

Pollution haven, green trade agreements and institutional governance: an empirical analysis on a panel of developed and developing countries

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Rim Mansouri and Said Tounsi

*Laboratory of Applied Economics, Faculty of Law, Economics and Social Sciences
Agdal, Mohammed V University, Rabat, Morocco*

Abstract

Purpose – This paper examines whether environmental provisions embedded in trade agreements mitigate the Pollution Haven Hypothesis (PHH), with a particular focus on their effect on outward investment location choices to developing host countries, where evidence remains limited.

Design/methodology/approach – The analysis relies on a panel of 43 countries over 2009–2021. A gravity model for outward FDI flows is estimated using Poisson Pseudo-Maximum Likelihood (PPML). To address endogeneity and unobserved heterogeneity, the empirical strategy incorporates high-dimensional fixed effects (country-pair, exporter-year and importer-year), complemented by an event-study and placebo tests to detect anticipatory dynamics.

Findings – Once bilateral heterogeneity and country-specific time-varying shocks are controlled for, the average effect of environmental provisions on outward FDI becomes economically modest and statistically insignificant. Event-study and placebo estimations reveal no evidence of pre-existing trends. Nevertheless, this average conceals substantial institutional heterogeneity. The deterrent effect is primarily concentrated in countries with weak governance and higher corruption, whereas it diminishes and becomes insignificant in better-governed environments. These findings suggest that environmental provisions exert their strongest influence precisely where enforcement capacity is limited, highlighting an institutional dimension of the pollution haven mechanism.

Originality/value – Rather than treating the PHH as a purely binary phenomenon, this study emphasizes its conditional nature. It shows that the average effect of environmental provisions becomes limited once rigorous fixed-effects are implemented, while institutional quality emerges as a key mediating factor. The paper contributes to the literature on trade policy, environmental regulation and governance in developing countries.

Keywords Pollution haven hypothesis, Green trade agreements, Institutional quality, Foreign direct investment (FDI), Environmental governance, Developing and developed countries, Corruption

Paper type Research article

1. Introduction

The growing integration of environmental clauses into trade agreements has emerged as one of the most significant developments in international economic governance over the past 2 decades (Morin and Jinnah, 2018; Leal-Arcas, 2025). Designed to reconcile trade liberalization with sustainability objectives, these provisions aim to prevent a “race to the bottom” in environmental standards (Esty and Geradin, 1998; Newstam, 2025). Yet, their actual

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effectiveness remains contested: are they merely symbolic statements, or do they genuinely influence economic actors' decisions—particularly regarding foreign direct investment (FDI)?

FDI occupies a strategic position in this debate, as it constitutes a major channel through which firms adjust their location strategies in response to environmental regulations (Copeland and Taylor, 2004). According to the classical Pollution Haven Hypothesis (PHH), stringent environmental regulations in home countries may encourage firms to relocate production activities toward jurisdictions characterized by laxer environmental standards (Copeland and Taylor, 1994). However, most empirical studies have focused primarily on domestic environmental regulations, paying comparatively limited attention to the role of trade agreements as instruments of supranational environmental governance (Bastiaens and Postnikov, 2017). This omission may partly explain why empirical evidence on the PHH remains mixed and inconclusive.

Environmental clauses may alter the traditional logic underlying the PHH. Rather than responding solely to domestic regulations, firms increasingly operate within an institutional framework shaped by trade agreements, which may either deter or redirect FDI depending on the governance quality of the host country.

This paper addresses this gap by examining whether the inclusion of environmental clauses in bilateral trade agreements affects outward FDI flows. Specifically, the study makes three main contributions. First, it estimates the impact of environmental clauses on outward investment location choices to developing host countries, using a PPML specification with high-dimensional fixed effects (country-pair, exporter-year, and importer-year), thereby controlling for time-invariant bilateral heterogeneity and country-specific annual shocks. Second, it implements an event study framework and placebo tests to assess robustness and rule out anticipatory or spurious effects. Third, it investigates the moderating role of host-country institutional quality, particularly corruption control, in order to determine whether the effectiveness of environmental clauses depends on governance conditions.

The empirical analysis relies on a gravity model estimated using PPML and an event-study design applied to a panel of 43 countries (21 developed and 22 developing) over the period 2009–2021. The results indicate that once unobserved heterogeneity and country-year shocks are adequately accounted for, the average deterrent effect of environmental clauses on outward FDI becomes economically small and statistically insignificant. Event-study and Placebo tests reveal no evidence of pre-existing trends, supporting the credibility of the identification strategy. However, this average effect conceals substantial institutional heterogeneity. In poorly governed and highly corrupt host countries, environmental clauses significantly reduce outward FDI, whereas in better-governed and less corrupt environments, the deterrent effect weakens and becomes statistically insignificant. These findings are consistent with the existence of an institutional pollution haven mechanism.

Overall, the findings suggest that the effectiveness of environmental clauses in trade agreements depends not only on their formal adoption, but also on their interaction with domestic institutional conditions. This study contributes to the literature on trade, environment, and FDI by showing that environmental provisions embedded in trade agreements may exert conditional effects on internationalization strategies. More broadly, the results caution against interpreting reduced-form estimates as causal in the absence of sufficient rich fixed-effects structures, given the attenuation observed once unobserved heterogeneity is properly addressed.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature. Section 3 describes the data, empirical framework, and methodology. Section 4 presents and discusses the empirical results. Section 5 concludes and outlines the main economic and policy implications.

2. Literature review: from the pollution haven hypothesis to environmental clauses in trade agreements

The relationship between international trade, investment, and the environment has long been central to academic debate. However, despite decades of research, the literature remains

characterized by persistent ambiguity rather than consensus. This ambiguity is not merely empirical; it reflects deeper conceptual and identification challenges that have prevented a unified understanding of how environmental regulation shapes international economic integration. Against this background, the literature has progressively shifted from a narrow focus on the PHH toward a broader institutional perspective in which trade agreements and their environmental clauses (ECs) play a growing role. This review follows this evolution and highlights why existing approaches remain insufficient to fully identify causal effects.

2.1 *The pollution haven hypothesis: conceptual framework and empirical evidence*

Formulated by [Copeland and Taylor \(1994\)](#), the PHH argues that differences in the stringency of environmental regulations create comparative advantages that may attract pollution-intensive production to countries with weaker standards. In its simplest form, this mechanism implies a relocation of dirty industries from strict to lax regulatory environments ([Levinson and Taylor, 2008](#)).

However, empirical evidence has never converged on a stable conclusion. While some micro-level studies find that environmental regulation significantly affects firms' location choices ([Keller and Levinson, 2002](#); [Cole et al., 2017](#); [Yu and Li, 2020](#)), a large body of work shows that traditional determinants of FDI—market size, labor costs, infrastructure, and institutional stability—often dominate environmental considerations ([Jaffe et al., 1995](#); [Eskeland and Harrison, 2003](#)). At the macro level, results remain equally mixed. [Antweiler et al. \(2001\)](#) show that trade openness can have offsetting effects on pollution, through scale, composition, and technique channels. Similarly, [Frankel and Rose \(2005\)](#) and [Cole and Elliott \(2005\)](#) emphasize that outcomes are highly heterogeneous across countries and sectors.

Taken together, this literature does not provide a clear validation or rejection of the PHH. Instead, it suggests that the PHH is not a structural law of international trade, but a conditional relationship whose effects depend on institutional and policy environments. Yet, most empirical studies have continued to focus primarily on domestic environmental regulations, implicitly treating policy as a national-level variable. This narrow perspective overlooks the growing role of international agreements in shaping environmental governance, leaving an important dimension of regulation insufficiently explored.

2.2 *Trade agreements as instruments of environmental governance*

In response to concerns about regulatory competition and a potential “race to the bottom,” environmental provisions have increasingly been incorporated into trade agreements ([Morin et al., 2018](#)). This development reflects a shift from purely national environmental policy toward a more fragmented but increasingly institutionalized system of transnational environmental governance.

Early empirical contributions mainly focused on environmental outcomes and trade flows. Some studies suggest that stronger environmental provisions are associated with lower emissions, particularly CO₂ ([Baghdadi et al., 2013](#); [Martínez-Zarzoso and Queslati, 2018](#)). However, less attention has been paid to the economic channels through which these provisions may influence outward FDI patterns toward host countries.

More recent work emphasizes that the impact of environmental clauses depends critically on their design and enforceability. Databases such as TREND distinguish between *procedural clauses*, which promote cooperation and dialogue, and *substantive clauses*, which impose binding commitments and standards, often accompanied by enforcement mechanisms ([Morin et al., 2018](#); [Bastiaens and Postnikov, 2017](#)). This heterogeneity is crucial, as it implies that environmental provisions are not a homogeneous policy instrument.

The literature offers two competing mechanisms regarding their impact on FDI. On the one hand, stricter and more credible environmental clauses may increase compliance costs and reduce the attractiveness of host countries relying on weak environmental standards as a competitive advantage ([Hoekman et al., 2023](#)). On the other hand, they may generate a “halo

effect” by improving regulatory certainty, reducing policy risk, and encouraging investment in cleaner and more efficient production activities (Brandi *et al.*, 2020; Satoglu and Salmon, 2024). Consistent with this broader regulatory perspective, Shapiro (2021) demonstrates that trade policies embody an implicit environmental bias capable of significantly affecting international trade patterns, while comparable evidence for FDI remains relatively limited. In addition, Dean *et al.* (2009) show that firms do not necessarily avoid regulated environments when regulation is associated with efficiency gains, in line with the Porter Hypothesis (Porter, 1991; Porter and Linde, 1995).

It should be noted, however, that not all ECs are legally binding. A significant share consists of so-called *permissive provisions*, reaffirming the right of states to adopt environmental measures, notably within the chapters on Technical Barriers to Trade (TBT). Although they do not impose strict obligations or sanctions, these provisions broaden the regulatory space for integrating environmental concerns (Morin *et al.*, 2018; Bastiaens and Postnikov, 2017). They may also enhance the legitimacy of domestic environmental policies and influence investors’ expectations by signaling a greener trajectory of governance (Jinnah and Morin, 2020; Baachus and Manak, 2021).

Importantly, much of the recent empirical literature on environmental provisions has primarily focused on trade flows, exports, or environmental outcomes rather than outward FDI decisions. For example, Brandi *et al.* (2020) mainly examine the relationship between environmental provisions and exports, while Berger *et al.* (2020) focus on trade-related effects of environmental regulation and institutional conditions. More recent contributions have begun to extend the analysis toward investment-related outcomes. For instance, Liu and Luo (2024) and Liu and Han (2026) examine how environmental regulation and environmental provisions influence outward FDI decisions, particularly in the case of Chinese multinationals. Similarly, Chiappini & Gérard (2025) highlight the role of environmental regulatory stringency in shaping foreign investment flows, emphasizing the importance of institutional and enforcement capacity. Evidence based on environmental certification, such as ISO 14001, also suggests that firms’ environmental compliance signals can facilitate international expansion and foreign investment decisions (Yan *et al.*, 2025). However, despite these advances, this emerging literature remains relatively limited and largely concentrated on emerging economy contexts or domestic regulatory frameworks rather than trade agreement provisions *per se*.

Overall, despite this growing literature, there is still no consensus on whether environmental provisions deter, attract, or merely reallocate FDI. This persistent ambiguity may reflect substantial heterogeneity across agreements, countries, and institutional settings, which remains insufficiently addressed in the existing empirical literature.

2.3 The moderating role of institutional quality

The effectiveness of ECs depends critically on the institutional context in which they are implemented. A large body of literature shows that environmental policies are effective only when supported by strong institutions and credible enforcement (Taylor, 2005; Fredriksson *et al.*, 2003). Moreover, international agreements may also create incentives for countries to strengthen environmental standards in anticipation of future economic gains (Baccini and Urpelainen, 2014). In weak institutional environments, even formally stringent regulations may remain ineffective in practice, thereby perpetuating pollution haven dynamics (Berger *et al.*, 2020).

Two main channels explain why institutions matter for the impact of environmental clauses. First, *enforcement credibility*: in contexts of weak governance or high corruption, regulations may not be effectively implemented, reducing their impact on firms’ behavior. Second, *policy predictability*: institutional quality shapes the stability and transparency of the regulatory environment, which is a key determinant of investment decisions (Smarzynska and Wei, 2000; Habib and Zurawicki, 2002).

These mechanisms imply that the effect of environmental clauses is likely to be conditional on institutional quality. In weakly governed countries, environmental provisions may be perceived as uncertain or inconsistently enforced, potentially discouraging investment. In contrast, in well-governed environments, such provisions may signal credible and stable regulatory frameworks, which could mitigate or even reverse their deterrent effect.

While the literature has acknowledged the importance of institutional factors, relatively few studies have systematically examined how institutional quality moderates the effect of environmental provisions on FDI. This study addresses this gap by explicitly modeling the interaction between environmental clauses and host-country governance.

2.4 Methodological challenges in identifying causal effects

Empirical studies of trade agreements and FDI face substantial identification challenges. Bilateral investment flows are influenced by persistent unobserved factors such as historical ties, cultural proximity, and long-term economic relationships. Failure to properly account for these factors can lead to biased estimates (Anderson and van Wincoop, 2003; Head and Mayer, 2014).

The adoption of Poisson Pseudo-Maximum Likelihood (PPML) estimators has become standard in gravity models due to their ability to handle heteroskedasticity and zero flows (Silva and Tenreyro, 2006). More recent advances emphasize the importance of high-dimensional fixed effects—specifically country-pair, exporter-year, and importer-year effects—to control for unobserved heterogeneity and multilateral resistance (Egger and Pfaffermayr, 2003; Larch *et al.*, 2019; Weidner and Zylkin, 2021).

These methodological considerations are particularly relevant when analyzing environmental provisions, whose adoption may be correlated with bilateral characteristics and country-specific dynamics. As a result, simple cross-sectional or low-dimensional fixed effects approaches may capture correlations rather than causal effects.

In addition, the staggered adoption of environmental provisions raises concerns about dynamic selection and pre-trends. Recent methodological developments in event-study and difference-in-differences frameworks (Sun and Abraham, 2021; Callaway and Sant'Anna, 2021; Baker *et al.*, 2022) provide tools to address these concerns and improve causal identification.

2.5 Literature gaps and contribution of the study

Three main gaps emerge from the existing literature. First, while the effects of environmental clauses on trade flows and emissions are relatively well documented, their macroeconomic impact on outward FDI from developed countries remains insufficiently explored. Second, many studies rely on empirical strategies that do not fully address endogeneity concerns, unobserved heterogeneity, or dynamic selection, raising doubts about the causal interpretation of estimated effects. Third, although institutional quality is widely recognized as important, its role as a systematic moderator of environmental provisions remains underexplored in a unified empirical framework.

This study addresses these gaps by combining three elements within a consistent identification strategy. First, it estimates the effect of environmental clauses on outward FDI using a PPML gravity model with high-dimensional fixed effects (country-pair, exporter-year, importer-year), ensuring a rich control for unobserved heterogeneity. Second, it implements event-study specifications and placebo tests to assess dynamic effects and rule out pre-treatment trends. Third, it explicitly models the interaction between environmental clauses and host-country institutional quality, thereby capturing heterogeneity in governance conditions.

Importantly, the contribution of this paper is not the mere recognition that institutions matter, but rather the estimation of their role within a more credible empirical framework than typically employed in the literature. By combining modern gravity techniques with a focus on

3. Data, variables and econometric methodology

3.1 Data sources, period and sample

The analysis is based on a panel of 43 countries—including 21 developed and 22 developing economies—observed over the period 2009–2021. This timeframe covers the post-global financial crisis phase, characterized both by the recovery of international trade and by the progressive inclusion of environmental provisions in trade agreements. The objective is to examine whether the inclusion of environmental clauses in these agreements affect investors' location decisions and, consequently, outward FDI flows, and whether these effects vary according to host-country institutional quality.

The empirical strategy proceeds in four stages. We estimate pooled PPML gravity specifications that serve as descriptive benchmarks. Second, we estimate a preferred high-dimensional fixed-effects PPML model designed to absorb persistent bilateral heterogeneity and county-specific annual shocks. Third, we implement an event-study framework to assess dynamic effects and examine the presence of pre-treatment trends around the activation of environmental clauses. Fourth, we explore institutional heterogeneity by interacting environmental clauses with host-country governance quality, measured through corruption control.

3.2 Variables and descriptive statistics

The dependent variable is the bilateral outward FDI flow (*FDI_outward*), measured as the nominal value (in million USD) of direct investments from country *i*, developed country, to country *j*, developing country. Data are sourced from the *IMF Direct Investment Positivity (DIP, 2025)* database.

The main explanatory variable, denoted *Env_trade_agreement*, takes the value 1 from the entry into force of a bilateral agreement containing an environmental clause recognizing a partner's right to prepare, adopt, or implement technical measures related to environmental protection (TBT chapter). Although not legally binding, this clause reflects a mutual acknowledgment of regulatory space between trading partners. Data come from the *TRade and ENvironment Database (TREND)* (Morin *et al.*, 2018; updated 2022).

To capture the moderating role of governance quality, we include the Control of Corruption Index of the host country (*Corruption_j*), obtained from the *World Governance Indicators (World Bank, 2025)*.

The model also incorporates standard gravity determinants: GDP of the source country (*GDP_i*) and host country (*GDP_j*), geographical distance between capitals (*Distance*), territorial contiguity (*Contiguity*), and common language (*Language*). These data are drawn from the *World Bank (2025)* and *CEPII (2022)*.

For the benchmark pooled specifications only, we control for host-country trade openness using the trade-to-GDP ratio (*Trade_GDP_j*), since host-country integration into international markets may influence inward FDI location decisions.

Table 1 highlights substantial heterogeneity across countries. About 32% of observations correspond to agreements containing an environmental clause (*Env_trade_agreement*), reflecting the growing diffusion of such provisions during the study period. In contrast, only 16.7% of country pairs share an official common language, and geographical contiguity is marginal, indicating the predominance of intercontinental investment relations in the sample.

Outward FDI flows (*FDI_outward*) average 6.013 (standard deviation: 2.871), with negative values reflecting divestment episodes. The mean GDPs of source (27.462) and host (26.458) countries—expressed in logarithms—indicate relatively large and homogeneous

Table 1. Descriptive statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
Env_trade_agreement	7,392	0.318	0.466	0	1
Language	7,392	0.167	0.373	0	1
Contiguity	7,392	0	0.012	0	1
FDI_outward	5,702	6.013	2.871	−11.618	12.556
Corruption_j	6,930	1.627	0.55	0.006	2.435
GDP_j	7,370	27.462	1.403	23.453	30.753
GDP_j	7,392	26.458	1.554	23.056	30.548
Trade_GDP_j	7,035	61.49015	32.490	22.106	186.676
Distance	7,392	8.869	0.582	6.389	9.875

economies. The host-country corruption index (Corruption_j), with a mean of 1.627, reveals a wide institutional diversity.

3.3 Estimation method

A classical log-linear model would require excluding numerous zero observations ($FDI_{outward} = 0$), thereby introducing selection bias and heteroskedasticity issues. To overcome these limitations, we estimate the gravity model using the Poisson Pseudo-Maximum Likelihood (PPML) method (Silva and Tenreyro, 2006). This approach naturally handles zero flows, provides consistent estimators under heteroskedasticity, and retains a straightforward economic interpretation of coefficients (Silva and Tenreyro, 2011).

Although alternative estimators exist (Gamma PML, Negative Binomial PML), the high prevalence of zero flows justifies the choice of PPML.

The preferred specification incorporates country-pair, exporter-year, and importer-year fixed effects. This structure absorbs all time-invariant bilateral characteristics as well as all source-country and host-country shocks varying over time. Identification therefore relies exclusively on within-pair variation in the timing of environmental clause activation.

The preferred specification is given by:

$$E(y_{ijt} | X_{ijt}) = \exp(\beta \cdot EC_{ijt} + \alpha_{ij} + \delta_{it} + \theta_{jt})$$

where y_{ijt} denotes bilateral FDI outward flows, EC_{ijt} is the environmental clause indicator (takes the value 1 when the environmental clause contained in the bilateral agreement is in force, and 0 otherwise), α_{ij} denotes country-pair fixed effects, δ_{it} exporter-year fixed effects, and θ_{jt} importer-year fixed effects. Country-pair fixed effects absorb all time-invariant bilateral determinants of FDI, such as distance, common language, contiguity, and any other persistent pair-specific heterogeneity. Exporter-year and importer-year fixed effects absorb all source-country and host-country shocks that vary over time, including macroeconomic conditions and other country-year factors.

Under this specification, identification comes from within-pair changes over time in the activation of the environmental clause, net of exporter-year and importer-year shocks. Standard errors are clustered at the country-pair level to allow for arbitrary serial correlation and heteroskedasticity within pairs.

3.4 Dynamic specification and event-study design

To examine dynamic adjustment and assess potential pre-treatment trends, the analysis complements the static specification with an event-study model centered on the first year in which the environmental clause becomes active for each pair.

Let G_{ij} denote that first treatment year. The event-study specification is:

$$E(y_{ijt} | X_{ijt}) = \exp \left(\sum_{K \neq -1} \beta_K \cdot 1 \{t - G_{ij} = K\} + \alpha_{ij} + \delta_{it} + \theta_{jt} \right)$$

where the omitted category is $K = -1$, the year immediately preceding treatment.

Because the sample period is limited, event-time coefficients are grouped into broader lead and lag bins at the tails of the distribution in order to preserve statistical power. The lead coefficients provide a diagnostic test for differential pre-treatment trends, while lag coefficients trace the post-treatment evolution of outward FDI after clause activation. Following recent methodological discussions on staggered treatment timing (Sun and Abraham, 2021; Callaway and Sant'Anna, 2021; Baker et al., 2022), the event-study is interpreted primarily as a diagnostic tool rather than as a standalone causal estimator.

3.5 Benchmark and heterogeneity specifications

For comparison purposes, we first estimate pooled PPML gravity models including standard gravity covariates and year fixed effects:

$$E(y_{ijt} | X_{ijt}) = \exp(\beta_0 + \beta_1 EC_{ijt} + \beta_2 GDP_{it} + \beta_3 GDP_{jt} + \beta_4 Distance_{ij} + \beta_5 Contiguity_{ij} + \beta_6 Language_{ij} + \beta_7 Trade_GDP_{ijt} + \tau_t)$$

Where y_{ijt} denotes bilateral outward FDI, EC_{ijt} is the environmental clause indicator, GDP_{it} and GDP_{jt} are log GDPs of source and host countries, $Distance_{ij}$ is log geographical distance, $Contiguity_{ij}$ and $Language_{ij}$ are binary indicators, $Trade_GDP_{ijt}$ is trade openness, and τ_t are year fixed effects (include in column 2 of Table 2).

These pooled specifications are interpreted as descriptive benchmarks rather than preferred identification strategies because they do not fully account for unobserved bilateral heterogeneity or country-specific annual shocks.

To examine institutional heterogeneity, we interact the environmental clause with the host-country corruption-control index standardized as a z-score:

$$E(y_{ijt} | X_{ijt}) = \exp(\beta EC_{ijt} + \psi EC_{ijt} \times Gov_{jt} + \alpha_{ij} + \delta_{it} + \theta_{jt})$$

The marginal effect of the clause at governance level g is then:

$$\% \Delta(g) = [\exp(\beta + \psi g) - 1] \times 100$$

Because importer-year fixed effects absorb the main effect of host-country governance, identification comes from the interaction term. Marginal effects are therefore computed across the governance distribution and reported with confidence intervals.

4. Empirical results

4.1 Baseline estimates

Table 2 presents benchmark PPML gravity estimates without the full set of fixed effects. In these pooled specifications, the coefficient on `Env_trade_agreement` is negative and statistically significant, ranging from -0.265 to -0.391 , which corresponds to an estimated reduction in outward FDI of about 23%–32%. Standard gravity controls display the expected signs: source and host GDP are positive, distance is negative, while contiguity, common language, and trade openness are positively associated with bilateral outward FDI.

Table 2. Effect of environmental clauses on outward FDI: PPML benchmark (without full fixed effects)

	(1)	(2)
Env_trade_agreement	−0.265*** (0.066)	−0.391*** (0.100)
GDP_i	0.646*** (0.023)	0.648*** (0.023)
GDP_j	0.738*** (0.016)	0.750*** (0.019)
Distance	−0.536*** (0.038)	−0.537*** (0.037)
Contiguity	0.640*** (0.104)	0.891*** (0.157)
Language	0.519*** (0.092)	0.524*** (0.093)
Trade_GDP_j	0.005*** (0.002)	0.005*** (0.002)
Year fixed effects	No	Yes
Constant	−25.221*** (0.751)	−25.874*** (0.788)
Observations	5,267	5,267
Pseudo R ²	0.482	0.483

Note(s): Standard errors in parentheses
 * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

However, these pooled estimates remain vulnerable to omitted variable bias because they do not absorb persistent bilateral heterogeneity or country-specific annual shocks. They should therefore be interpreted as descriptive correlations rather than causal estimates.

4.2 Preferred fixed-effects estimates

Table 3 presents the preferred high-dimensional fixed-effects PPML estimates. Under this stricter specification, the coefficient on Env_trade_agreement remains negative but becomes substantially smaller in magnitude and loses statistical significance. In the full sample, the estimated coefficient is −0.132, which corresponds to an average decline of about 12.4%, while in the event-study sample it is −0.121, equivalent to roughly 11.4%. The similarity of

Table 3. Estimation results of the effect of environmental clauses on outward FDI using the preferred specification and the event-study sample

	(1) Preferred FE: full sample	(2) Preferred FE: event- study sample
Env_trade_agreement	−0.132 (0.117)	−0.121 (0.123)
Constant	−3.432*** (0.053)	−3.452*** (0.052)
Fixed effects	Yes	Yes
Observations	5,275	5,171
Pseudo R ²	0.304	0.305

Note(s): Standard errors in parentheses
 * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

these two estimates indicates that the weaker average effect is not driven by the restriction to the event-study sample, but rather by the inclusion of richer fixed effects.

This attenuation is substantively important. It suggests that part of the strong negative association observed in the pooled benchmark models was capturing persistent bilateral characteristics or country-year shocks rather than a robust within-pair treatment effect of clause activation itself. Put differently, once all time-invariant dyadic factors and all exporter-year and importer-year shocks are absorbed, the average deterrent effect of environmental clauses on outward FDI appears more modest and less precisely estimated than in simpler models.

The similarity between the full-sample estimate and the restricted event-study sample further suggests that the attenuation is driven primarily by the richer fixed-effects structure rather than by sample composition.

4.3 Dynamic effects and pre-trends

Figure 1 presents the event-time estimates relative to the year immediately preceding clause activation. The lead coefficients are close to zero and jointly insignificant, providing no evidence of differential pre-treatment trends. The post-treatment coefficients are predominantly negative and become larger in magnitude from two years after activation onward, consistent with a gradual decline in outward FDI following treatment. At the same time, the confidence intervals remain wide and the post-treatment coefficients are only jointly marginally significant, so these dynamic estimates should be interpreted as supportive rather than definitive evidence.

4.4 Robustness checks: placebo test

To assess robustness, we conduct placebo tests using temporal shifts. The aim is to ensure that the observed effect results from the implementation of environmental clauses, rather than pre-trends or statistical coincidences.

We construct two placebo variables: *placebo_before*, assigning treatment three years prior to actual implementation, and *placebo_after*, three years after the agreement’s signature. We then re-estimate the full model by replacing the original treatment variable with each placebo,

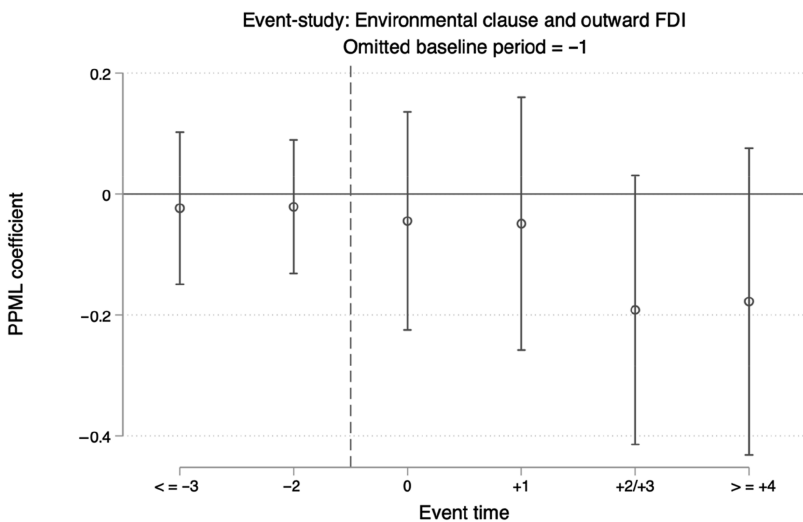


Figure 1. Event-study estimates relative to the year prior to clause activation

using these fictitious treatment dates. If the main results were driven by pre-existing trends or chance, placebo variables would appear significant.

The models to be estimated are as follows:

Placebo model–Lead (+3 years)

$$E(y_{ijt} | X) = \exp(\beta_0 + \beta_1 \text{placebo_before} + \beta_2 \text{lgdp}_i + \beta_3 \text{lgdp}_j + \beta_4 \text{comlang}_{ij} + \beta_5 \text{ldist}_{ij} \\ + \beta_6 \text{contig}_{ij} + \beta_7 \text{trade}_{ij})$$

Placebo Model–Lag (–3 years)

$$E(y_{ijt} | X) = \exp(\beta_0 + \beta_1 \text{placebo_after} + \beta_2 \text{lgdp}_i + \beta_3 \text{lgdp}_j + \beta_4 \text{comlang}_{ij} + \beta_5 \text{ldist}_{ij} \\ + \beta_6 \text{contig}_{ij} + \beta_7 \text{trade}_{ij})$$

As shown in Table 4, the results confirm the absence of placebo effects: coefficients on *placebo_before* (0.0389) and *placebo_after* (0.00579) are statistically insignificant ($t = 0.38$ and 0.11). Their economic magnitude is negligible (+3.9% and +0.6%), well below the –20% to –28% reduction observed for the actual environmental clause. Control variable coefficients remain stable, ruling out model instability. These tests reinforce the causal credibility of the main results.

Importantly, these placebo exercises are estimated using pooled PPML specifications rather than the preferred high-dimensional fixed-effects model, since the inclusion of multiple fixed effects absorbs most placebo variation. Accordingly, the placebo exercises should be interpreted as [supplementary](#) evidence rather than as formal validation of the preferred specification.

Table 4. Placebo test: effect of fictitious environmental clauses three years before and after implementation

	(1) FDI_ outward	(2) FDI_ outward
GDP_i	0.765*** (32.95)	0.765*** (32.92)
GDP_j	0.741*** (40.27)	0.742*** (40.35)
Language	0.722*** (8.50)	0.723*** (8.53)
Distance	–0.771*** (–24.31)	–0.771*** (–24.31)
Contiguity	0.480*** (3.99)	0.447*** (5.98)
Trade_gdp	0.00873*** (6.81)	0.00874*** (6.94)
placebo_before	0.0389 (0.38)	
placebo_after		0.00579 (0.11)
Constant	–27.28*** (–34.73)	–27.27*** (–34.93)
Observations	2,891	2,891
Pseudo R ²	0.749	0.749

Note(s): t statistics in parentheses
^{*} $p < 0.05$, ^{**} $p < 0.01$, ^{***} $p < 0.001$

4.5 Institutional heterogeneity effects: role of governance

We examine whether the effect of environmental clauses varies with host country institutional quality, measured by control of corruption.

Table 5 reports the heterogeneity analysis based on the interaction between environmental clauses and host-country corruption control, in the preferred fixed-effects PPML framework. The coefficient on the environmental clause indicator is negative but statistically insignificant at the mean level of governance. The interaction between clause activation and host-country control of corruption is positive and statistically significant, implying that the estimated effect of the clause becomes less negative as governance improves.

Figure 2 translates this interaction into marginal effects across the governance distribution. At low levels of governance, clause activation is associated with a sizeable decline in outward FDI, whereas the estimated effect moves toward zero and eventually becomes positive in point estimates as governance improves. However, the confidence intervals widen substantially at higher governance levels, so the positive range should be interpreted cautiously. Overall, the heterogeneity results suggest that the negative association between environmental clauses and outward FDI is concentrated in weaker-governance host countries rather than amplified in

Table 5. Heterogeneous effects: interaction between environmental clauses and host country corruption control

	(HTE)
Env_trade_agreement	−0.072 (0.101)
Corruption_j # Env_trade_agreement	0.330** (0.158)
Constant	−3.443*** (0.045)
Fixed effects	Yes
Observations	5,275
Pseudo R ²	0.303

Note(s): t statistics in parentheses
* p < 0.05, ** p < 0.01, *** p < 0.001

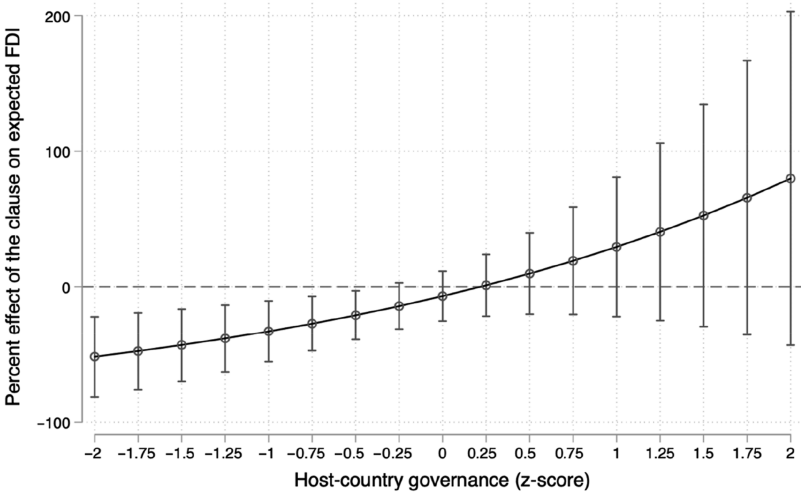


Figure 2. Marginal effect of environmental clause across governance levels

stronger-governance environments. This pattern is consistent with an institutional interpretation in which the effectiveness and perceived credibility of environmental provisions depend critically on domestic governance conditions.

5. Conclusion

This paper revisits whether environmental clauses embedded in trade agreements are associated with bilateral outward FDI and whether that relationship depends on host-country institutional governance. Using a panel of 43 developed and developing economies over the period 2009–2021, the analysis estimates gravity-type PPML models with country-pair, exporter-year, and importer-year fixed effects and complements the static specification with a dynamic event-study framework centered on the first year in which the environmental clauses become active.

Three main findings emerge. First, pooled gravity estimates suggest a negative association between environmental clauses and outward FDI once standard gravity controls are included, but these descriptive models remain sensitive to unobserved bilateral heterogeneity. Second, in the preferred high-dimensional fixed-effects PPML specification, the average coefficient on the environmental clauses remains negative but is estimated imprecisely, indicating that the large deterrent effects reported in simpler models should not be interpreted as robust average treatment effects. Third, the event-study provides no evidence of differential pre-trends before treatment and shows a predominantly negative post-treatment pattern, consistent with a gradual adjustment of outward FDI after clause activation, although the dynamic estimates remain imprecise. Finally, additional heterogeneity results suggest that the negative association is concentrated in host countries with weaker corruption control, while it weakens and becomes statistically insignificant in better-governed environments. This result points to a potentially important institutional asymmetry in the relationship between environmental provisions and investment flows.

Taken together, these findings suggest that environmental provisions in trade agreements may influence investment decisions, but that their effects are more conditional and more limited than pooled estimates initially imply. In particular, the results support an institutional interpretation in which environmental clauses affect investors not only through direct compliance costs, but also through the credibility of domestic enforcement and the expectations they generate regarding future regulatory trajectories. The stronger deterrent effect observed in weakly governed countries may indicate that environmental provisions become more constraining precisely where domestic enforcement is otherwise limited, or alternatively, that investors anticipate greater regulatory uncertainty in such environments. Institutional quality should therefore be viewed less as a simple interaction term than as a broader conditioning factor shaping whether treaty commitments are likely to be implemented credibly or remain largely symbolic.

At the same time, several limitations should be acknowledged. Because the analysis relies on aggregate bilateral FDI rather than pollution-intensive sectoral investment flows, the results should be interpreted as evidence on overall investment responses that are consistent with, but do not by themselves prove, a pollution haven mechanism. More broadly, the determinants of FDI location extend well beyond environmental regulation, implying that changes in aggregate flows should not be attributed to treaty provisions alone without caution.

The policy implications are therefore nuanced. Environmental clauses should not be expected to generate uniform or immediate effects on outward FDI. Their effectiveness depends critically on whether domestic institutions render environmental commitments credible and whether firms perceive a durable shift in the regulatory environment of host countries. Future research could extend the analysis by focusing on pollution-intensive sectors, distinguishing between binding and non-binding provisions, and examining more directly the mechanisms through which institutional conditions shape the effectiveness of environmental clauses. Ultimately, the effectiveness of environmental provisions appears to

depend less on their formal inclusion in trade agreements than on the institutional environments in which they operate.

Supplementary material

The supplementary material for this article can be found online.

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Corresponding author

Rim Mansouri can be contacted at: rim_mansouri@um5.ac.ma