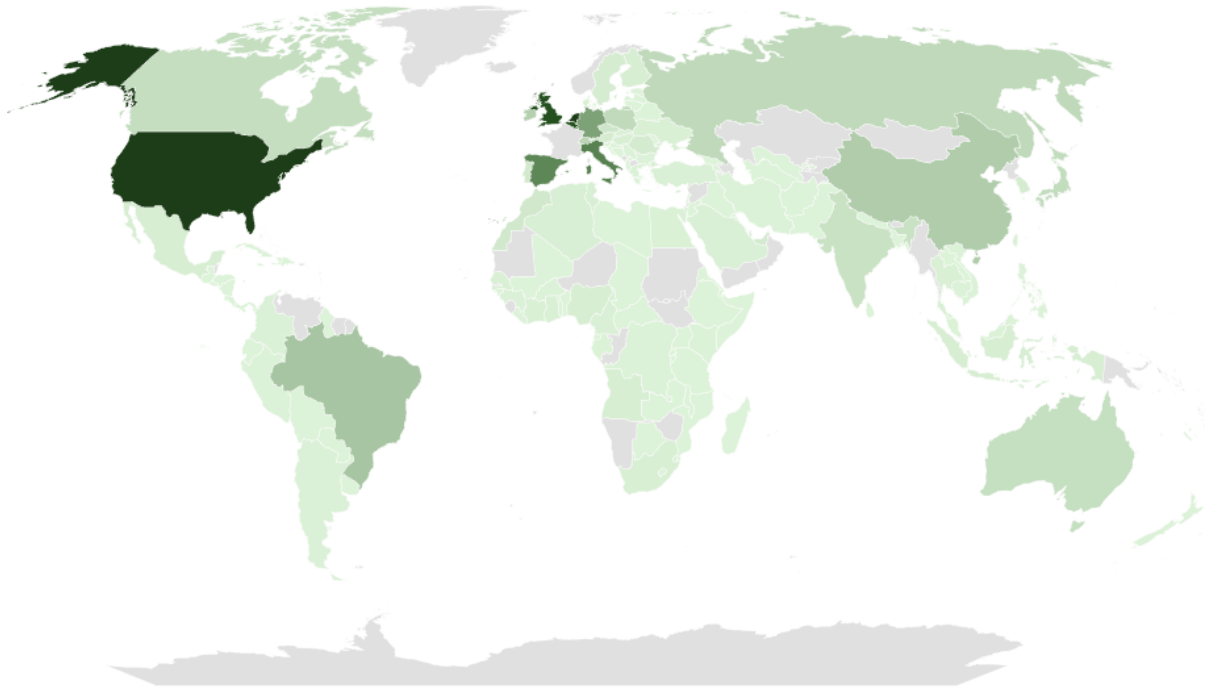


Figure 5: 2023 French FDI Outward Flows in the World

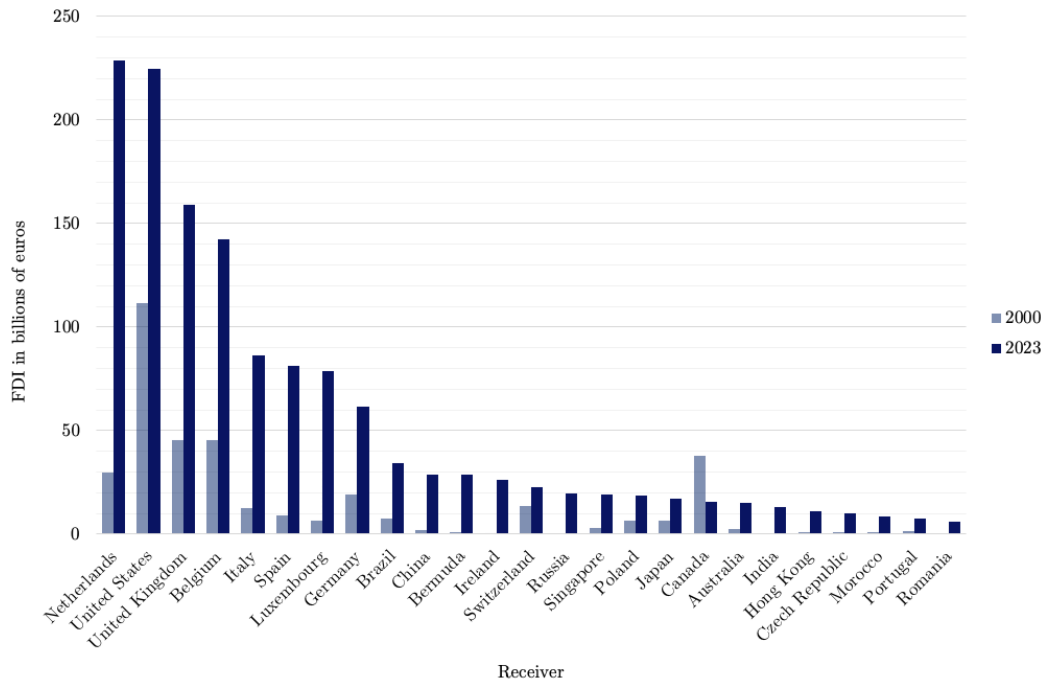


Figure 6: French FDI Outward Flows in 2000 and 2023

Taken together, these patterns suggest that the growing stock of outward FDI, particularly in manufacturing, not only reflects globalization trends but may also signal relocation dynamics with environmental implications. FDI is notably concentrated in textiles, food, and chemicals sectors historically linked to high pollution levels. Between 2000 and 2015, their share of domestic emissions declined, pointing to greater reliance on imported inputs and deeper integration into GVCs. This trend reinforcing the potential presence of a pollution haven phenomenon, which posits that firms relocate polluting activities to countries with laxer environmental standards. The geographical distribution of French FDI supports this view: Fig.6 highlights rising flows toward emerging economies, especially BRICS and African countries, which offer both lower labor costs and more lenient regulations.

3 Pollution Embodied in French FDI

This section presents the methodology used to measure emissions embodied in FDI. The analysis is limited to the manufacturing sector since it is the main recipient of FDI and its contribution to emissions is substantial. Other sectors, such as finance and real estate, also attract foreign investment, but their relative contribution to emissions is small. Whereas sectors such as transport and construction are also important polluters, their limited mobility across borders makes them less relevant to understand the dynamics of offshoring and emissions displacement.

Our analytical framework is based on the methodology proposed by [Levinson \(2023\)](#), who computed the evolution of the pollution embodied in trade over time for the USA. To assess the extent to which high-income countries reduce domestic pollution by importing emissions-intensive products, he employs a multi-step accounting exercise. First, this approach requires to calculate total emissions generated during the production process of each product. A metric for emission intensities is obtained by dividing the total amount of emissions emitted by the product's total value, expressed in tons of emissions per dollar. Pollution displacement is then obtained as the product of emission intensities and the value of imported goods, indicating how much pollution would have been released if these goods had been made domestically. The total amount of out-sourced pollution can be obtained by summing the displaced pollution across all imports, which represents the pollution avoided through trade.

3.1 Methodology

Extending Levinson’s Framework to FDI. We apply and adapt Levinson’s methodology to FDI stocks. Using FDI instead of trade flows presents several advantages. First, it provides a clearer signal of structural and long-term shifts in production, since trade flows can fluctuate due to short-term economic cycles, exchange rate variations, or temporary trade policies. Second, FDI captures corporate decision-making regarding production relocation, while imports are largely shaped by demand-side factors such as consumer preferences for specific foreign goods. Finally, unlike imports, FDI allows us to isolate the role of environmental regulations in shaping firms’ offshoring strategies, indicating whether firms actively relocate pollution-intensive activities to countries with laxer environmental standards.

To determine the total amount of embodied emissions $EE_{FR,jt}$ from France (FR) to country group j at time t , we compute the ratio of CO_2 emissions to output for each sector (k) to evaluate emission intensities. We then multiply the ratio by the amount of FDI sent from France to country group j in the given sector at time t , as expressed in the following equation:

$$EE_{FRjt} = \sum_{k=1}^K \left(\frac{CO2_{\{FR,j\}kt}}{Output_{\{FR,j\}kt}} \times FDI_{FRjkt} \right) \quad (1)$$

An equivalent equation is used to compute the emission embodied in country group j for FDI stocks directed to France by interchanging the subscripts.

Accounting Exercise. To disentangle the scale, composition, and technique effects, we adapt Eq. (1) by fixing certain dimensions.

In a first step, we assume constant emission intensities (fixed t) to separate the scale and composition effects from the technique effect. We do so by computing emissions embodied in FDI using a fixed year for french emission intensities.

$$EE_{FRjt} = \sum_{k=1}^K \left(\frac{CO2_{FRk}}{Output_{FRk}} \times FDI_{FRjkt} \right) \quad (2)$$

We take emission intensities in the year 2000, the first year of the sample. This step mimics Levinson’s methodology.

In the second step, we allow for spatial heterogeneity in emission intensities by replacing French values with those of the destination region, still using 2000 as the reference year. This adjustment provides a more realistic measure of the emissions embodied in French FDI, revealing the composition effect based on destination-specific emission intensities and improving our understanding of France’s environmental impact abroad.

$$EE_{FRjt} = \sum_{k=1}^K \left(\frac{CO2_{jk}}{Output_{jk}} \times FDI_{FRjkt} \right) \quad (3)$$

We also work on the time variation and compute emissions embodied in French FDI using annual emission intensities for France to compute the technique effect :

$$EE_{FRjt} = \sum_{k=1}^K \left(\frac{CO2_{FRkt}}{Output_{FRkt}} \times FDI_{FRjkt} \right) \quad (4)$$

In the third step, we account for both spatial and temporal heterogeneity from step 2 to assess potential carbon leakage, by calculating the emissions embodied in FDI using the annual emission intensities of the destination groups.

$$REE_{FRjt} = \sum_{k=1}^K \left(\frac{CO2_{jkt}}{Output_{jkt}} \times FDI_{FRjkt} \right) \quad (5)$$

By subtracting the emissions calculated using French emission intensities (as detailed in Eq. (4)) from $REE_{FR,jt}$ (Eq.(5)), we obtain a measure of carbon leakage. This difference represents the environmental cost disparity between producing abroad and producing domestically. A positive gap ($REE_{FRjt} > EE_{FRjt}$) indicates that offshoring leads to higher global emissions, suggesting potential carbon leakage due to less efficient technologies.

In a nutshell, we propose a refinement of Levinson’s original methodology by incorporating country group- and year-specific data on CO_2 emissions, capturing variations in emission intensities, both across countries and over time. [Levinson \(2023\)](#) relied solely on the US Environmental Protection Agency’s National Emissions Inventory (NEI), using US based emission intensities from 2017 across all countries in his analysis. This simplification allowed him to work with highly detailed industry data, with the trade-off of assuming that imports and exports were produced with US technology. Access to a similarly detailed international dataset would enable a more precise understanding of pollution intensities across different countries. As countries vary significantly in their emission intensities due to differences in technology, policy, and production costs, it is important to take into account these disparities in the computations. While some countries benefit from advanced low-emission technologies that allow them to generate lower emissions per unit of production, these processes are often more costly. Moreover, countries with higher emission intensities may rely on production methods that emit more per unit produced but are less expensive. This can be a source of comparative advantage for companies, who decide to offshore production to these high-emission-intensities countries, in order to benefit from lower production costs despite

the higher environmental impact. Accounting for these emission intensities differences by country is therefore important to accurately assess the impact of offshoring on global emissions, as it reveals the economic motivations behind production shifts alongside their environmental consequences.

Methodology to Disentangle Effects. As a way to separate the scale, composition, and technique effects, we adopt the methodology from Copeland and Taylor (2000). Each effect is calculated as a ratio of the values from the last period to the first period. Specifically, for the scale effect, we compare the amount of FDI sent from France to each country group between the last and the first period. For the composition effect, we use the results of embodied emissions in FDI, employing constant emission intensities to control for changes in technology. By correcting these results for the scale effect, we can identify shifts in the sectoral distribution of investments. Lastly, to determine the technique effect, we compute the emissions embodied in FDI using current emission intensities. We then subtract the ratio of the last period to the first period from the previously calculated scale and composition effects. This step helps us to isolate changes in emissions due to improvements in production technologies. Appendix B1 provides the formulas used to compute each effect.

Unpacking the Role of Regulations in Decoupling. Finally, to better understand the drivers behind the observed de-correlation between emissions and output, we investigate in section 6 the role of environmental regulations. We focus on how these regulations affect the two main mechanisms identified as sources of decoupling: pollution displacement (Eq.(6)), and changes in emission intensities, which reflect innovation in cleaner technologies (Eq.(7)). The model specifications are given by :

$$CL_{FRjt} = \gamma_1 + \gamma_2 \ln(ERTR_{FRt}) + \gamma_3 \ln(ERTR_{jt}) + \eta_j + \eta_t + \epsilon_{FRjt} \quad (6)$$

$$\ln(EI_{it}) = \gamma_1 + \gamma_2 \ln(ERTR_{it}) + \eta_i + \eta_t + \epsilon_{it} \quad (7)$$

The dependent variables in Eq.(6) and Eq.(7) correspond respectively to the additional emissions generated by production relocated abroad and to the emission intensity of each country (i) at time (t). The carbon leakage (CL) measure in Eq.(6) is computed as the difference of the logarithms between Eq.(5) and (4), isolating the extra emissions attributable to the offshoring of French production. Eq. (7) focuses on emission intensities, defined as the quantity of emissions per unit of output. As proxies for environmental policies, we use Environmentally Related Tax Revenues ($ERTR$) data from the OECD for both France (FR) and destination countries (j), which reflect the total environmental taxes collected. The model includes country fixed effects ($\eta_{\{i,j\}}$) to

control for time-invariant characteristics of countries, as well as time fixed effects (η_t) to capture global trends. Estimations are performed using Ordinary Least Squares (*OLS*).

3.2 Data and Sources

Data for CO_2 emissions, both direct and indirect, as well as output figures, are sourced from the Resolved Multi-Regional Input-Output (RMRIO) database, developed by Cabernard and Pfister (2021) and refined by De Melo and Solleder (2023). This database covers 189 countries and 163 sectors from 1995 to 2015, making it one of the most comprehensive databases available to analyze emissions by sector and country. The sectors are classified according to the EXIOBASE classification system. For sector-level FDI data, we rely on information from the Banque de France, which provides detailed statistics on both inward and outward investments by sector and destination group for the period 2000 to 2023¹. The sectors in this dataset are organized according to the International Standard Industrial Classification of Economic Activities (ISIC).

Given the different classification systems used in the two datasets, we needed to adjust the emissions database to align it with the ISIC format. Since no official conversion table exists, this adjustment was performed manually. The detailed correspondence is provided in Appendix B2, and the list of countries included in each group is reported in Appendix B3. Table 2 displays the sectors included in our study².

¹Given that some data are confidential, we restrict the analysis to cases where both inward and outward FDI were available for a given country pair, in order to limit potential distortions due to partial reporting.

²We retain only the sectors for which both FDI and emission intensities data are available. As a result, sectors C15, C21, C23, and C27 are excluded from the analysis.

Table 2: Frequency Distribution of Activity Codes

Activity Code	Frequency	Percent	Cumulative
C10, C11, 12	122	10.32	10.32
C13, C14	104	8.80	19.12
C16, C17, C18	101	8.54	27.66
C19	65	5.50	33.16
C20	122	10.32	43.49
C22	100	8.46	51.95
C24, C25	113	9.56	61.51
C26	120	10.15	71.66
C28	120	10.15	81.81
C29	126	10.66	92.47
C30	89	7.53	100.00

Source: Authors calculations.

An alternative source used for FDI stocks is the World Bank’s bilateral FDI data, available for 247 countries from 2001 to 2022. We rely on this dataset to estimate the empirical model assessing the role that environmental regulations play in explaining carbon leakage. This database is particularly well suited for country-level analysis, as the Banque de France only provides FDI data aggregated by broad geographical regions and a limited set of countries, making it unsuitable for our purpose. Our empirical sample will focus on 69 countries that together represent over 95% of total French outward FDI over the period 2001–2015 (see Appendix C1 for the complete list). Whereas the previous accounting exercise focused specifically on the manufacturing sector, due to its high emission intensities, significant FDI, and greater mobility, the econometric analysis in this section takes a broader approach and considers total FDI stocks across all sectors. This shift is primarily due to data constraints, as no consistent dataset provides sector-disaggregated bilateral FDI stocks for a broad country sample over the 2000–2015 period. Despite this limitation, using total FDI remains informative, as manufacturing typically represents a large share of FDI and is likely to drive a significant portion of aggregate movements. To proxy for environmental regulations, we use the ERTR dataset provided by the OECD. This database captures the total environmental taxes collected by governments and is among the most reliable indicators of policy stringency. Summary statistics for the accounting exercise are reported in Appendix B4, while those for the empirical analysis are provided in Appendix C2.

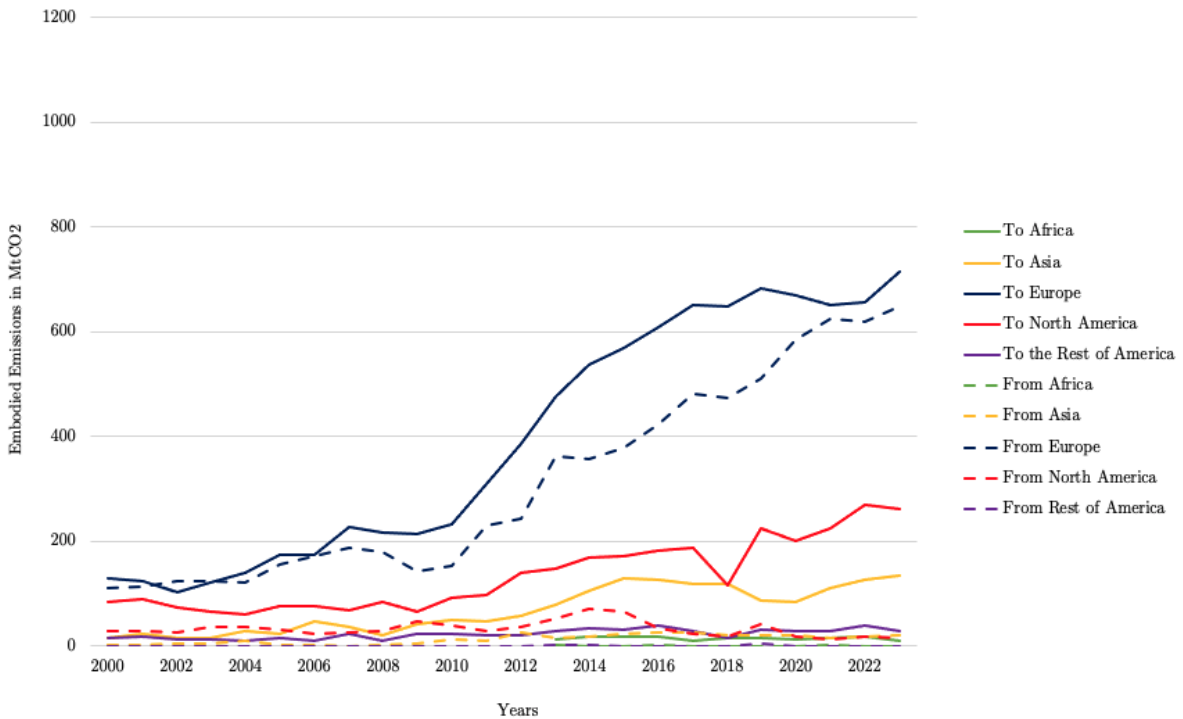
4 Main Results

To compute both uniform and destination-year specific emission intensities, our analysis is divided into three parts, as outlined in section 3.1. In section 4.1, we replicate Levinson’s approach, assuming all countries operate with the same emission intensities as France in a fixed year. That is, we use constant emission intensities, taking 2000 as the reference year. In section 4.2, we refine the analysis by introducing variations in emission intensities by country group of destination j over time t allowing us to distinguish between composition and technique effects. Finally, we assess carbon leakage in section 4.3 by comparing emissions embodied in FDI using foreign versus french emission intensities.

4.1 Emissions Embodied in FDI: Scale and Composition Effects

Emissions embodied in French outward FDI are calculated according to Eq.(2). Exchanging the order of the subscripts, a similar equation is used to compute inward FDI from country group j to France (FR), also using French emission intensities. Figure 7 presents the estimation results applying constant 2000 French emission intensities to both inward and outward FDI.

Figure 7: Pollution embodied in FDI by Country Group considering 2000 French EI



Note: Solid lines refer to EE in outward FDI and dotted lines to EE in inward FDI.

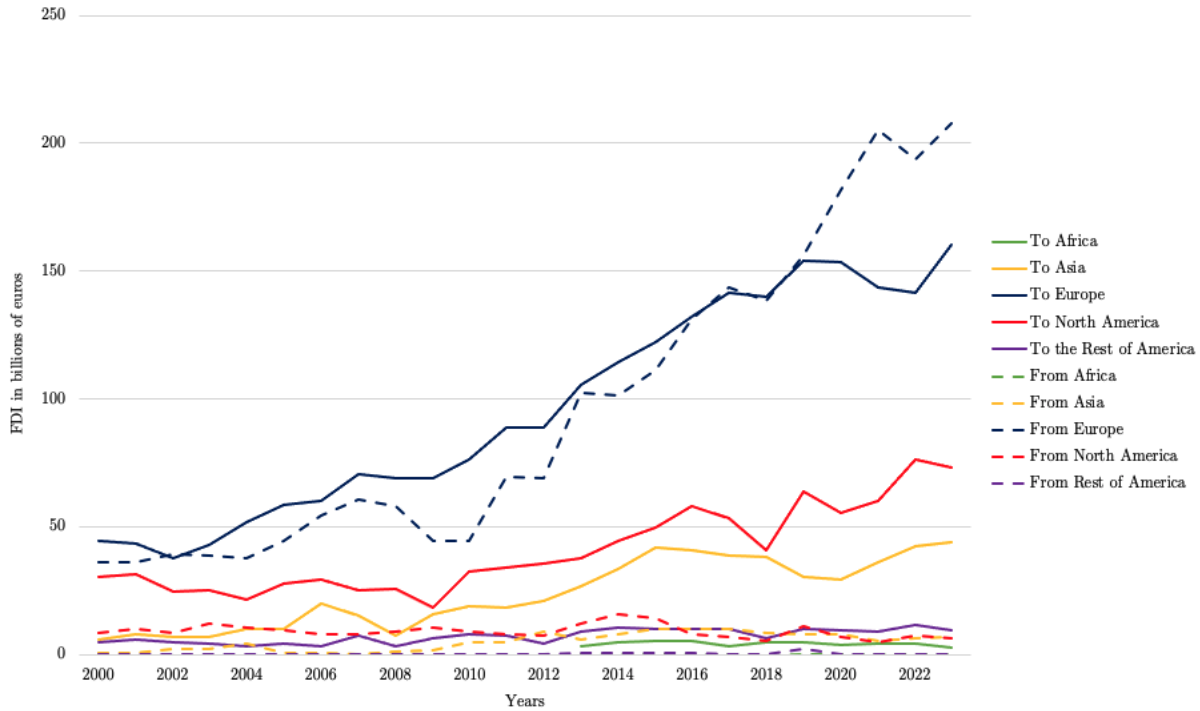
The solid lines illustrate the emissions that would have been generated in France if the production had not been offshored to each country group, that is, the emissions embodied in French outward FDI, calculated using French emission intensities. In contrast, the dotted lines correspond to emissions actually produced within France as a result of inward FDI, reflecting pollution generated by foreign investments operating on French territory.

Fig.7 shows a consistent upward trend in emissions embodied in FDI over time with a remarkable increase in emissions embodied in French FDI to and from the rest of Europe following the 2008 financial crisis. A less pronounced increase is observed for French FDI directed toward North America and Asia. For instance, emissions related to North American investments intensified from 85 $MtCO_2$ in 2000 to 262 $MtCO_2$ in 2023, while pollution embodied in FDI to Asia saw an increase of about 821%. These changes over time suggest potential relocation effects, as French firms increasingly moved production activities abroad.

Another observed pattern is the gap between emissions embodied in outward and inward FDI, which is present for all regions but almost vanished for Europe. For example, emissions linked to French FDI in North America reached 262 $MtCO_2$ in 2023, compared to 16 $MtCO_2$ for North American investments in France. Similarly, emissions associated with French FDI in Asia increased post-2008, reaching 134 $MtCO_2$ in 2023, far exceeding emissions from Asian FDI in France, which stayed comparatively low. This imbalance indicates that French firms might be offshoring some activities to these regions, potentially due to less stringent environmental regulations or more cost-efficient production practices.

It is important to notice that the increase in emissions cannot be exclusively taken as evidence of offshoring polluting activities. Figure 7 illustrates two key effects: the scale effect, which captures changes in the overall volume of FDI, and the composition effect, which reflects shifts in the industries contributing to that total FDI volume. The changes in embodied emissions partly stem from variations in the FDI volume, as France could be investing more in these regions than it receives in return. This larger outward flow of investment naturally correlates with higher embodied emissions, as a reflection of the scale effect. Figure 8 shows that FDI volume trends closely match those of embodied emissions shown in Figure 7. This indicates that emissions embodied in FDI are mainly driven by the scale of investment flows between country groups rather than by the nature of the investments, pointing towards the dominance of the scale effect over the composition effect, consistent with [Levinson \(2023\)](#).

Figure 8: FDI by Country Group between 2000 and 2023



Note: Solid lines refer to outward FDI and dotted lines to inward FDI.

Table 3 decomposes the scale and composition effects following the methodology of Copeland et al. (2021). Column (1) reports the scale effect, calculated as the ratio of FDI volumes in 2023 to those in 2000. Column (2) presents the combined scale and composition effect, measured as the ratio of embodied emissions (from Eq. 2) between 2023 and 2000. The difference between columns (2) and (1) isolates the composition effect, capturing the impact of changes in the sectoral structure of investments on emission trends. The scale effect appears particularly pronounced, with values greater than 1 indicating an increase in investment volumes compared to the initial period. In contrast, the composition effect is considerably weaker, confirming the findings of Levinson (2023). Despite its smaller magnitude, the composition effect remains positive for French outward FDI, suggesting that the sectoral composition of French investments abroad has slightly contributed to increase emissions. Conversely, the composition effect for inward FDI into France is mostly negative, implying that incoming investments tend to be directed toward cleaner, less polluting sectors.

4.2 Dynamic Assessment of Emission Intensities

This subsection presents the results of the computations that allow us to separate scale, composition and technique effects. We seek to give an answer to these two key questions: (i) what are

Table 3: Scale and Composition Effects Ratios using French Emission Intensities (2000-2023)

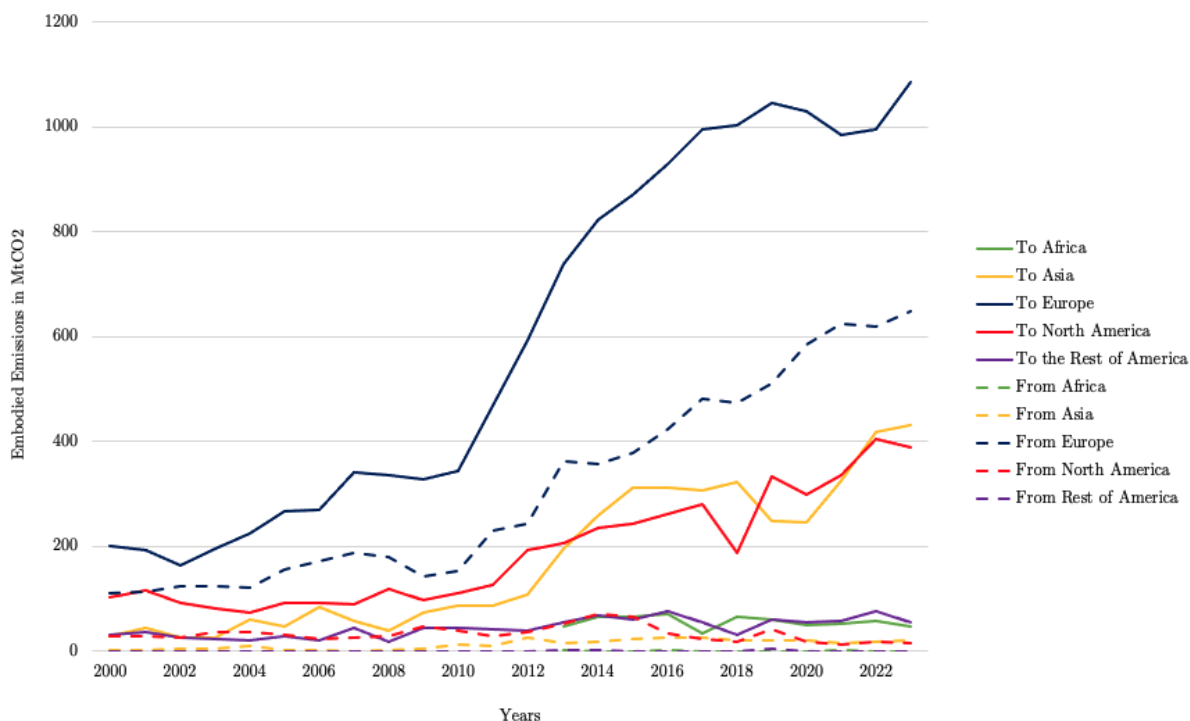
	(1)	(2)	(3)
Region	Scale Effect	Scale & Composition Effect	Composition Effect
To Africa	28.20	28.83	0.62
To Asia	7.33	9.21	1.89
To Europe	3.59	5.55	1.96
To North America	2.41	3.07	0.67
To the Rest of America	1.90	1.73	-0.17
To the World	3.45	4.63	1.18
From Africa	1.35	1.19	-0.16
From Asia	9.43	12.76	3.32
From Europe	5.79	5.84	0.05
From North America	0.76	0.58	-0.18
From Rest of America	5.44	4.58	-0.86
From World	4.29	3.61	-0.69

Note: Column (1) reports the ratio of FDI volume between 2023 and 2000. Column (2) is based on Eq. (2), and Column (3) presents the difference between Columns (2) and (1).

the actual emissions generated abroad as a result of French FDI, using destination intensities, and (ii) how have these intensities evolved over time, to assess the role of the technique effect. This is done by examining how FDI emission intensities varies across countries and how it changes over time. Exploring these patterns helps clarify what is driving France’s declining carbon footprint and what it implies for global emissions.

Accounting for Destination Emission Intensities. First, using host country groups emission intensities in a fixed year, we are able to more accurately calculate the scale and composition effects. Figure 9 reports the results based on constant 2000 emission intensities of the destination country group j using the Eq. (3). The same logic is applied to calculate emissions embodied in inward FDI.

Figure 9: Embodied Emissions by Country Group with Destination Emission Intensities



Note: Solid lines refer to outward FDI and dotted line to inward FDI.

Considering destination instead of French emission intensities reveals some interesting insights. Figure 9 illustrates a clear scale effect, showing a steady rise in emissions tied to FDI over time. This effect is especially prominent for emissions within Europe and French FDI directed toward Asia and North America. However, comparing Figures 7 and 9 highlights three major differences. First, the magnitude of embodied emissions in French outward FDI is substantially larger when using destination-based intensities. For instance, emissions linked to French FDI in Europe increase from 129 to 715 $MtCO_2$ in Figure 7, but from 200 to 1085 $MtCO_2$ in Figure 9. Similar increases appear across other regions. Second, the regional ranking by emission intensities shifts. Emissions embodied in French FDI to Asia now exceed those to North America, reversing the pattern observed under the French intensity assumption. Third, the gap between outward and inward FDI emissions widens considerably. In 2023, emissions embodied in French FDI to Asia were 22 times higher than those from Asian FDI to France, compared to a sevenfold difference using the constant French intensity from Levinson (2023). A similar increase occurs for other regions like North America, where the gap grows from 16 to 24.

These differences reflect a stronger composition effect driven by the relocation of production to more polluting sectors abroad, as confirmed by Table 4. Although the sectors are the same, foreign production tends to rely on more emission-intensive technologies. Hence, taking destination-based

intensities reveals that French firms tend to relocate production to countries where the same activities generate significantly more emissions, amplifying the composition effect beyond what French intensities alone suggested.

Table 4: Scale and Composition Effects Ratios using Destination Emission Intensities (2000-2023)

	(1)	(2)	(3)
Region	Scale Effect	Scale & Composition Effect	Composition Effect
To Africa	28.20	20.51	-7.69
To Asia	7.33	14.53	7.20
To Europe	3.59	5.41	1.82
To North America	2.41	3.77	1.36
To the Rest of America	1.90	1.77	-0.13
To the World	3.45	4.65	1.20
From Africa	1.35	1.19	-0.16
From Asia	9.43	12.76	3.32
From Europe	5.79	5.84	0.05
From North America	0.76	0.58	-0.18
From Rest of America	5.44	4.58	-0.86
From World	4.29	3.61	-0.69

Note: Column (1) reports the ratio of FDI volume between 2023 and 2000. Column (2) is based on Eq. (3), and Column (3) presents the difference between Columns (2) and (1).

Table 5 corroborates the graphical findings from Figure 9 as well as the results presented in Table 4. Using destination-based emissions intensities nearly doubles the estimated emissions across all regions in 2023. Thus, by comparing emissions computed with French (Eq.(2)) versus destination-based intensities (Eq.(3)), it offers an informative interval that brackets the environmental cost of France’s investment activity abroad. This framing is critical, as it highlights how relying on France’s own emission intensities likely underestimates the true global environmental footprint of French investments abroad, which appears significantly larger when host country intensities are taken into account.

Table 5: EE in French Outward FDI Using Different EI (2023, in MtCO₂)

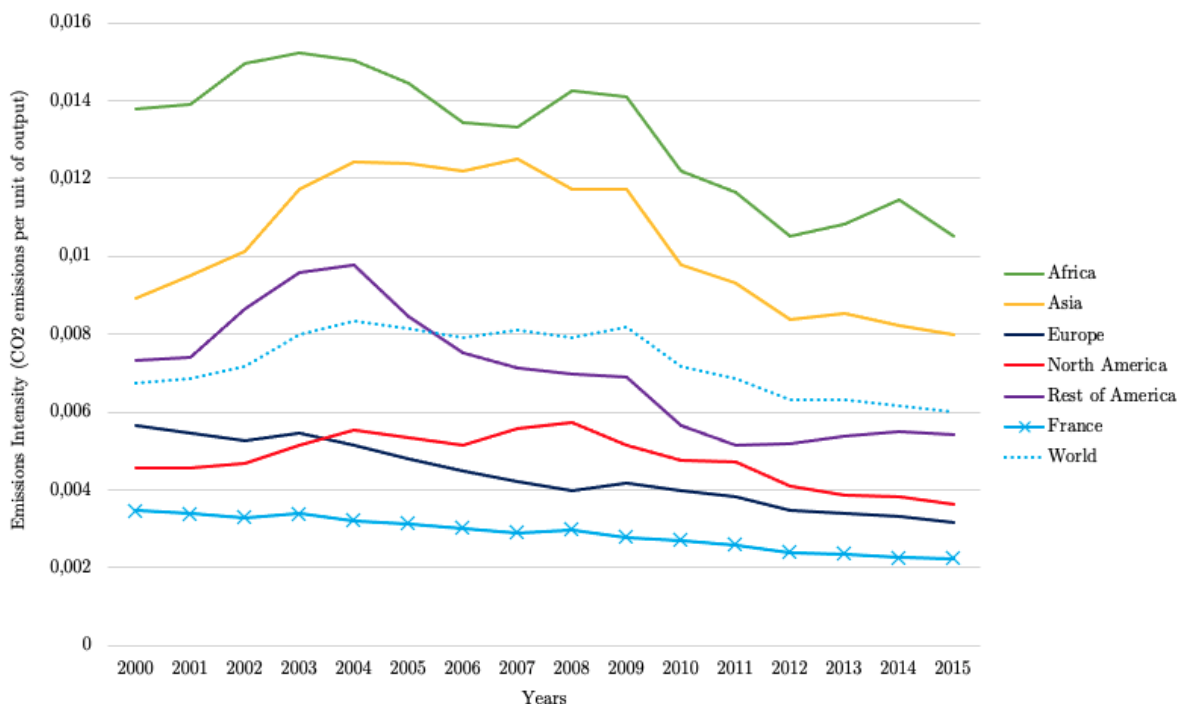
	(1)	(2)	(3)
Region	EE with French EI	EE with Destination EI	EI Multiplier
To Africa	11.11	47.08	4.24
To Asia	133.78	431.06	3.22
To Europe	715.05	1085.43	1.52
To North America	261.71	390.19	1.49
To the Rest of America	28.02	55.50	1.98
To the World	1242.04	2471.09	1.99

Note: EE stands for Embodied Emissions and EI for Emission Intensities. Column (1) is calculated using Eq.(2), Column (2) using Eq.(3), and Column (3) shows the ratio of Column (2) to Column (1).

Considering the Time Dimension. The next step consists of computing emissions attributed to FDI using Eq. (4). We use current emission intensities to assess whether the composition effect observed for France is offset by a technique effect, reflecting improvements in emission intensities and production practices. Due to data limitations, this analysis is restricted to the 2000–2015 period.

Figure 10 illustrates the evolution of CO_2 emissions per unit of output across various regions from 2000 to 2015. France achieved a significant reduction in emission intensities, with a net decline of 35% over this period. This progress highlights France’s leadership in lowering emission intensities compared to other regions and reflects the broader European success, where the average reduction across European countries reached 44%. In contrast, Africa and Asia consistently exhibit emissions intensities above the global average. The Americas show notable improvements, indicating advances in cleaner technologies, yet still lag behind Europe. Overall, France’s sustained performance underscores a strong technique effect in reducing emission intensities.

Figure 10: Evolution of emission intensities by geographical units between 2000 and 2015



By comparing Eq. (4) with the embodied emissions estimates from Eq. (2), which jointly capture scale and composition effects, we are able to isolate the net contribution of the technique effect in the case of France. Alongside Eq. (2), we quantify the total emissions France avoids producing domestically through the combined impact of offshoring and technological improvements.

Table 6 presents the results based on the methodology of Copeland and Taylor (2000), computing the ratio of each effect. Across all destination regions, the technique effect consistently reduces the level of embodied emissions in French FDI. This suggests that, regardless of the destination and the sectoral distribution of FDI, the technique effect has played a mitigating role in the emissions embodied in French FDI. Table 7 shows the relative contribution in percentage of the scale, composition, and technique effects, showing the dominant role of the scale effect. On average, the technique effect accounts for roughly one-fifth of the total reduction in emissions observed in France over the period. Taken together, these findings suggest that the observed decoupling between emissions and output in France over the 2000–2015 period can be explained by the combined influence of scale, composition, and technique effects. The increase in the volume of worldwide outward FDI accounts for 53% of the reduction in emissions recorded in France, the offshoring of more pollution-intensive activities explains around 20%, and improvements in production technologies contribute roughly 27%.

Table 6: Scale, Composition, and Technique Effects Ratios on Emissions in French FDI (2000–2015)

	(1)	(2)	(3)
Region	All Effects	Scale & Composition Effect	Technique Effect
To Africa	38.16	48.39	-10.23
To Asia	6.03	8.91	-2.88
To Europe	2.75	4.43	-1.68
To North America	1.28	2.01	-0.73
To the Rest of America	1.33	1.98	-0.65
To the World	2.19	3.45	-1.26

Note: Column (1) is based on Eq.(4), Column (2) on Eq.(2), and Column (3) shows the difference between Columns (1) and (2).

Table 7: Relative Contribution of Scale, Composition, and Technique Effects in EE

Share of Each Effect	Scale Effect	Composition Effect	Technique Effect
French FDI in Africa	81%	3%	16%
French FDI in Asia	59%	16%	24%
French FDI in Europe	45%	28%	27%
French FDI in North America	60%	14%	27%
French FDI in the Rest of America	75%	1%	4%
French FDI in the World	53%	20%	27%

4.3 Effect of Offshoring on Emissions

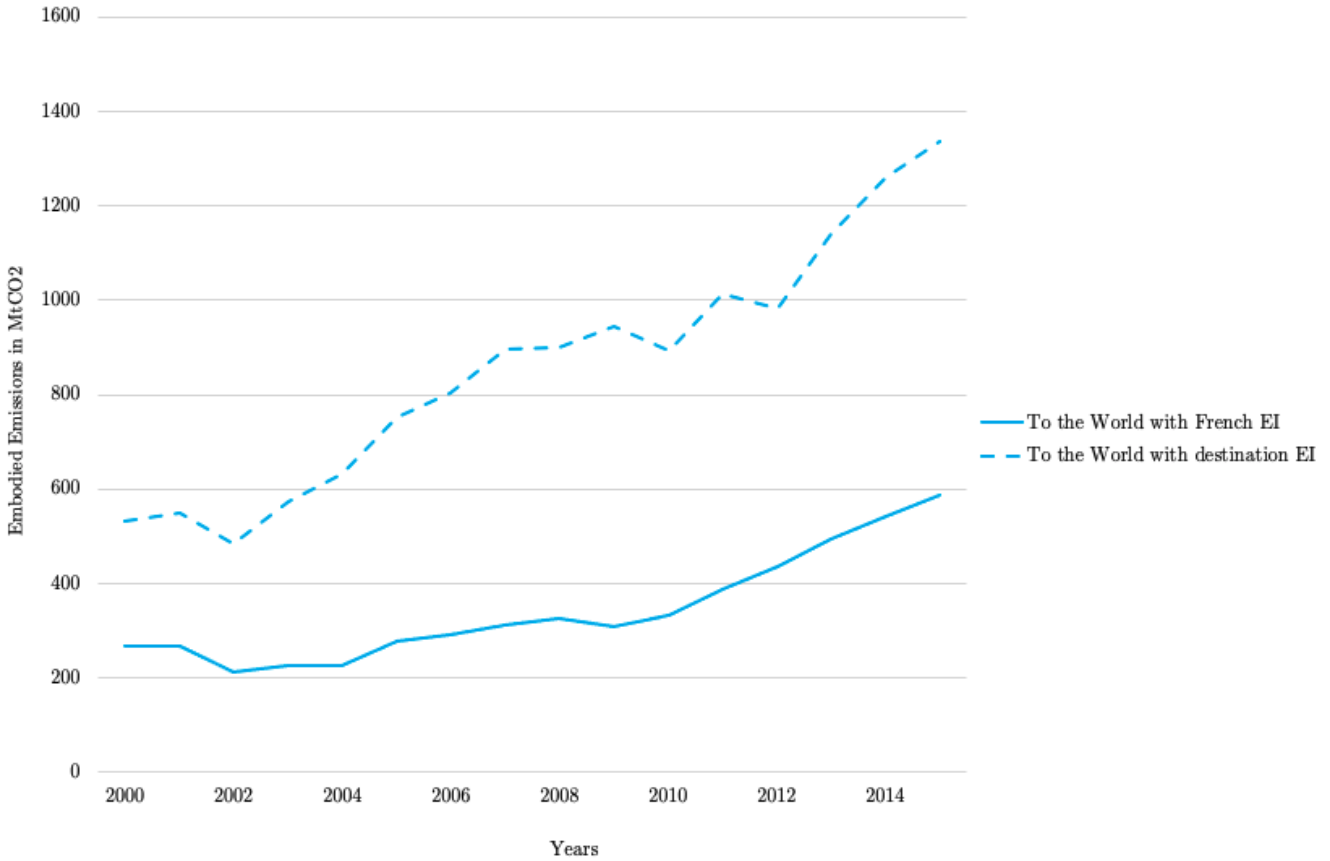
As mentioned above, French production has considerably lowered its environmental footprint through the combined influence of scale, composition, and technique effects. Nevertheless, this pattern has not been observed across all country groups, as shown in the previous section. Other regions show higher EI than France, even before accounting for the time dimension in section 4.2.

In this step, we jointly relax the assumptions of cross-country homogeneity in emission intensities and time invariance, allowing for a more realistic representation of emissions generated abroad. We compare the observed emissions from offshoring ($REE_{FR RoWt}$) to the rest of the world (RoW) as given by Eq. (5) with the counterfactual emissions that would have occurred if the same goods had been produced domestically in France ($EE_{FR RoWt}$), corresponding to Eq. (4), thereby accounting simultaneously for scale, composition, and technique effects.

This comparison helps to place the environmental cost of offshoring within an interval: from the lower bound of domestic emissions to the upper bound of emissions generated with foreign technologies. This allow us to assess the potential magnitude of carbon leakage. Eq.(4) and (5) are used to draw the two lines shown in Figure 11.

Figure 11 illustrates the main finding and indicates that offshoring has led to a significant increase in emissions. In 2000, emissions based on destination intensities were already twice as high as those calculated using French intensities, and by 2015, they were 2.3 times higher. This indicates that the emissions embodied in FDI are higher when using host country technologies compared to the case when production would have remained in France. This widening gap reflects not only differences in production technologies but also the fact that other regions have made slower progress in reducing their emission intensities over time, thereby amplifying the negative environmental impact of offshoring. These results could raise concerns among policymakers. The decision to offshore is likely influenced by the stringent environmental regulations imposed on French firms. While this may lead to a reduction in domestic emissions, it could come at the cost of an increase in global CO_2 emissions. In this regards, international cooperation is the only way to achieve reductions in global emissions. In the next section, we explore the extent to which environmental regulations partly explain this gap.

Figure 11: Real Pollution Embodied in FDI vs. Counterfactual Emissions Without Offshoring



Note: Solid line refers to Eq.(4) and dashed line to Eq.(5)

5 The Role of Environmental Regulations

In this section, we present estimation results of our empirical model to investigate the role of environmental regulations in explaining both carbon leakage and technique effect. First, we examine whether stricter French regulations lead firms to relocate pollution to countries with laxer standards, thereby increasing global emissions. Second, we assess how environmental regulations affect emission intensities across countries, providing insights into the contribution of cleaner production techniques.

Carbon Leakage. Table 8 reports the estimation results based on Eq. (6), using country fixed effects. In all specifications, the dependent variable is the difference in the logarithms of emissions embodied in FDI, calculated using the destination-country emission intensities (from Eq.(5)) and the counterfactual French emission intensities (from Eq.(4)). Column (1) assesses the effect of both origin and destination environmental regulations. Column (2) focuses on the regulatory gap

between France and the host country. Columns (3) and (4) replicate these specifications while additionally controlling for time fixed effects, capturing global time-varying shocks. Finally, columns (5) to (8) restrict the sample to African and Asian destinations to explore regional heterogeneity in the relationship between environmental regulations and carbon leakage.

Table 8: Identification of a carbon leakage effect

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All countries				Africa & Asia			
$Ln(ERTR_{it})$	0.233*** (0.0580)		0.345*** (0.0741)		0.409*** (0.110)		0.586*** (0.135)	
$Ln(ERTR_{jt})$	-0.127*** (0.0342)		-0.127*** (0.0341)		-0.0612** (0.0278)		-0.100*** (0.0257)	
$Diff Ln(ERTR_{ijt})$		0.110*** (0.0355)		0.127*** (0.0341)		0.00330 (0.0313)		0.100*** (0.0257)
Observations	973	973	973	973	323	323	323	323
R-squared	0.107	0.082	0.154	0.154	0.225	0.000	0.307	0.307
Number of countries	69	69	69	69	25	25	25	25
Destination FE	YES	YES	YES	YES	YES	YES	YES	YES
Time FE	NO	NO	YES	YES	NO	NO	YES	YES

Robust standard errors in parentheses.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The results indicate that environmental regulations play a significant role in shaping pollution patterns. The estimated coefficients show that both French and host-country environmental policies affect the emissions gap, with the effect of French regulations being more pronounced. According to column (3), which includes time fixed effects, a 1% increase in French environmental tax revenues is associated with a 0.35% increase in the emissions gap, while a 1% increase in the host country's environmental stringency reduces the gap by approximately 0.13%. Column (4), which uses the regulatory gap between France and the destination country as the main explanatory variable, confirms this pattern: a 1% reduction in the regulatory gap is associated with a 0.127% decrease in the emissions difference. Hence, harmonizing regulations across countries can mitigate carbon leakage.

When focusing specifically on African and Asian destinations, results in columns (7) and (8) indicate that the effect of French environmental policies is even more pronounced than for the whole sample. A 1% increase in French regulatory stringency is associated with a 0.59% increase in the emissions gap (column (7)), compared to 0.35% overall. This stronger effect likely reflects the higher carbon intensity of production in these regions. Since the dependent variable measures the difference in embodied emissions using local versus French emission intensities, any shift in production from France to more polluting countries leads to a sharper increase in the gap. Put differently, stricter French regulations push firms to offshore more emissions-intensive activities,

amplifying the emissions France indirectly generates abroad. In contrast, regulations in host countries have a far weaker impact, nearly five times smaller, suggesting limited enforcement capacity or structural constraints preventing firms from adjusting their production practices.

Introducing time fixed effects in columns (3)-(4) and (7)-(8) substantially improves the model’s explanatory power. The R-squared increases from 0.107 to 0.154 for all countries, and from 0.225 to 0.307 for Africa and Asia. This suggests that time-specific factors account for approximately 31% of the variation in the emissions gap for all countries, and 27% for Africa and Asia. Figures C4 and C5 show that the time-fixed effects coefficients exhibit a clear upward trend, indicating that time common factors, that go beyond firm- and country-specific characteristics have contributed to changes in pollution embodied in FDI over time. The financial crisis of 2008 appears to coincide with a temporary dip, possibly reflecting reduced industrial activity. In developing economies, the time fixed effects show a much steeper increase, which may reflect the rapid industrialization these economies experienced during this period.

Technique Effect. Another aspect we investigate is whether the previously identified technique effect is linked to the increased stringency of environmental regulations. Using emissions per unit of production as a proxy for the technique effect, Table 9 presents the estimation results of Eq. (7). For even-numbered columns, we estimate the impact of environmental taxes on emission intensities for each country group using only country fixed effects. For odd-numbered columns, we additionally include time fixed effects to account for global shocks. Models are estimated separately for different world regions.

Table 9: Identification of a technique effect

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	All countries		Africa and Asia		Europe		North America		Latin America	
$Ln(ERTR_{it})$	-0.509*** (0.0641)	-0.129*** (0.0344)	-0.355*** (0.0553)	-0.100*** (0.0257)	-0.810*** (0.0759)	-0.275*** (0.0527)	-1.214* (0.175)	-0.581*** (3.90e-06)	-0.333** (0.128)	-0.132** (0.0599)
Observations	992	992	323	323	460	460	30	30	175	175
R-squared	0.537	0.846	0.543	0.794	0.742	0.956	0.911	0.991	0.352	0.755
Number of countries	70	70	25	25	31	31	2	2	12	12
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time FE	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

The estimated coefficients indicate that environmental regulations significantly reduce emission intensities. A 1% increase in environmental taxes leads to a 0.13% decline in emission intensities (column (2)). The effect varies across regions: in developed economies, environmental regulations have a stronger impact. Specifically, a 1% increase in environmental tax stringency corresponds to

a reduction in emission intensities of 0.28% in Europe and 0.58% in North America (columns (6)–(8)), likely reflecting the influence of well-enforced policies in these regions. However, in emerging and developing economies such as Africa, Asia, and Latin America, the effect is smaller. For these regions, a 1% increase in regulatory stringency is associated with around a 0.10% reduction in emission intensities, less than half the effect observed in developed countries. This disparity may be attributed to differences in regulatory enforcement, as environmental regulations in some developing and emerging economies may be difficult to implement. Finally, these results help explain the findings on carbon leakage presented in Table 8.

6 Concluding Remarks

This study aimed to investigate the paradoxical relationship between the increase in French production and the simultaneous decline in emissions over time. Three mechanisms were considered to explain this divergence: the scale effect, where outward FDI replaces domestic production to reduce domestic emissions, the composition effect, as firms relocate activity to more polluting sectors abroad, and the technique effect, with cleaner technologies lowering emissions per unit of output at home.

Using a methodology based on the [Levinson \(2023\)](#) framework, which is adapted to the French context through the lens of manufacturing FDI, we find results consistent with economic theories. Our analysis supports the existence of a strong scale effect, driven by the expansion of French outward FDI, whereas the composition effect appears much weaker under the approach of [Levinson \(2023\)](#).

To better understand FDI dynamics, we expanded the analysis by using a comprehensive dataset on emissions, which provides country-specific and time-varying emissions intensities. This allows us to identify both a composition and a technique effect, in addition to the scale effect already documented. Our results indicate that the scale effect is the primary driver of the reduction in domestic emissions, accounting for over half (53%) of the decline. The composition effect also contributes but remains modest overall (20%), with notable variations across regions. Finally, the technique effect has helped reduce emission intensities, explaining 27% of the overall decline. Nevertheless, while France achieves clear decoupling and emission reductions, it is crucial to also consider the global impact. By comparing embodied emissions in FDI using French and destination emissions intensities, we clearly identify a phenomenon of carbon leakage. In 2015, emissions linked to offshoring were 2.3 times higher than if production had remained in France. This significant carbon leakage suggests that domestic environmental gains may come at the cost of increased global emissions, highlighting the need for international cooperation.

By disentangling these effects, our study also provides a framework to understand the broader implications of environmental policies. We estimate an empirical model to examine the role that environmental regulations play in explaining carbon leakage and technique effects at the country level. Our results provide some evidence that can guide policymakers. Specifically, we find that environmental regulations reduce the pollution embodied in FDI. When effectively enforced and uniformly implemented across countries, such regulations could play a crucial role in addressing the climate crisis and in mitigating carbon leakage.

Future research should focus on a more detailed analysis, particularly through the use more disaggregated data that go beyond broad sectors. As identified by [Levinson \(2023\)](#), dividing the data into only 11 manufacturing sectors could either overestimate or underestimate the pollution associated with FDI activities. A more granular database would provide a clearer picture of emissions across different industries, enhancing the precision of the analysis. Moreover, the availability of data only until 2015 restricts the evaluation of emissions by country and hinders the assessment of the technique effect, which could be more visible in recent years. With the increasing environmental rigor following the Paris Agreements, it is likely that more significant re-allocations of production emerged in subsequent years, calling for further investigation to examine and evaluate these developments.

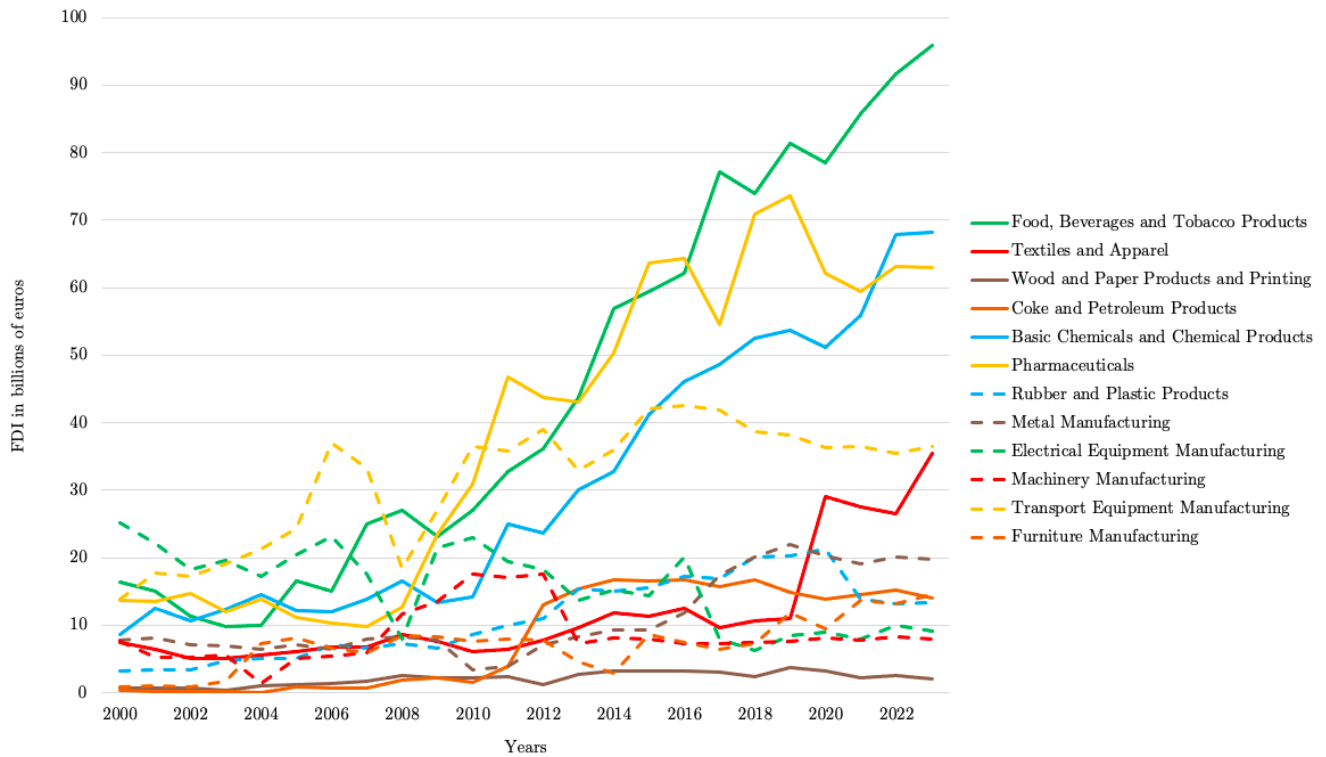
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Appendix

Appendix A: FDI Top Sectors

Figure A1: Evolution of French manufacturing FDI outward from 2000 to 2023



Appendix B: Accounting Exercise

Table B1: Decomposition of Emissions Change: Scale, Composition, and Technique Effects

Effect	Formula
Scale Effect (SE)	$\frac{\sum_k \text{FDI}_{FRjkT}}{\sum_k \text{FDI}_{FRjk2000}}$
Composition Effect (CE)	$\frac{\sum_k \text{FDI}_{FRjkT} \cdot EI_{FRjk2000}}{\sum_k \text{FDI}_{FRjk2000} \cdot EI_{FRjk2000}} - \text{SE}$
Technique Effect (TE)	$\frac{\sum_k \text{FDI}_{FRjkT} \cdot EI_{FRjkT}}{\sum_k \text{FDI}_{FRjk2000} \cdot EI_{FRjk2000}} - \text{SE} - \text{CE}$

Note: T denotes the final year of the sample, while 2000 refers to both the initial year and the reference year for constant emission intensities. FR denotes France as the investing country, j the host country, and k the sector.

Table B2: Correspondence Between RMRIO Codes and NACE Divisions

NACE Division	RMRIO Codes	NACE Division	RMRIO Codes
C10	35–43, 45	C20	56–60, 69
C11	44	C22	91
C12	90	C23	61–67
C13	46	C24	70–81
C14	47	C25	82, 92
C15	48	C26	84, 86, 87
C16	49, 50	C27	85
C17	51–53	C28	83
C18	134	C29	88
C19	54, 55	C30	89

Table B3: List of Countries by Group

Groups	Countries ISO Codes
Africa	<i>AGO, BDI, BEN, BFA, BWA, CAF, CIV, CMR, COD, COG, DJI, DZA, EGY, ERI, ETH, GAB, GHA, GIN, GMB, KEN, LBR, LBY, LSO, MAR, MDG, MLI, MOZ, MRT, MUS, MWI, NAM, NER, NGA, RWA, SEN, SLE, SOM, STP, SWZ, SYC, TCD, TGO, TUN, TZA, UGA, ZAF, ZMB, ZWE</i>
Asia	<i>AFG, ARE, ARM, AZE, BGD, BHR, BRN, BTN, CHN, GEO, HKG, IDN, IND, IRN, IRQ, ISR, JOR, JPN, KAZ, KGZ, KHM, KOR, KWT, LAO, LBN, LKA, MAC, MDV, MMR, MNG, MYS, NPL, OMN, PAK, PHL, PRK, QAT, SAU, SGP, SYR, THA, TJK, TKM, TWN, UZB, VNM, YEM</i>
Europe	<i>ALB, AUT, BEL, BGR, BIH, BLR, CHE, CYP, CZE, DEU, DNK, ESP, EST, FIN, GBR, GRC, HRV, HUN, IRL, ISL, ITA, LIE, LTU, LUX, LVA, MDA, MKD, MLT, MNE, NLD, NOR, POL, PRT, ROU, RUS, SMR, SRB, SVK, SVN, SWE, TUR, UKR</i>
Rest of America	<i>ABW, ARG, ATG, BHS, BLZ, BMU, BOL, BRA, BRB, CHL, COL, CRI, CUB, CYM, DOM, ECU, GTM, GUY, HND, HTI, JAM, MEX, NIC, PAN, PER, PRY, SLV, SUR, TTO, URY, VEN, VGB</i>
North America	<i>CAN, USA</i>

Table B4: Summary Statistics to Estimate the Carbon Leakage

Variable	Obs	Mean	Std. Dev.	Min	Max
<i>Year</i>	1,182	2012.778	6.785571	2000	2023
<i>FDI_{FRjkt}</i>	1,182	7128.327	11570.83	0	95828
<i>FDI_{jFRkt}</i>	1,182	4514.279	9455.237	0	78717
<i>Direct CO₂Emissions_{jkt}</i>	703	197436.8	387488.6	206.1923	2768089
<i>Indirect CO₂Emissions_{jkt}</i>	703	826905.2	1090664	11751.69	5732031
<i>Output_{jkt}</i>	703	1.57e+08	1.66e+08	2660961	9.65e+08
<i>Direct CO₂ Emissions_{FRkt}</i>	703	6373.206	6542.705	483.3978	25137.38
<i>Indirect CO₂ Emissions_{FRkt}</i>	703	30661.18	27098.3	5660.72	113710
<i>Output_{FRkt}</i>	703	1.37e+07	6488997	3241919	3.34e+07

Appendix C: Empirical Model

Table C1: List of countries

Europe	Africa	Latin America	Asia and Pacific	North America
Austria	Cameroon	Argentina	Australia	Canada
Belgium	Congo, Rep	Bahamas, The	Bangladesh	United States
Bulgaria	Cote d'Ivoire	Brazil	China	
Croatia	Egypt, Arab Rep.	Chile	Hong Kong	
Cyprus	Gabon	Colombia	India	
Czech Republic	Israel	El Salvador	Japan	
Denmark	Kenya	Mexico	Korea, Rep.	
Estonia	Mali	Panama	New Zealand	
Finland	Mauritius	Paraguay	Pakistan	
France	Morocco	Peru	Philippines	
Germany	Nigeria	Uruguay	Singapore	
Greece	Senegal	Venezuela, RB		
Hungary	South Africa			
Ireland	Uganda			
Italy				
Kazakhstan				
Latvia				
Lithuania				
Luxembourg				
Netherlands				
Norway				
Poland				
Portugal				
Romania				
Slovak Republic				
Slovenia				
Spain				
Sweden				
Switzerland				
Ukraine				
United Kingdom				

Table C2: Summary Statistics to Estimate the Carbon Leakage

Variable	Obs	Mean	Std. Dev.	Min	Max
<i>Year</i>	973	2008.145	4.293809	2001	2015
<i>Diff Ln(PEinFDI_{ijt})</i>	973	0.7801875	0.6133462	-0.6190279	3.088759
<i>Ln(ERTR_i)</i>	973	10.86752	.2174627	10.31669	11.08222
<i>Ln(ERTR_j)</i>	973	7.575359	2.246971	-2.432957	11.83138
<i>DiffLn(ERTR_{ijt})</i>	973	3.292158	2.233053	-1.19857	12.88016

Table C3: Summary Statistics to Estimate the Technique Effect

Variable	Obs	Mean	Std. Dev.	Min	Max
<i>Year</i>	992	2008.162	4.296864	2001	2015
<i>Ln(EI_j)</i>	992	-0.6749531	0.6798565	-2.250074	2.194321
<i>Ln(ERTR_j)</i>	992	7.622774	2.262836	-2.432957	11.83138

Figure C4: Evolution of year dummies for the whole sample

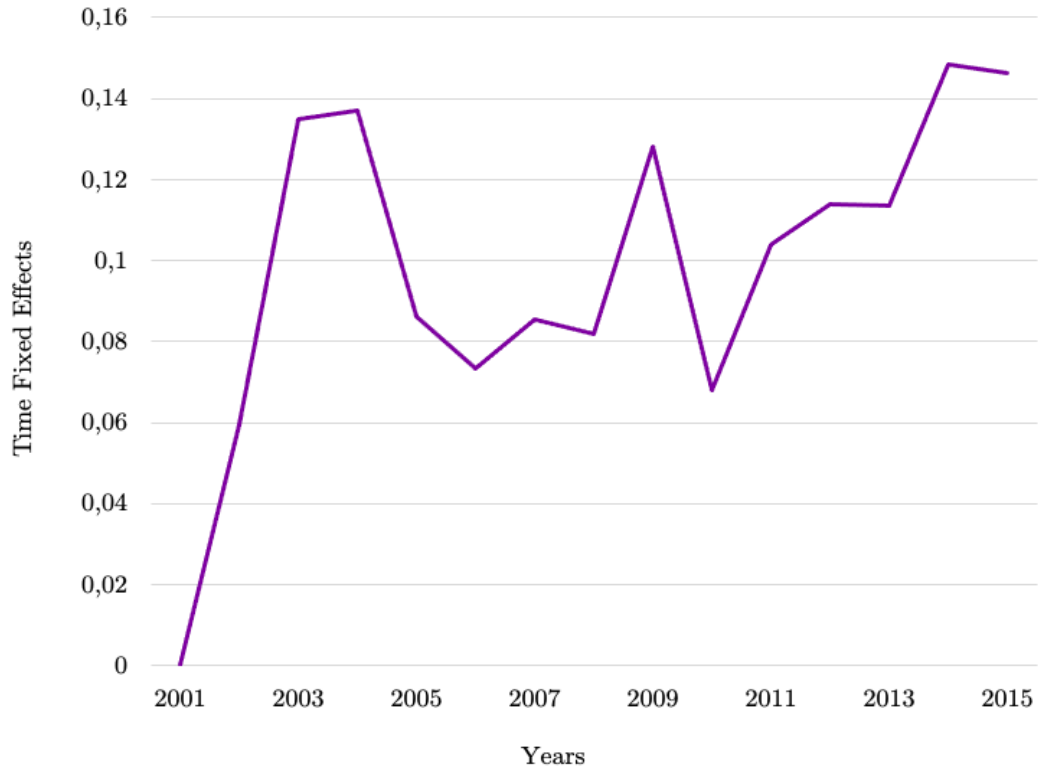


Figure C5: Evolution of year dummies for Africa and Asia

