ESG Disclosure Mandates and Emissions in Global Value Chains *

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Abstract

This paper examines whether mandatory Environmental, Social, and Governance (ESG) disclosure policies affect emissions in global value chains by incentivizing foreign suppliers to align with the environmental priorities of regulated buyers. I construct an industry-level measure of exposure to the European Union's Non-Financial Reporting Directive (NFRD) for non-EU exporters and study its effects in an event-study framework. Greater exposure induces improvements in ESG reporting among high-income non-EU countries, accompanied by a temporary decline in ESG performance scores, suggesting greater transparency rather than cleaner production. More exposed industries also reduce emissions embodied in exports to the EU through a scale effect, driven by a contraction in intermediate exports rather than a decline in emissions intensity. I find no evidence that trade or emissions are redirected toward the rest of the world.

JEL codes: O44, O31, O33, Q55, Q37

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1 Introduction

Reducing global carbon emissions is the central objective of international climate policy. Coordinating policy responses across countries, however, is hindered by competing national interests, economic asymmetries, and institutional constraints. As a result, many developed economies have implemented stringent domestic environmental regulations, while most developing countries lag behind. This regulatory imbalance across countries incentivizes firms to relocate pollution-intensive activities to countries with weaker environmental standards (Copeland and Taylor 1994; Cole 2004; Frankel and Rose 2005) or outsource production entirely by importing intermediate goods. Shifting emissions across borders undermines the effectiveness of environmental laws and often places heavier burden on countries with weak environmental management.

To account for this fragmented regulatory landscape, countries have begun deploying creative unilateral measures targeting carbon embedded in supply chains. A range of interventions have been explored, with carbon border adjustments—such as the European Union's CBAM[1]—emerging as the solution *du jour*. Although carbon borders theoretically internalize the carbon costs embedded in imports, there are significant practical barriers to implementation, including compatibility with international trade agreements, scope of the carbon border, and tracking of emissions across global value chains (Fowlie and Reguant 2022; Cosbey, Droege, Fischer, and Munnings 2019). Moreover, such measures often impose disproportionate trade barriers on developing nations, exacerbating global inequities.

An alternative policy approach might lie in mandating disclosure of firms' Environmental, Social, and Governance (ESG) data. Rather than imposing direct limits on emissions or taxing firms for polluting, these policies reshape firm behavior by requiring them to publicly report data on key environmental and social metrics, including greenhouse gas emissions. Greater transparency in corporate practices allows rating agencies to generate more accurate ESG scores, enabling investors and consumers to make more informed decisions, and driving competition among firms to differentiate themselves on sustainability grounds (Flammer 2015). As market-based pressures mount, firms face strategic incentives to improve sustainability practices—not due 'to regulatory penalties or subsidies, but because disclosure changes the economic consequences of inaction.

This paper examines whether disclosure-based environmental regulation can lower the emissions embedded in goods entering regulated markets. I study the European Union's Non-Financial Reporting Directive (NFRD), adopted in 2014 and implemented in 2017, which requires large EU firms to disclose non-financial information—including environmental, social, and human rights im-

[1] https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en

pacts—across both their operations *and* supply chains (Parliament and of the European Union 2014). Since ratings agencies incorporate upstream emissions into ESG scores, EU firms regulated by the NFRD have incentives to push suppliers to adopt cleaner production methods. Alternatively, they may choose to replace emissions-intensive suppliers with lower-emitting ones. Both channels have the potential to reduce the carbon content of intermediate goods imported into the EU. Given that firms differ in the extent to which they trade with EU-regulated buyers, the strength of regulatory pressure is likely to vary across countries and industries. At the same time, local emissions in non-EU countries may decline as exporting firms adopt cleaner production methods to meet the sustainability expectations of their EU corporate customers.

To evaluate the NFRD's impact on behavior outside the EU, I construct an export-based *exposure* measure estimating the degree to which non-EU country-industries are affected by the regulation. Exposure is defined as the share of a country-industry's total output sold to regulated EU firms. Industries with stronger trade linkages to regulated EU firms—that is, industries that sell a larger share of their output to NFRD-covered buyers—are more likely to face indirect pressure to improve environmental performance. I exploit variation in exposure to estimate the effect of the NFRD on non-EU industries in an event study framework from 2010 to 2020. Although the NFRD applies to firms, I conduct the analysis at the industry level to pick up systemic effects beyond individual firms. Focusing solely on firm-level responses may reveal changes in disclosure or emissions behavior, but it cannot answer whether the regulation has broader consequences for environmental performance across the supply chain.

First, I examine whether the NFRD affects ESG activity outside the European Union. I find that industries more exposed to the regulation increase ESG disclosure by approximately 4% more than less exposed industries, driven primarily by environmental disclosures. This increase in transparency is accompanied by a temporary 10% decline in environmental scores for more exposed industries, suggesting expanded reporting reveals previously undisclosed environmental risks. Over time, however, the difference in ESG disclosure and scores between more and less exposed industries dissipates in the full sample, while remaining persistent in the high-income sample.

Turning to trade and emissions outcomes, I find that exposure to the NFRD leads to gradual reductions in the emissions embedded in exports to the European Union. These reductions appear to operate through a scale effect rather than improvements in emissions intensity (Levinson and Taylor 2008; Shapiro 2016; Copeland and Taylor 2004). Industries more exposed to the NFRD reduce exports to the EU by 10% upon implementation of the policy. This decline is driven primarily by a reduction in intermediate goods exported to the EU. I do not find an accompanying increase in intermediate exports to countries outside the EU, suggesting that more exposed country-industries do

not fully redirect these exports to alternative markets. The decline in intermediate exports appears concentrated in high-income exporting countries. Taken together, these results indicate that exposure to the NFRD reshapes trade patterns with the EU, particularly in intermediate supply chains, and reduces emissions embodied in EU-bound trade primarily through lower trade volumes rather than cleaner production.

This work contributes to the growing literature studying how environmental policies shape the global distribution of emissions through international trade. While most research has focused on price-based policies such as carbon taxes or border adjustments, far less is known about how emissions reporting-based policies influence global production networks. By studying the NFRD, I provide evidence on how mandatory ESG disclosure affects the trade flows and supply chains through which emissions may enter regulated markets.

More broadly, I contribute to the literature on mandatory ESG regulation by examining how disclosure mandates affect economic activity beyond the firms directly subject to regulation. A growing body of work finds that ESG requirements imposed on large firms can propagate through global value chains, encouraging suppliers to improve disclosure practices and, in some cases, environmental performance (Dai, Liang, and Ng 2021; Schiller 2017; Tang, Wang, and Liu 2023). By analyzing outcomes at the country-industry level, this paper evaluates whether these supply-chain spillovers translate into broader changes in environmental activity among exporting industries outside the EU. Additionally, this study examines how disclosure-based environmental policies affect international trade patterns and the organization of global supply chains. If mandatory ESG disclosures alter firms' sourcing decisions or increase compliance costs for suppliers abroad, they may reshape trade flows in ways that resemble traditional environmental trade policies.

Lastly, I contribute to the literature on the distributional consequences of environmental regulation across countries at different income levels. Firms in high-income countries may be better positioned to comply with ESG standards due to existing sustainability frameworks and access to compliance resources, whereas suppliers in lower-income countries may face greater challenges adapting to these reporting requirements. By examining heterogeneous effects across country income groups, this study sheds light on whether ESG disclosure mandates reshape participation in global supply chains and potentially reinforce existing inequalities in international trade.

The rest of the paper is organized as follows. Section II reviews the relevant literature on ESG regulations, supply chain spillovers, and environmental policy. Section III outlines the data and empirical methodology, including the construction of the exposure measure and event study framework. Section IV presents the main results, and section V concludes.

2 Background and Conceptual Framework

Originally outlined in the United Nations Global Compact's *Who Cares Wins* (2004) report, ESG data refer to a set of non-financial metrics intended to integrate environmental and social considerations into financial decision-making. These metrics capture how such factors affect firm risk and performance, and also how firm activities, in turn, shape external environmental and social outcomes. Firms typically report ESG data voluntarily, which rating agencies aggregate into scores used by investors and consumers to evaluate non-financial performance. These scores can shape competitive dynamics, as firms use ESG performance to bolster reputation and customer trust (Saeidi, Sofian, Saeidi, Saeidi, and Saaeidi 2015). Disclosure also serves as a credible signal of transparency, reducing information asymmetries and helping firms differentiate themselves in capital markets, thereby lowering their cost of capital (Lambert, Leuz, and Verrecchia 2007, 2012). Additionally, firms with better ESG scores also benefit from lower equity and debt financing costs (El Ghoul, Guedhami, Kwok, and Mishra 2011; Kleimeier and Viehs 2018; Apergis, Poufinas, and Antonopoulos 2022), enhanced firm value (Mohammad and Wasiuzzaman 2021), and greater resilience during periods of economic downturn (Agliardi, Alexopoulos, and Karvelas 2023).

Despite these benefits, voluntary ESG reporting has come under increased scrutiny due to concerns over selective reporting, inconsistent standards, and the risk of greenwashing. In response, a number of countries have introduced *mandatory* ESG disclosure policies requiring firms to report on their sustainability practices. These rules pull previously non-reporting firms, often those with weaker ESG performance, into the practice of public disclosure. The results are mixed: while such policies can lead to real improvements in environmental and social outcomes, they may also impose significant compliance costs and reduce operational efficiency (Chen, Hung, and Wang 2018; Christensen, Floyd, Liu, and Maffett 2017; Tomar 2023; Fiechter, Hitz, and Lehmann 2022; Jouvenot and Krueger 2019). What is clear is that once reporting becomes mandatory, even previously disengaged firms begin to improve and compete on ESG metrics, contributing to a broader race to the top in sustainability practices (Christensen, Hail, and Leuz 2021; Ioannou and Serafeim 2017).

The European Union's Non-Financial Reporting Directive (NFRD, Directive 2014/95/EU) is the global standard for mandatory ESG disclosure policies. Adopted in 2014 and enforced beginning in 2017, the directive aims to enhance corporate transparency by requiring large public-interest companies to disclose non-financial information. Firms with more than 500 employees must report on their policies, risks, and outcomes related to the environment and social matters. Approximately 11,700 firms across the EU were subject to the legislation upon implementation.[2] Some of these firms

[2]See European Commission, *Commission Staff Working Document: Impact Assessment Report Accompanying the Commission Delegated Regulation (EU)*, SWD(2021), p.55 https://ec.europa.eu/finance/docs/level-2-measures/taxonomy-reg

had already been covered by earlier national-level disclosure regimes, such as France's Grenelle II Act and the Netherlands' Transparency Benchmark (Schiller 2017). While the NFRD establishes a formal reporting requirement, it also allows firms flexibility in determining what information is "material," enabling them to tailor disclosures to their own operations. Fiechter et al. (2022) finds that the NFRD led to measurable changes in firm behavior, including reductions in domestic pollution-intensive activities and shifts in capital allocation.

The regulation also extends beyond firm-level activity by requiring companies to report on their supply chains, including any due diligence procedures. This supply chain provision was not an afterthought but part of a broader policy push to increase transparency and accountability across global value chains. In tandem with the NFRD, the EU commissioned a study on due diligence requirements to guide firms in identifying, tracking, and managing sustainability risks throughout their supply chains (British Institute of International and Comparative Law, Civic Consulting, Directorate-General for Justice and Consumers (European Commission), LSE, Torres-Cortés, Salinier, Deringer, Bright, Baeza-Breinbauer, Smit, Tejero Tobed, Bauer, Kara, Alleweldt, and McCorquodale 2020). Under this framework, due diligence entails a structured process of identifying, preventing, and mitigating adverse environmental and human rights impacts. This includes mapping the full supply chain to understand sourcing relationships, assessing the severity and likelihood of ESG risks, collecting emissions data where feasible, and establishing monitoring systems, such as audits, risk-ranking tools, or supplier self-assessments, to evaluate supplier performance and compliance. Rather than disengage with risky operations, firms are encouraged to use their leverage to influence supplier practices. Taken together, the NFRD and the due diligence framework reflect a coordinated effort to extend EU sustainability norms beyond its borders by compelling firms to monitor the origin of inputs and address upstream ESG risks.

These provisions underscore the role of supply chains as a natural channel through which ESG policies might propagate beyond regulated countries. Previous studies suggest that sustainability preferences from corporate customers influences the behavior of upstream suppliers. Dai et al. (2021) show how firms that voluntarily prioritize ESG performance pass those expectations along to their suppliers. This happens through assortative matching, where customers favor ESG-aligned suppliers, but also through improvements by existing suppliers in response to customer demands. Similar patterns emerge in the Chinese setting, where suppliers' ESG scores are more responsive to their customers' ESG performance when those customers are located abroad (Tang et al. 2023). Yet however careful these studies are, drawing causal conclusions from voluntary ESG engagement remains challenging due to selection concerns. Firms that choose to prioritize sustainability may differ systematically from those that do not, which could lead studies on voluntary ESG mechanisms to

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overstate the true effect of the spillovers.

Schiller (2017) addresses this challenge by studying the staggered adoption of *mandatory* ESG reporting requirements across European countries. The study finds a similar response to corporate customer ESG pressure, but with a larger magnitude, suggesting that mandatory disclosure policies may produce stronger spillover effects than voluntary firm initiatives. It also takes an important step by examining whether these improvements extend to real environmental outcomes. However, because the analysis is conducted at the firm level, it can only draw limited conclusions about the broader significance of these effects. The availability of reliable environmental outcome data restricts the secondary analysis to U.S.-based suppliers. Moreover, even where outcome data are available, the localized nature of firm-level variation offers limited insight into whether mandatory disclosure produces broader, systemic impacts across global supply chains.

In light of these limitations, a fundamental question remains: do these firm-level responses add up to anything meaningful? Understanding how mandatory disclosures reshape sourcing strategies, shift trade flows, or mitigate total carbon leakage requires analysis beyond the firm level. I address this gap by analyzing the effects of the EU's NFRD at the country-industry level, allowing me to detect whether policy spillovers are large enough to shift industry-wide outcomes. By leveraging industry variation in exposure to the NFRD, the analysis captures systemic responses that remain obscured in firm-level studies, offering new insight into how mandatory ESG disclosure policies reverberate through global value chains.

3 Methods and Data

3.A Measuring Indirect Exposure to the NFRD

I construct a variable in the style of Choi, Kuziemko, Washington, and Wright (2024), henceforth referred to as *exposure*, that captures how non-EU country-industries are affected by the NFRD through trade. For simplicity, I refer to non-EU countries as *origin* and EU countries as *destination*. The objective is to quantify the *dosage* of regulatory pressure each origin industry expects to face when the NFRD is implemented. Functionally, the exposure measures simply estimates how much of an origin industry's intermediate goods are sold to regulated European firms. For example, if a non-EU industry sends most of its intermediates to large EU companies subject to reporting mandates, it will likely face greater pressure to improve its ESG performance, and is therefore *more exposed*.

Since this variable isn't directly observed in the data, I estimate it as the *share of gross intermediate output* sold to regulated European firms. The variable combines two components: the value of intermediate output exported to the EU ($X^{fj}_{ci,2010}$), and the share of those exports purchased by firms subject to the NFRD (ψ^{fj}_{2010}). Trade flow data comes from OECD ICIO tables and aggregated firm purchase data from Eurostat. While trade flows can be directly calculated from the data[3], measuring the share of intermediate goods purchased by regulated firms is more complicated as I do not directly observe which firms within each destination industry purchase intermediate goods. As a proxy, I use the share of *total intermediate inputs* purchased by large firms. [4] A limitation of this approach is that I observe input purchases at the destination industry level, not by origin-destination pair. This requires the assumption that large firms purchase the same proportion of inputs from all non-European country-industries, a simplification that may not hold if sourcing is concentrated among specific foreign suppliers.

I construct the exposure variable as follows. For each country-industry, I take a vector of intermediate exports to the destination country-industries and weight each element by the share of inputs purchased by NFRD regulated firms. I then sum the weighted values over all destination country-industries and normalize by the total output of the origin country-industry as follows:

$$UnscaledExposure_{ci,2010} = \frac{\sum_F \sum_J \left[X^{fj}_{ci,2010} \times \psi^{fj}_{2010} \right]}{\Omega_{ci,2010}} \tag{1}$$

$$c \in C = \{\text{non-EU Countries}\}, \quad f \in F = \{\text{EU Countries}\}$$

Where $c \in C$ denotes the origin country outside of the EU, and i the industry within that country. Superscript fj identifies the destination country-industry, where $f \in F$ denotes the destination country within the EU, and j the industry. The term $X^{fj}_{ci,2010}$ represents intermediate exports flowing from the origin country-industry (c, i) to the destination country-industry (f, j) in the year 2010. A high value of $X^{fj}_{ci,2010}$ reflects a strong trade linkage between the origin and destination country-industries. The value of intermediate exports is then weighed by ψ^{fj}_{2010}, which denotes the share of inputs purchased by regulated firms in destination country-industry (f, j). Intuitively, the product $X^{fj}_{ci,2010} \times \psi^{fj}_{2010}$ represents the value of exports from any origin-destination pair purchased by NFRD-regulated firms. Summing that product over all EU countries $f \in F$ and their respective industries

[3]For each origin country-industry, exports are computed by summing all ICIO destination columns for intermediate inputs and final demand while excluding domestic flows. Total exports equal the sum of intermediate and final exports.

[4]I calculate total intermediate input purchases by subtracting firm value added from total revenue, using Eurostat data. "Large firms" refers to those with more than 500 employees, which is the threshold for NFRD coverage. Due to data limitations, I use Eurostat statistics for firms with more than 250 employees as a proxy. I discuss the implications of this approximation and associated robustness checks later in the paper.

$j \in J$ yields the *total* intermediate exports from an origin country-industry that are sold to regulated firms across the EU.

Of course, the numerator will be driven in part by the size of the origin country-industry. Thus, I normalize the sum by the total output of the origin country-industry, $\Omega_{ci,2010}$, giving the *share* of output from a given country-industry sold to firms subject to NFRD regulations. To ensure the exposure variable reflects the overall significance of EU-linked trade for each country-industry, the measure is normalized by total output rather than by exports. This allows the exposure variable to account for how much of a country-industry's entire production is subject to indirect regulatory pressure, assigning lower values to industries that rarely export. This variable thus captures the indirect influence of the regulation on non-EU industries by integrating both the intensity of trade linkages and the relevance of the regulation in the destination market.

Importantly, in order for the exposure measure to serve as a valid proxy for an industry's degree of indirect regulatory pressure from the NFRD, I fix it at its 2010 value—prior to both the announcement and implementation of the regulation. This ensures that exposure reflects pre-existing trade relationships, rather than any endogenous adjustments in response to the policy itself. If the exposure variable were permitted to evolve dynamically over time, changes in regulatory exposure might be correlated with contemporaneous shifts in industry practices that independently influence ESG outcomes, trade patterns, and emissions. This could bias the estimates, undermining the identification of causal effects from the regulation.

Since the raw exposure measure lacks direct economic interpretability, I again follow Choi et al. (2024) and rescale the exposure variable using the inter-quartile range. This allows me to interpret the estimated coefficients as the effect of shifting from the 25th percentile (bottom quartile) to the 75th percentile (top quartile) of the exposure distribution, rather than as a marginal effect. The estimations can therefore be understood as capturing the practical consequences of a meaningful increase in regulatory exposure across country-industries.

$$Exposure_{ci,2010} = \frac{UnscaledExposure_{ci,2010}}{E[UnscaledExp_{ci,2010}|\text{top quartile}] - E[UnscaledExp_{ci,2010}|\text{bottom quartile}]} \tag{2}$$

3.B Data

Exposure

To construct the exposure variable, I rely on two main data sources: the OECD Inter-Country Input-Output (ICIO) tables, and aggregate firm data from Eurostat. The OECD ICIO tables provide detailed bilateral trade data—denoted $X_{ci,2010}$ in the exposure measure—covering 76 countries, including all EU member states. Since my focus is on non-EU countries' exposure to EU regulations, I construct the exposure variable for all 49 non-EU countries in the OECD dataset. Trade flows are disaggregated into 45 industries based on the International Standard Industrial Classification (ISIC). I focus specifically on extraction and manufacturing sectors (ISIC Sections B and C) to ensure that comparisons are made across industries meaningfully integrated into global value chains. I am able to calculate the exposure metric for 20 sub-industries within the manufacturing and extraction sectors across 49 countries. The data span from 2010 to 2020, providing sufficient coverage for both the pre- and post-regulatory periods.

These countries in the sample span a wide range of development levels. Approximately one-third are classified by the World Bank as high-income (e.g., Australia, Canada, Switzerland), while the remainder consist of upper-middle-income (e.g., China, Brazil, South Africa), lower-middle-income (e.g., India, Egypt, Ukraine), and low-income economies (e.g., Cambodia, Myanmar). Table 2 in Appendix A provides the full list of countries by income group. Several of these countries are members of the OECD, though the broader sample reflects a mix of advanced, emerging, and developing economies integrated into global production networks. Together, these countries account for roughly 90% of all EU intermediate input imports from non-EU trading partners between 2008 and 2020. This coverage ensures that the analysis captures the bulk of global trade exposure relevant to the NFRD, while preserving heterogeneity in institutional capacity, regulatory alignment, and value chain positioning.

The second component of the exposure variable captures the share of exports from non-EU industries purchased by NFRD-regulated firms—represented by ψ^{fj}_{2010}. Ideally, I would observe firm-level data on both size and purchasing behavior precisely identifying which EU firms are subject to the NFRD and how they source their inputs. In the absence of such data, I rely on Eurostat data which has some limitations. The data reports aggregated firm statistics by size category for 20 industries at the ISIC sub-section level. I observe total revenue and value added for firms with fewer than 250 employees and those with 250 or more. While the threshold does not perfectly align with the NFRD's 500-employee cutoff, it offers a valuable advantage: I can estimate intermediate input purchases by firm size as the difference between total revenue and value added. Disaggregated pur-

chasing data is not publicly available, and this feature of the Eurostat dataset makes it uniquely well-suited to my research question.

Figure 1 shows the distribution of the baseline exposure measure. The measure is highly skewed, with a substantial mass of observations clustered near zero exposure. Summary statistics in table 1 confirm this pattern: the mean exposure is below 1% and exhibiting a long right tail. This reflects the fact that many non-EU industries export little or nothing to large EU firms, limiting observable variation in regulatory exposure across much of the sample. While this lack of variation imposes constraints on identification, it also highlights the meaningful differentiation for industries at the upper end of the distribution.

Outcomes

I test the effects of exposure to the NFRD on several outcomes. To see how industries change their ESG reporting and performance behavior, I use Morgan Stanley Capital International (MSCI) ESG data, a third party aggregator of firm ESG data. MSCI assigns firms scores from 0 to 10 across 33 key issues, based on both disclosed and publicly available information. Importantly, each ESG issue is composed of two distinct components: a measure of realized risk or performance in a given category, and a measure of the policies, commitments, and management practices firms report to address that risk. This distinction allows me to separately capture outcomes related to observable environmental exposure and those related to how firms communicate their approach to managing it.

To capture disclosure, I calculate the share indicators for which each firm receives a score, then take the average across all firms in a given country-industry. Table 1 shows that the average disclosure share is roughly 31%, though with considerable heterogeneity across the sample. Figure 2 provides a visual breakdown of disclosure over time by quartile of exposure. Disclosure levels increase substantially beginning in 2014, with the largest post-2017 increases concentrated among more exposed industries—suggesting a potential anticipatory and behavioral response to NFRD-related pressures. To measure performance, I focus on a single environmental issue—carbon emissions—and use the average firm-level score on that indicator, aggregated to the country-industry level. As shown in Table 1, average baseline performance is moderately high, with a mean score of 6.03 out of 10.

The remaining outcome variables draw on OECD data and capture how non-EU country-industries adjust both the emissions embodied in their exports to the EU and the overall volume of that trade.

I begin with emissions embodied in exports to the EU, which I construct by linking OECD Inter-Country Input-Output (ICIO) trade flow data to sector-level emissions data from the International Energy Agency (IEA). This measure captures the emissions associated with EU-bound exports and allows me to test whether more exposed industries reduce the carbon content of the goods they sell into the European market. I then turn to exports from each country-industry to the EU, measured using the OECD ICIO tables. This variable captures the value of cross-border trade in goods and allows me to test whether more exposed industries adjust their trade volumes in response to the NFRD.

3.C Empirical Strategy

I estimate the spillover effects of the NFRD using a difference-in-differences framework. This approach is particularly well-suited to my setting, given variation along two dimensions: time and intensity of treatment. The NFRD constitutes an exogenous policy *treatment*. Although non-EU industries are only indirectly affected, the policy takes effect simultaneously for all industries, creating a clear distinction between pre- and post-policy periods (difference one). The exposure metric quantifies the intensity of treatment, allowing me to compare industries receiving different levels of regulatory pressure from the NFRD (difference two), as in Callaway, Goodman-Bacon, and Sant'Anna (2024).

To examine the dynamic effects of the NFRD during both the lead-up period and the years following its implementation, I adopt an event-study approach using panel data from 2010 to 2020. Rather than grouping industries into bins of low or high exposure, I estimate the effect of the NFRD on outcome variables linearly as a function of the continuous exposure measure, interacting it with a full set of year indicators allowing the effect to vary flexibly over time. In effect, this specification tests how variation in exposure to the NFRD in 2010 correlates with changes in the outcome variables in each year. It also facilitates an assessment of the parallel trends assumption by examining pre-treatment coefficients in the years leading up to the policy. The resulting estimation equation is as follows:

$$Y_{cit} = \alpha + \sum_{\tilde{t} \neq 2013} \beta_t (Exposure_{ci,2010}) \times 1(\tilde{t} = t) + W_{ct} + \gamma_{ci} + \lambda_t + \epsilon_{cit} \tag{3}$$

Here, Y_{cit} is the outcome variable for an origin country c, industry i, and year t; $Exposure_{ci,2010}$ is the continuous measure of ex ante exposure to the NFRD, scaled using the interquartile range of

the distribution; and γ_{ci} and λ_t denote country-industry and year fixed effects, respectively. The coefficient β_t captures how exposure relates to the outcome in year t, relative to 2013. I cluster standard errors at the country-industry level to account for serial correlation in outcomes within the same unit over time.

The vector W_{ct} accounts for country-level factors that could influence both ESG reporting and environmental outcomes independently of the NFRD. I control for GDP per capita to proxy a country's level of economic development and its industrial capacity to invest in sustainability. I also include a variable measuring the annual flow of environmental policies enacted in each country. This variable captures contemporaneous changes in domestic environmental policy that may influence firm behavior independently of international regulatory pressure. In robustness checks, I include a cumulative measure of environmental policy stock [5].

I interpret the β_t coefficients as the *causal* effect of increasing exposure to the NFRD from the bottom to the top quartile of the exposure distribution. While identification of average differences across exposure groups over time relies on the standard parallel trends assumption, interpreting the coefficients as causal responses to changes in exposure requires a stronger identifying condition. In particular, it requires that industries with higher exposure would have followed the same outcome trajectory as less exposed industries had they experienced lower dosage of exposure — a version of the strong parallel trends assumption (Callaway et al. 2024).

In my setting, several features support the plausibility of this assumption. First, the exposure variable is constructed using trade relationships and firm characteristics measured in 2010, before the announcement or implementation of the NFRD. This eliminates concerns that industries strategically adjusted in anticipation of treatment. Second, as I show in the results, nearly all estimated coefficients in the pre-policy period are statistically indistinguishable from zero. The observed similarity of pre-trends across exposure levels suggests that, in the absence of treatment, higher- and lower-exposure industries would have followed similar outcome trajectories, supporting the stronger identifying assumptions required for causal interpretation.

4 Results

This section evaluates the effects of the NFRD on non-EU country-industries along three related dimensions. I begin by examining whether exposure to the directive influences ESG disclosure and

[5] The stock policy variable does not include information on the expiration date of each policy, likely overstating the number of active policies.

performance outside the European Union. I then turn to environmental outcomes by analyzing changes in the carbon emissions embedded in bilateral trade flows. Finally, I assess whether exposure to the NFRD affects trade patterns, with particular attention to changes in export behavior across destinations. Together, these results trace the progression from reported ESG outcomes to emissions and, ultimately, to trade responses.

4.A ESG Results

4.A.1 Disclosure

I begin by testing whether the firm-level spillovers documented by Schiller (2017) are strong enough to generate detectable changes in average behavior at the industry level. If regulatory pressure transmitted through global value chains prompts widespread supplier adaptation, I should observe aggregate improvements in ESG reporting, sustainability scores, and possibly emissions performance among more exposed country-industries outside the EU.

Figure 3 presents the ESG disclosure results for the full sample. Across the full set of ESG disclosure measures, shown in panels 3a and 3b, I find little evidence of such an effect. The estimated coefficients remain close to zero and statistically insignificant throughout the post-period, both when considering all ESG variables and when restricting attention to the environmental pillar. These results suggest that, at an aggregate level, increased exposure to the NFRD does not lead to sustained differences in ESG disclosure across industries outside the EU.

Restricting the analysis to disclosure variables that exclude management-related components reveals a different pattern. Figures 3c and 3d show a positive and economically meaningful response in the immediate post-treatment period. More exposed industries exhibit an increase in ESG reporting of approximately 4 % and in environmental reporting of roughly 5 %. This initial response aligns with the spillover mechanism emphasized by Schiller (2017), suggesting that upstream suppliers adjust reporting behavior when faced with heightened scrutiny from EU buyers. However, this effect is short-lived. The positive differential associated with exposure dissipates in subsequent years, and the estimates fall back toward zero.

Disaggregating the results by country income level, shown in Figure 4, sheds light on important heterogeneity. As in the full sample, including management-related components yields no statistically significant effects for either high-income or middle-income countries. Restricting attention to measures that exclude management-related components, however, shows a strong and persistent

response among high-income countries. In these countries, more exposed industries increase ESG and environmental reporting on impact, with these effects remaining elevated throughout the post-period. Middle-income countries, in contrast, exhibit no comparable response. The estimated effects remain insignificant and, in later years, turn negative, though imprecisely estimated. This pattern indicates that the sustained increases observed in high-income countries are offset by the absence of a response—and potential decline—in middle-income countries, which attenuates the full-sample estimates over time.

The disclosure response seems to operate through firm- and industry-level constraints that differ systematically across income groups. Firms in high-income countries are likely better equipped to adjust along the reporting margin, as they face lower costs of collecting and standardizing ESG information and operate within more developed auditing and verification environments. This allows exposure to translate into sustained increases in disclosure. In contrast, firms in middle-income countries may face higher compliance frictions that limit their ability to respond through formal reporting. At the same time, EU buyers may be less able to influence disclosure requirements in these settings or may instead adjust sourcing relationships when suppliers do not meet expected standards. As a result, exposure does not generate observable increases in ESG disclosure among middle-income countries, even though these industries remain connected to EU-regulated firms.

The absence of a corresponding increase in management-related disclosures across all samples indicates that firms do not adjust how they communicate strategies for addressing ESG risks, even as reporting on realized exposure increases. Although the NFRD calls for disclosure of both environmental risks and the policies used to manage them, the observed response is concentrated in measures capturing realized exposure and performance, particularly among high-income countries. This asymmetry may reflect that such strategies remain underdeveloped or that firms are reluctant to disclose forward-looking actions that carry competitive or regulatory implications.

4.A.2 Performance

Turning to ESG performance in Figure 5, I assess whether the increase in disclosure translates into measurable changes in observed environmental performance measures. Unlike disclosure measures, ESG scores capture evaluated outcomes rather than reporting alone and therefore provide a closer proxy for firms' realized environmental performance.

Across both the overall environmental pillar score and the more specific carbon emissions score, I find evidence of a pronounced anticipatory decline associated with exposure to the NFRD. For the

full environmental pillar, more exposed industries experience a drop in scores in the years leading up to implementation and on impact, after which the estimates converge back toward zero, indicating no persistent differences between highly and weakly exposed industries. A similar pattern emerges for the carbon emissions score. More exposed industries exhibit a decline beginning in the pre-treatment period, which persists through implementation and into 2018, before dissipating in later years. By 2019 and 2020, there is no longer a statistically meaningful difference in scores across exposure levels.

Disaggregating by income level (Figure 6) shows that this pattern is driven entirely by high-income countries. In these countries, more exposed industries experience up to a 30 % decline in carbon emissions scores in the anticipatory period. Given that lower scores correspond to worse emissions performance, this represents a meaningful deterioration in measured outcomes prior to implementation. Middle-income countries, in contrast, exhibit no comparable response.

These findings suggest that the NFRD initially induces firms to reveal previously unreported or under-reported environmental risks, leading to a deterioration in observed ESG scores among more exposed industries. Over time, however, this gap disappears, consistent with a combination of adjustment in reporting practices and potential improvements in performance. In this sense, the NFRD appears to affect how emissions are measured and reported in the short run without generating sustained differences in observed environmental performance across more and less exposed industries.

4.B Trade Results

4.B.1 Emissions in Bilateral Trade

Building on the evidence that exposure to the NFRD affects ESG carbon emissions scores, I examine whether these changes translate into differences in emissions embodied in international trade to the EU. Figure 7 presents the estimated effects separately for emissions embodied in exports to the EU (left panels) and to the rest of the world (right panels). For exports to non-EU destinations, I find no evidence of a systematic response. Moreover, the absence of parallel pre-trends in these specifications limits the ability to draw causal conclusions for the rest of the world.

In contrast, the results for exports to the EU suggest a decline in emissions embodied in trade among more exposed industries. This pattern is driven primarily by intermediate goods and emerges around the time of policy implementation. However, while the point estimates move in a negative

direction beginning on impact, they remain statistically indistinguishable from zero until 2020. As such, the evidence points to a gradual reduction in emissions embodied in exports to the EU, though the timing and precision of the estimates limit strong conclusions about the immediate effects of the policy. Disaggregating by income level, shown in Figure 8, again reveals that this pattern is concentrated among high-income countries. In these countries, emissions embodied in trade begin to decline earlier, with statistically meaningful effects emerging by 2019. This suggests that the aggregate pattern is again driven by responses among high-income exporters.

The results thus indicate that exposure to the NFRD is associated with a reduction in the total amount of emissions embodied in exports to the EU, but that this adjustment unfolds gradually and with a notable delay relative to the response in ESG reporting. While disclosure responds quickly—particularly around the announcement and implementation periods—the effects on emissions embodied in trade only become statistically distinguishable several years later. This temporal gap is consistent with the idea that reporting adjusts along a relatively low-cost margin, whereas changes in production or trade relationships require longer adjustment horizons. In this sense, the NFRD appears to affect what firms report in the short run, while its influence on emissions embodied in trade emerges more slowly.

The absence of any systematic response in exports to the rest of the world suggests that the decline in emissions embodied in EU trade is not accompanied by a reshuffling of emissions across destinations. Instead, the adjustment appears to be specific to trade with the EU. While it is unclear which of the standard channels—scale, technique, or composition—drives this reduction, the results make clear that it is not driven by a reallocation of emissions across destinations. This implies that the observed decline reflects changes within existing EU-linked supply relationships rather than a redirection of emissions-intensive production elsewhere.

4.B.2 Bilateral Trade

To distinguish between scale and technique effects, I turn to trade outcomes directly, which allow me to assess whether the reduction in emissions embodied in trade reflects changes in trade volumes rather than improvements in emissions intensity. Figure 9 presents the results, separating exports to the EU and to the rest of the world across total, intermediate, and final goods.

The results reveal a clear and economically meaningful decline in total exports to the EU among more exposed industries. As shown in panel 9a, this decline begins in the anticipatory period following the announcement of the policy and becomes more pronounced after implementation, with the

largest effects appearing in 2019 and 2020. Industries with higher exposure experience a reduction in intermediate exports to the EU of approximately 10 % relative to less exposed industries, with effects accumulating over the post-implementation period rather than reflecting a one-time drop.

Importantly, this effect is concentrated entirely in intermediate goods (panel 9c). While total exports to the EU also decline, there is no comparable change in exports of final goods (panel 9e). This pattern suggests that the response operates through supply chains rather than through changes in final consumer demand. Consistent with this interpretation, the decline in emissions embodied in trade reflects a reduction in the volume of traded intermediates rather than improvements in emissions intensity.

Disaggregating by country income level shows that the statistically significant declines in exports to the EU are driven by high-income countries. However, the point estimates for middle-income countries follow a similar trajectory, exhibiting declines in intermediate exports in both the anticipatory and post-implementation periods, albeit with considerably more noise. This suggests that the response may extend beyond high-income exporters, but the estimates for middle-income countries are too imprecise to draw strong conclusions.

Exports to non-EU destinations remain largely unchanged across all categories, indicating that more exposed industries do not compensate for the loss of EU demand by expanding into alternative markets. As a result, the decline in exports to the EU reflects an overall contraction in trade rather than a reallocation across destinations. While similar patterns emerge for middle-income countries, the estimates are imprecisely estimated, suggesting that the aggregate results are again driven primarily by high-income exporters.

Taken together, these results point to a reduction in emissions embodied in trade that is driven by a scale effect rather than by changes in production technology or the composition of trade. The decline in emissions embedded in exports to the EU reflects a contraction in the volume of intermediate goods traded, rather than improvements in emissions intensity or a reallocation of exports toward cleaner destinations. In other words, more exposed industries do not appear to become cleaner suppliers to EU firms; instead, they export less. This implies that the policy operates by weakening supplier relationships rather than inducing cleaner production or shifting trade toward less carbon-intensive partners.

5 Conclusion

This paper evaluates whether mandatory ESG disclosure policies, such as the European Union's Non-Financial Reporting Directive (NFRD), generate spillovers along global value chains that affect environmental outcomes outside the EU. Using a novel industry-level exposure measure, I examine whether firms in non-EU countries adjust their ESG reporting, environmental performance, and trade behavior in response to regulatory pressure transmitted through European buyers. The results point to limited effects on observed environmental performance measures but reveal meaningful adjustments in trade patterns that reduce emissions embodied in EU-bound trade.

Despite firm-level evidence suggesting that ESG mandates can generate supply chain spillovers, I find limited and heterogeneous effects on ESG disclosure and no sustained improvements in environmental performance. Increases in ESG reporting are concentrated among high-income countries and are driven by measures excluding management-related components, while middle-income countries exhibit no comparable response. At the same time, carbon emissions scores initially deteriorate among more exposed industries, consistent with firms revealing previously unreported information, before converging back to baseline levels. Taken together, these findings suggest that the NFRD affects reporting behavior—particularly along margins that are easier to adjust—but does not induce persistent improvements in observed environmental performance scores among foreign suppliers.

In contrast, the most pronounced effects emerge in trade outcomes. More exposed industries experience a substantial decline in intermediate exports to the EU, with effects that begin in the anticipatory period and intensify following implementation. This contraction in trade is not offset by increased exports to the rest of the world, indicating that the response does not reflect a reallocation of trade across destinations. Instead, the results point to a reduction in emissions embodied in EU-bound trade that is driven by a scale effect: emissions fall because less is traded, not because production becomes cleaner.

These findings have important implications for how ESG disclosure mandates operate in practice. Rather than inducing foreign suppliers to upgrade production processes or adopt cleaner technologies, the NFRD appears to alter sourcing decisions within supply chains. This pattern suggests that ESG mandates may operate more through supply-chain de-linking than through technological upgrading.

From a broader perspective, these results highlight a key limitation of disclosure-based environmental policies. While such policies can influence reporting behavior and reduce emissions embodied in imports, they may do so without generating meaningful changes in production practices

abroad. This raises important questions about the extent to which transparency alone can drive global decarbonization. If firms respond by adjusting sourcing relationships rather than improving environmental performance, the effectiveness of disclosure mandates as tools of environmental policy may depend critically on complementary measures that directly target production processes.

In sum, the NFRD demonstrates that ESG disclosure mandates can reshape global supply chains and reduce emissions entering regulated markets. However, these reductions appear to arise from a contraction in trade rather than from cleaner production. Understanding how to translate disclosure-induced pressure into genuine technological change remains an important avenue for future research.

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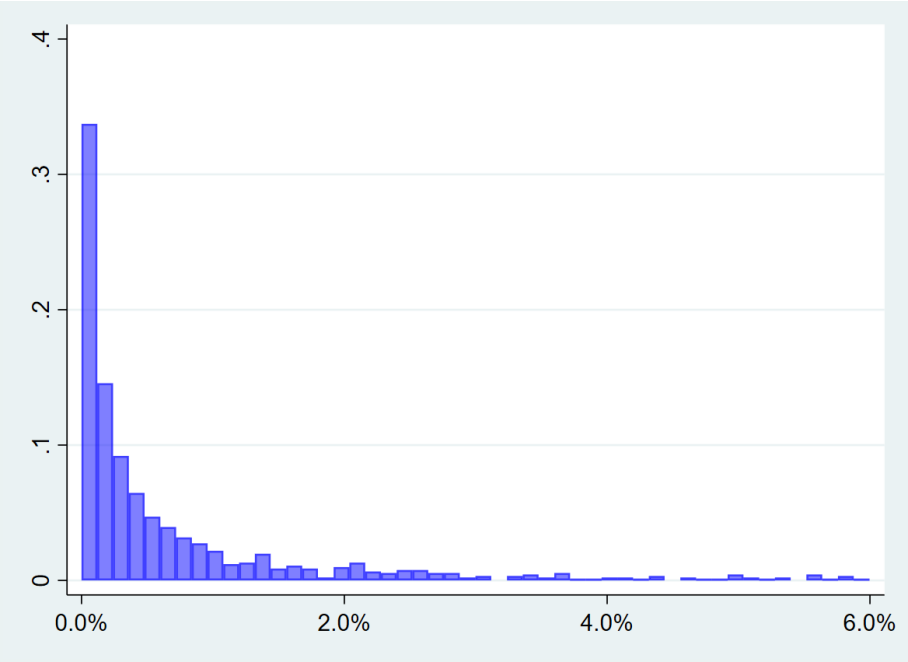
6 Tables

Table 1: Descriptive Statistics

Variable	Mean	SD	Min	Median	Max	N
Exposure						
Exposure 2010	1.28%	3.24	0.00	0.31%	40.30%	10,560
ESG Variables						
ESG Disclosure Share	0.31	0.25	0.00	0.24	1.00	3,575
ESG Env. Disclosure Share	0.37	0.25	0.00	0.31	1.00	3,575
ESG Disclosure Share (Excl. Mngmt.)	0.38	0.27	0.00	0.33	1.00	3,575
ESG Env. Disclosure Share (Excl. Mngmt.)	0.47	0.32	0.00	0.42	1.00	3,575
ESG Environmental Pillar Score	4.43	1.50	0.00	4.41	10.00	3,274
ESG Carbon Emissions Score	6.03	2.31	0.00	6.12	10.00	3,093
Emissions in Bilateral Trade						
Emissions to EU in Intermed. Trade	0.73	3.94	0.00	0.02	86.86	10,560
Emissions to EU in Final Trade	0.30	1.53	0.00	0.01	35.58	10,560
Emissions to EU in Total Trade	1.03	4.91	0.00	0.04	93.43	10,560
Emissions to ROW in Intermed. Trade	3.96	13.79	0.00	0.19	224.63	10,560
Emissions to ROW in Final Trade	1.91	8.52	0.00	0.09	170.59	10,560
Emissions to ROW in Total Trade	5.87	19.73	0.00	0.35	300.06	10,560
Exports						
Total Exports to EU	1,107.53	4,412.24	0.00	57.52	94,018.51	10,560
Intermed. Exports to EU	697.13	2,984.70	0.00	34.30	58,956.82	10,560
Final Exports to EU	410.39	1,951.44	0.00	14.90	45,787.77	10,560
Total Exports to ROW	6,592.50	22,256.15	0.00	477.29	479,148.50	10,560
Intermed. Exports to ROW	4,051.00	13,254.95	0.00	277.75	280,468.50	10,560
Final Exports to ROW	2,541.50	11,332.51	0.00	124.89	265,358.50	10,560

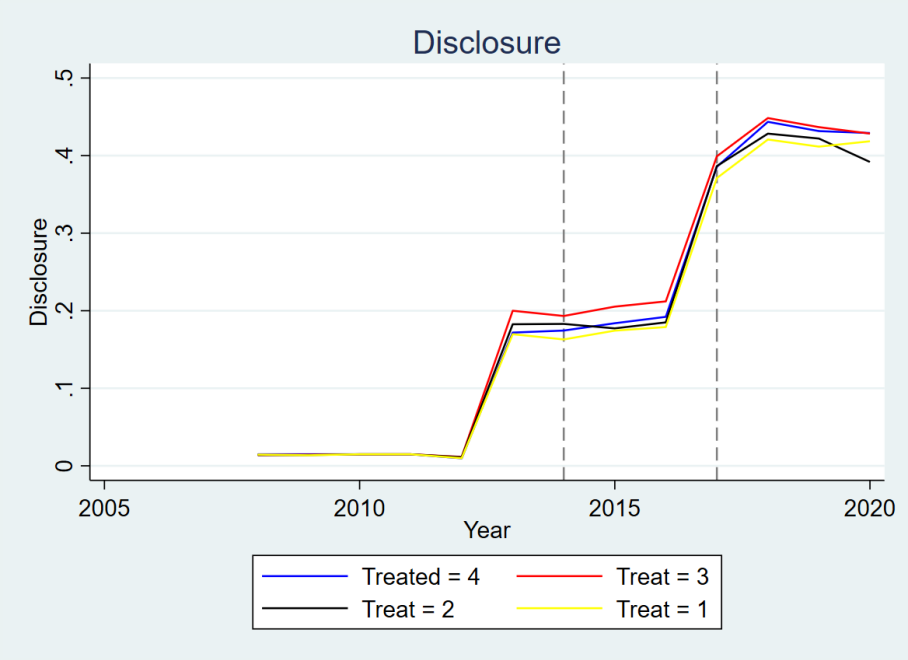
7 Figures

Figure 1: Exposure Variable Distribution



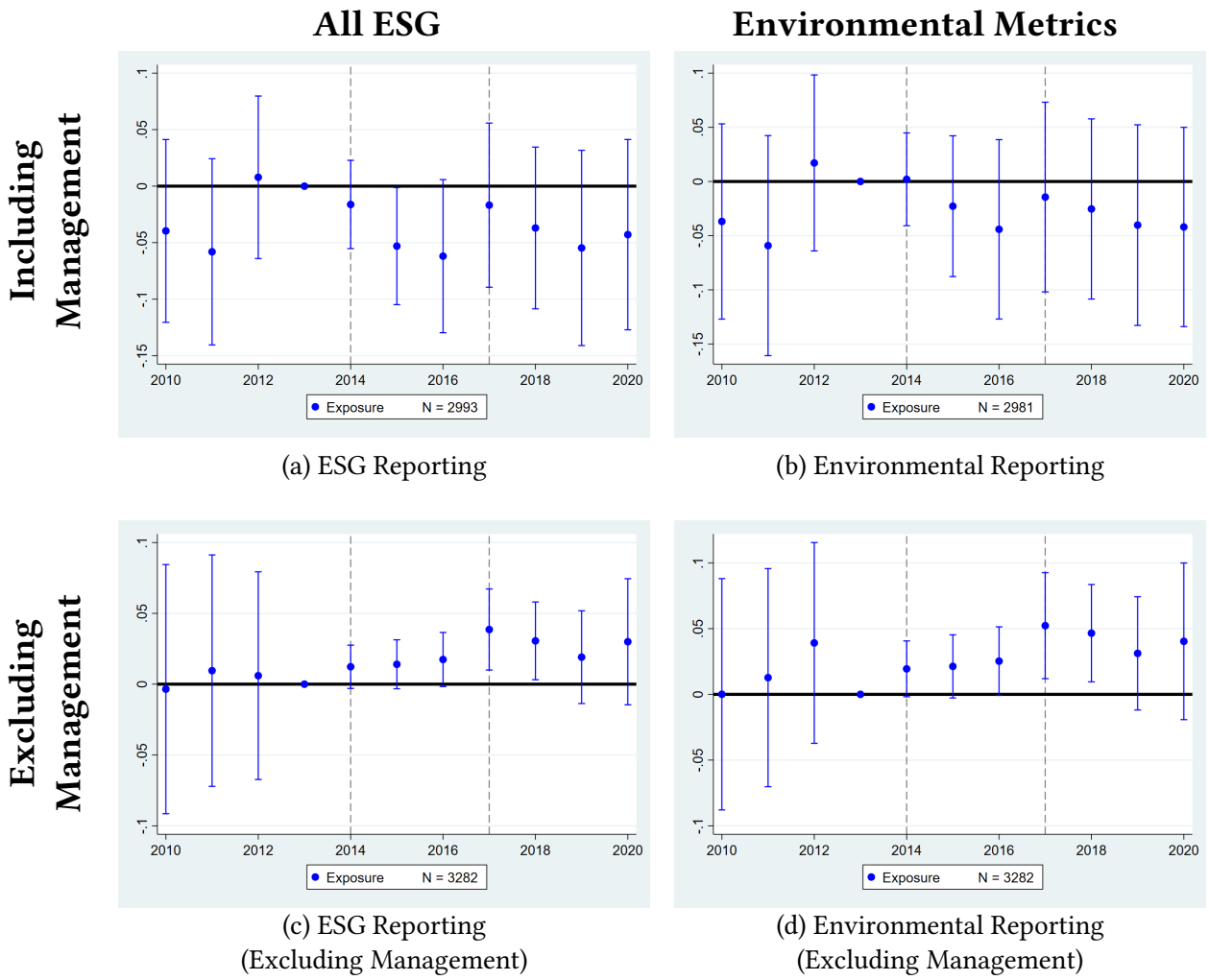
Notes: This figure shows the distribution of the exposure variable across country-industry observations. The histogram reveals a highly right-skewed distribution, with most observations concentrated at low levels of exposure and a long tail of industries with relatively higher exposure to the NFRD.

Figure 2: Raw Disclosure Rates, by Treatment Quartile



Notes: This figure plots average ESG disclosure over time by treatment intensity, where treatment bins are defined by exposure to the NFRD (Treat = 1 denotes the lowest exposure and Treat = 4 the highest). Disclosure is measured as the share of ESG metrics for which firms receive a score, reflecting the extent to which firms provide sufficient information for evaluation. The series exhibit similar pre-trends across groups, and disclosure increases sharply across the board after 2013.

Figure 3: ESG Disclosure Metrics



(a) ESG Reporting

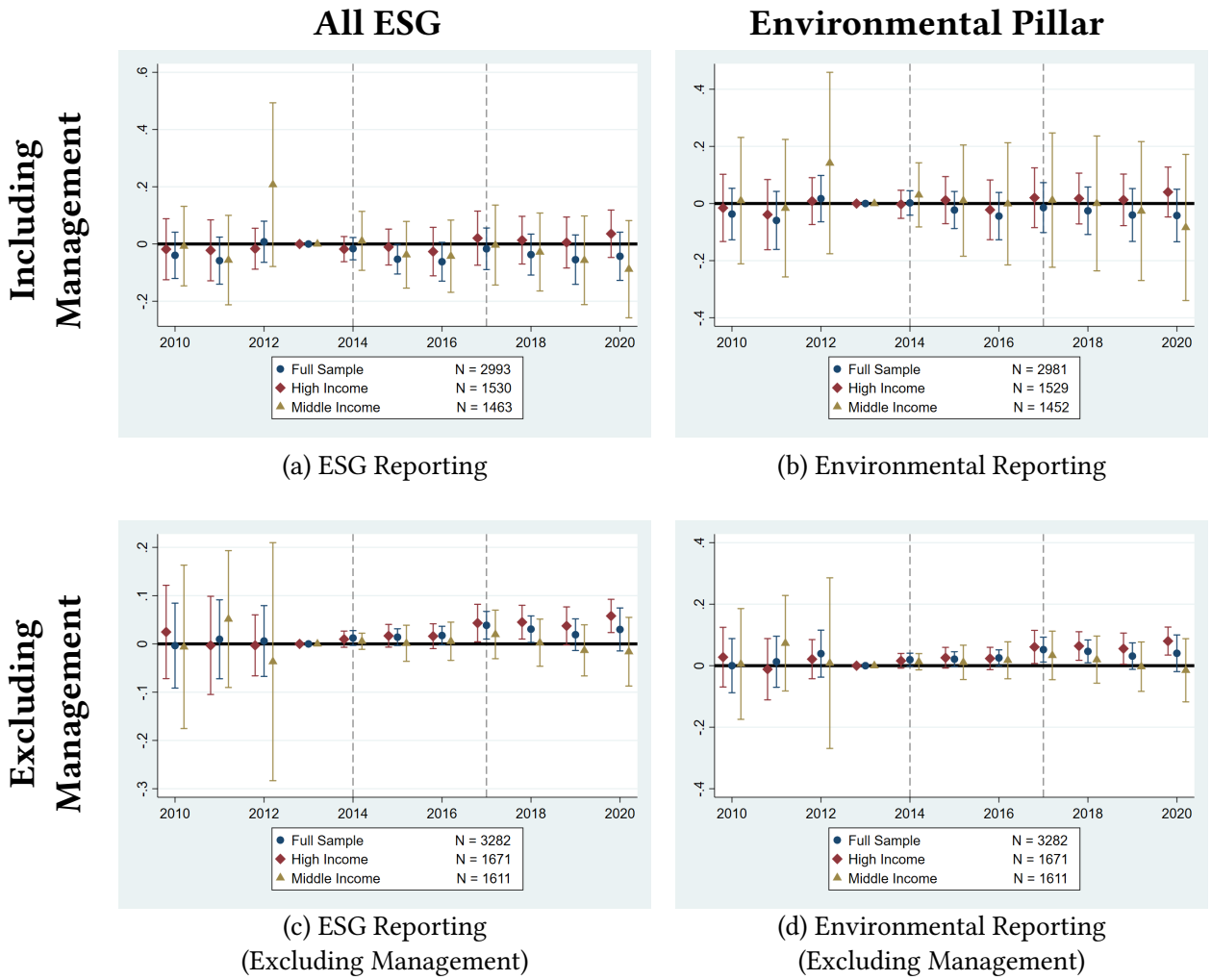
(b) Environmental Reporting

(c) ESG Reporting (Excluding Management)

(d) Environmental Reporting (Excluding Management)

Notes: Panels (a)-(d) reports the effect of exposure to the NFRD on ESG disclosure. The top row shows disclosure across all ESG variables, while the bottom row excludes management variables, focusing on risk reporting. The left column includes all ESG indicators, and the right column restricts to the environmental pillar. Points denote estimates and bars show 95 % confidence intervals.

Figure 4: ESG Disclosure Metrics - By Country Income



(a) ESG Reporting

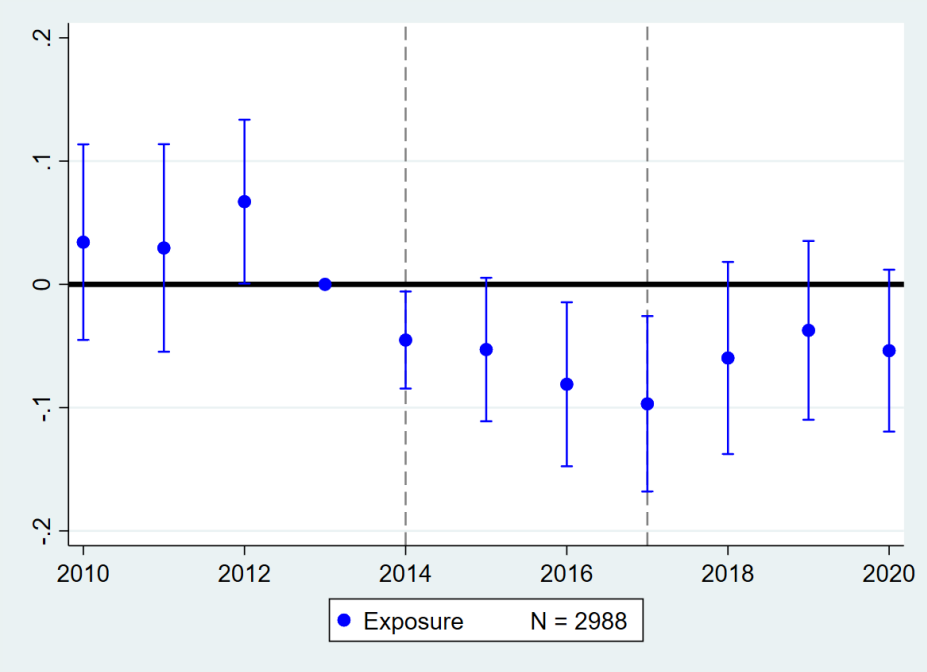
(b) Environmental Reporting

(c) ESG Reporting (Excluding Management)

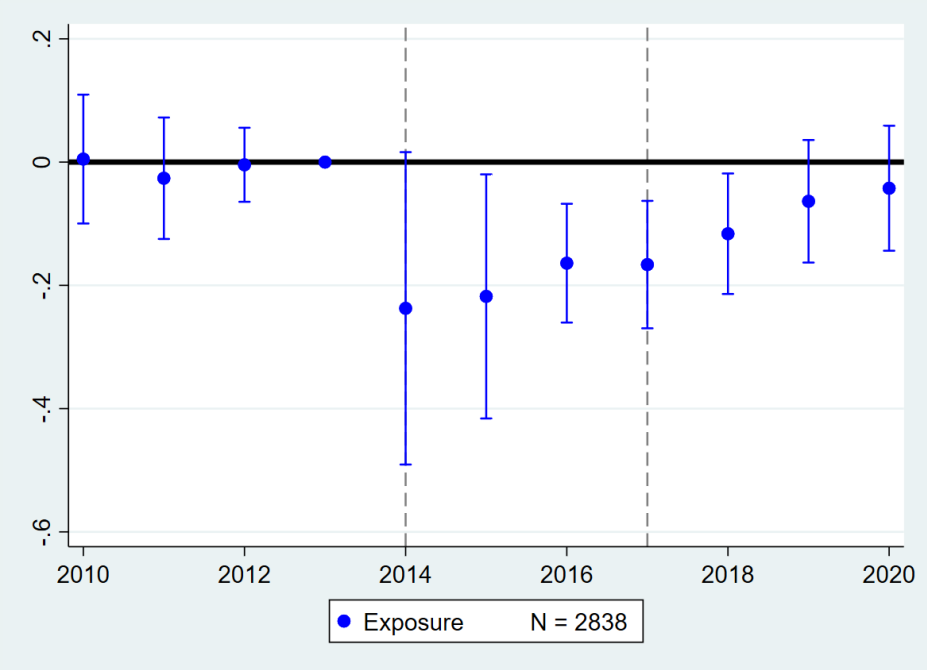
(d) Environmental Reporting (Excluding Management)

Notes: Panels (a)–(d) replicate the baseline disclosure results while additionally reporting estimates by income group. The top row shows disclosure across all ESG variables, while the bottom row excludes management variables. The left column includes all ESG indicators, and the right column restricts to the environmental pillar. Points denote estimates and bars show 95 % confidence intervals. Estimates are shown for the full sample in navy, high-income countries in maroon, and middle-income countries in brown.

Figure 5: Environmental Scores



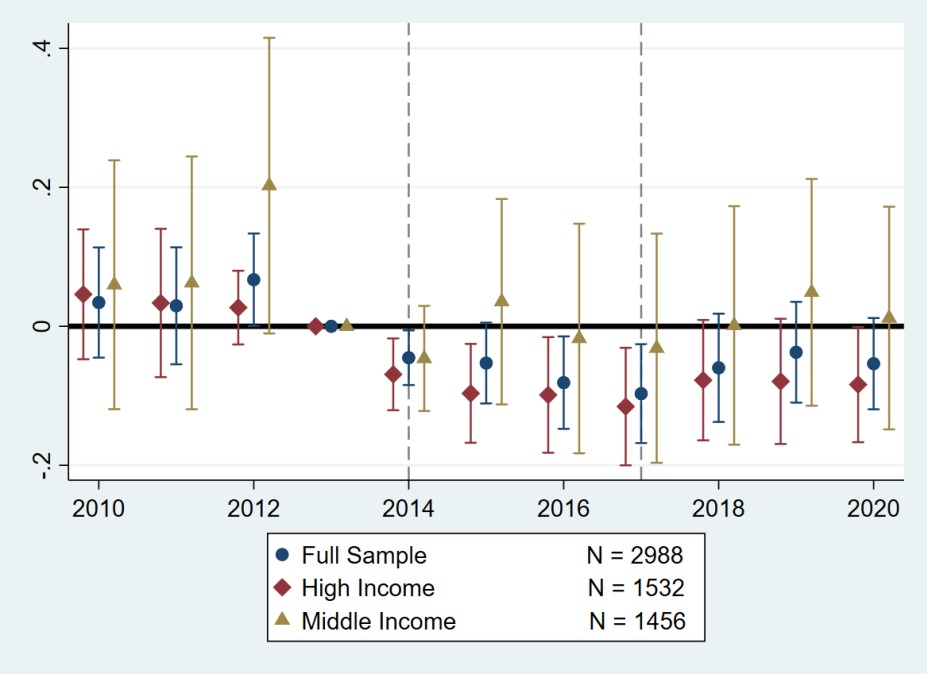
(a) Environmental Pillar Score



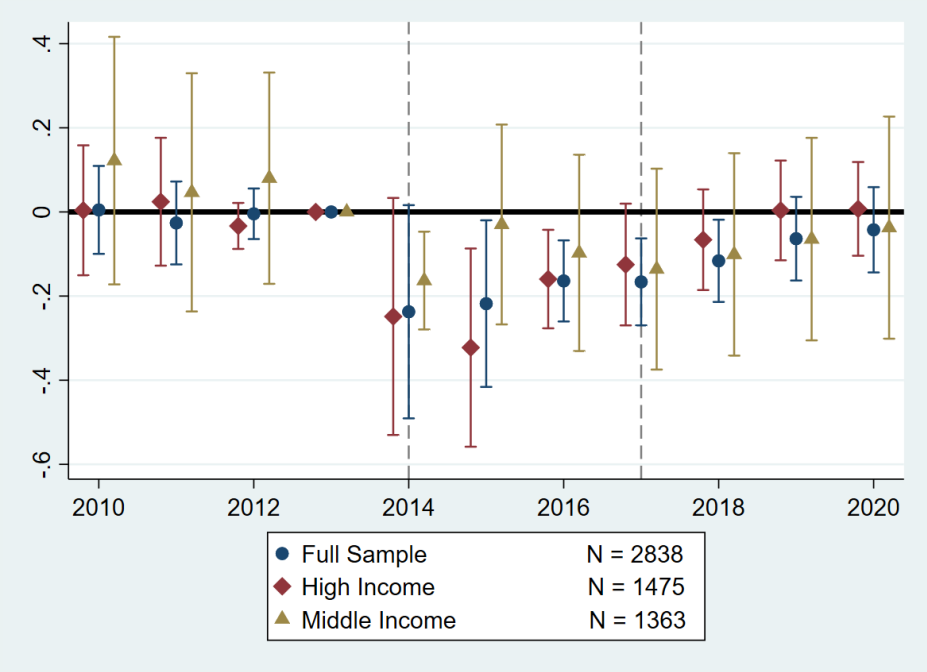
(b) ESG Carbon Emissions Score

Notes: Panel (a) & (b) report the effect of exposure to the NFRD on select environmental metrics scores. The top panel shows results for the full environmental pillar score, while the bottom panel shows results for the ESG carbon emissions score. Points denote estimates and bars show 95 % confidence intervals.

Figure 6: Environmental Scores - By Country Income



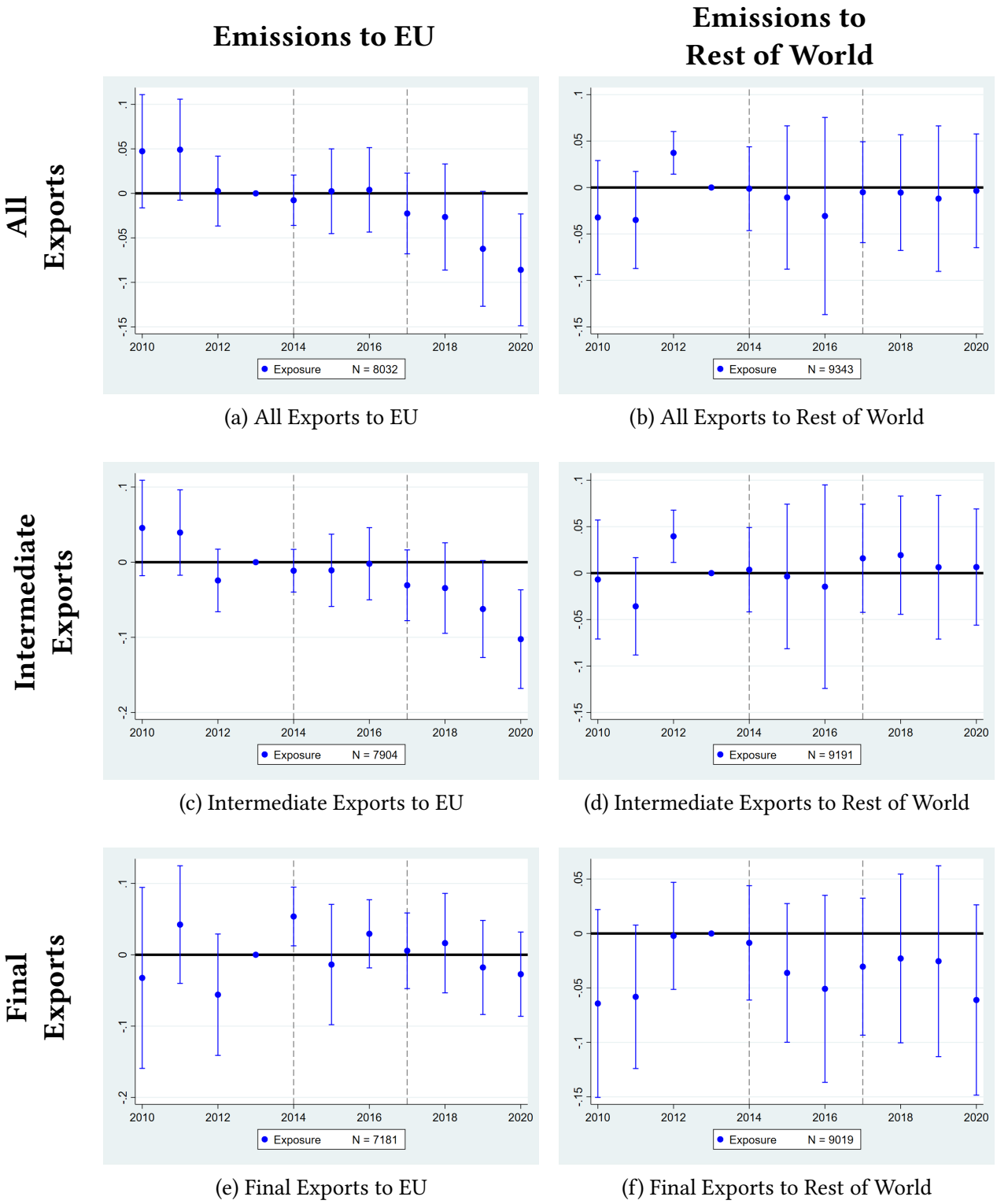
(a) Environmental Pillar Score



(b) ESG Carbon Emissions Score

Notes: Panels (a)–(b) replicate the baseline environmental score results while additionally reporting estimates by income group for select environmental scores. Panel (a) shows results for the full environmental pillar score, while panel (b) shows results for the ESG carbon emissions score. Points denote estimates and bars show 95 % confidence intervals. Estimates are shown for the full sample in navy, high-income countries in maroon, and middle-income countries in brown.

Figure 7: Emissions Embedded in Trade Outcomes



(a) All Exports to EU

(b) All Exports to Rest of World

(c) Intermediate Exports to EU

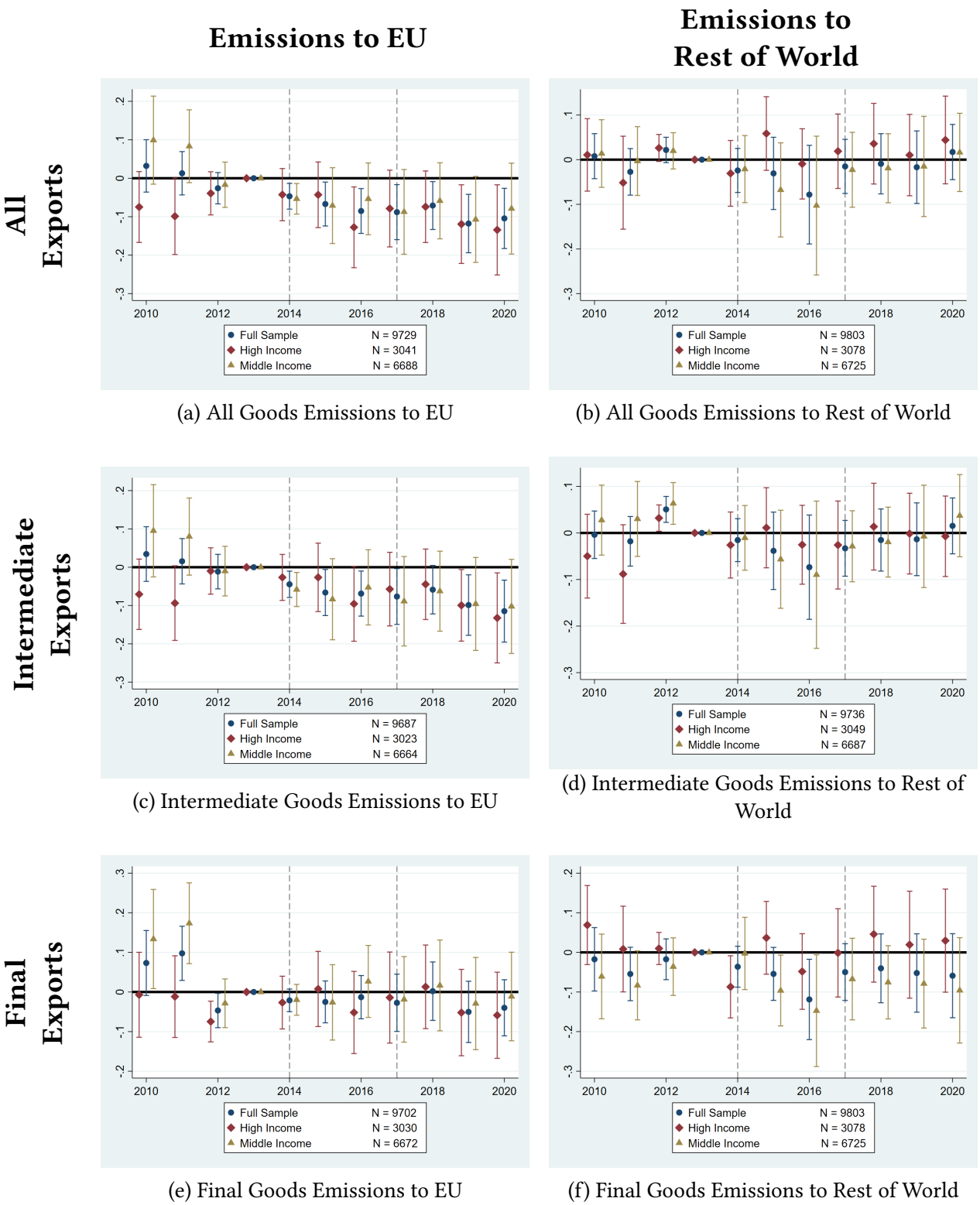
(d) Intermediate Exports to Rest of World

(e) Final Exports to EU

(f) Final Exports to Rest of World

Notes: Panels (a)-(f) report the effect of exposure to the NFRD on emissions embedded in trade outcomes. Rows correspond to all exports, intermediate exports, and final exports. The left column shows trade with the EU, while the right column shows trade with the rest of the world. Points denote estimates and bars show 95 % confidence intervals.

Figure 8: Emissions Embedded in Trade Outcomes - By Country Income



(a) All Goods Emissions to EU

(b) All Goods Emissions to Rest of World

(c) Intermediate Goods Emissions to EU

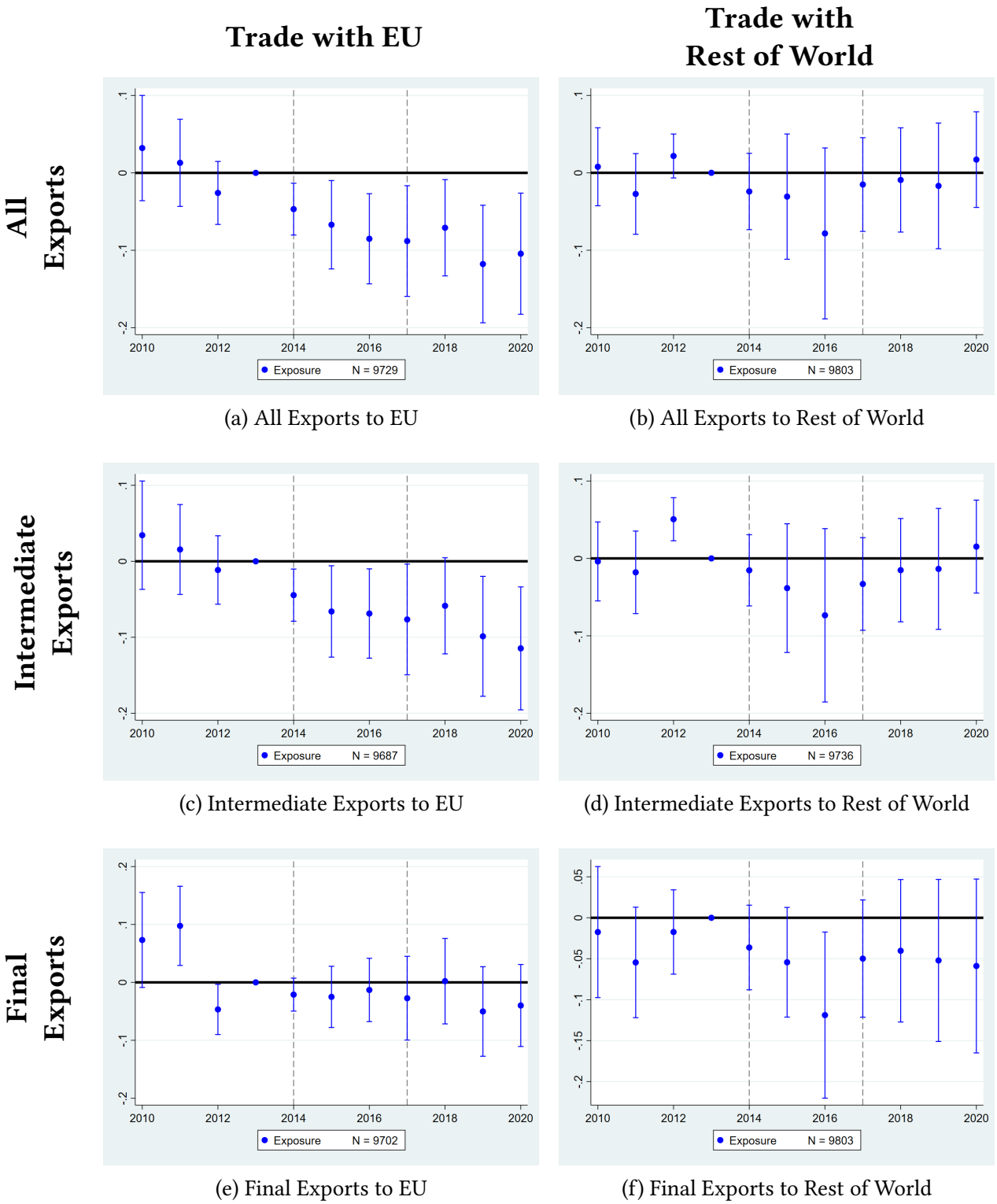
(d) Intermediate Goods Emissions to Rest of World

(e) Final Goods Emissions to EU

(f) Final Goods Emissions to Rest of World

Notes: Panels (a)–(f) replicate the baseline emissions embedded in trade results while additionally reporting estimates by income group. Rows correspond to all exports, intermediate exports, and final exports. The left column shows trade with the EU, while the right column shows trade with the rest of the world. Points denote estimates and bars show 95 % confidence intervals. Estimates are shown for the full sample in navy, high-income countries in maroon, and middle-income countries in brown.

Figure 9: Trade Outcomes



(a) All Exports to EU

(b) All Exports to Rest of World

(c) Intermediate Exports to EU

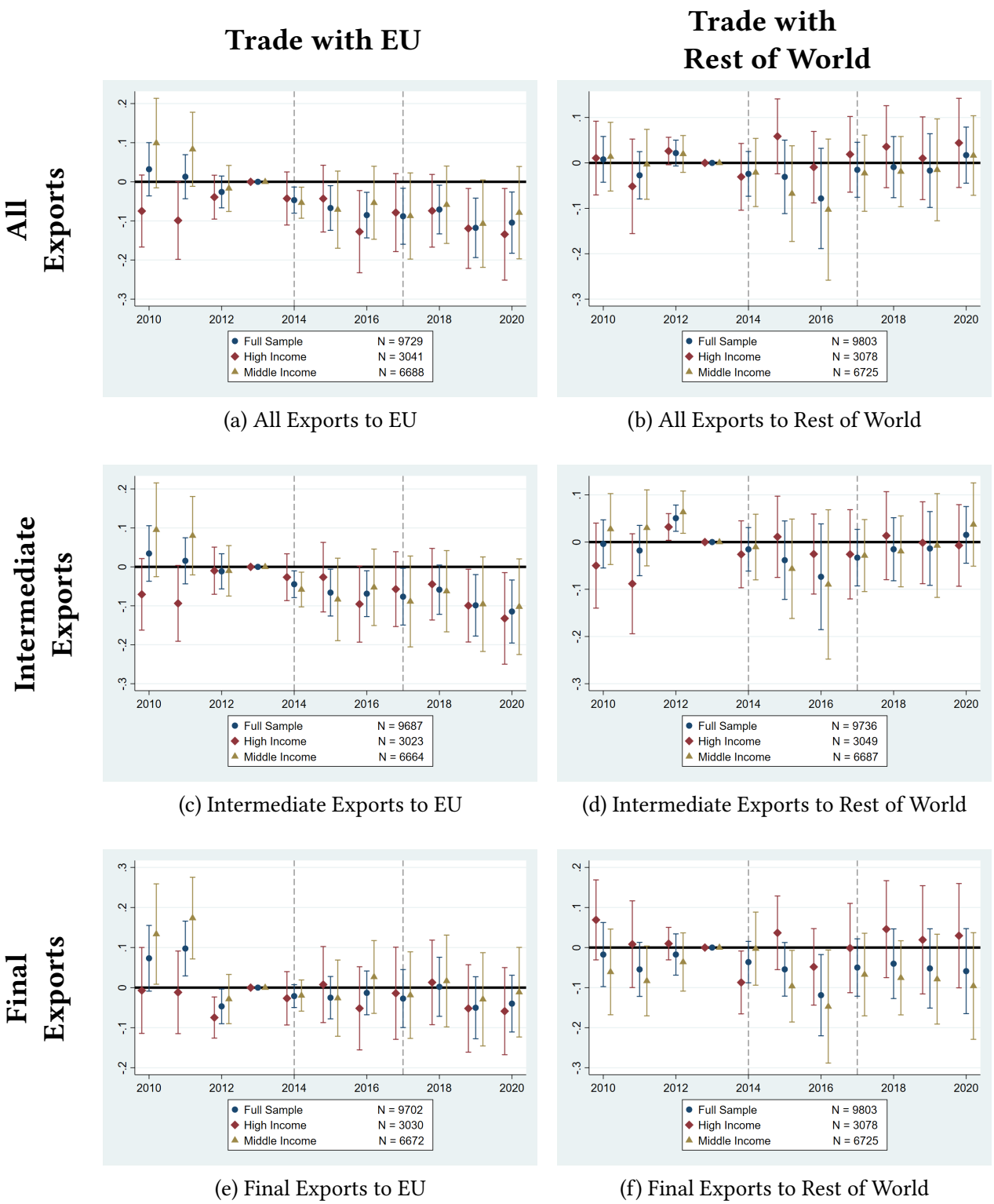
(d) Intermediate Exports to Rest of World

(e) Final Exports to EU

(f) Final Exports to Rest of World

Notes: Panels (a)-(f) report the effect of exposure to the NFRD on trade outcomes. Rows correspond to all exports, intermediate exports, and final exports. The left column shows trade with the EU, while the right column shows trade with the rest of the world. Points denote estimates and bars show 95 % confidence intervals.

Figure 10: Trade Outcomes - By Country Income



(a) All Exports to EU

(b) All Exports to Rest of World

(c) Intermediate Exports to EU

(d) Intermediate Exports to Rest of World

(e) Final Exports to EU

(f) Final Exports to Rest of World

Notes: Panels (a)–(f) replicate the baseline trade results while additionally reporting estimates by income group. Rows correspond to all exports, intermediate exports, and final exports. The left column shows trade with the EU, while the right column shows trade with the rest of the world. Points denote estimates and bars show 95 % confidence intervals. Estimates are shown for the full sample in navy, high-income countries in maroon, and middle-income countries in brown.

Appendix

A Countries in Sample

Table 2: Appendix Table A1: Countries by World Bank Income Group Classification

High-Income	**Upper-Middle-Income**	**Lower-Middle-Income**	**Low-Income**
Australia	Argentina	Bangladesh	Cambodia
Brunei Darussalam	Belarus	Cameroon	Myanmar
Canada	Brazil	Côte d'Ivoire	
Chile	China	Egypt	
Hong Kong	Colombia	India	
Iceland	Costa Rica	Morocco	
Israel	Indonesia	Nigeria	
Japan	Jordan	Pakistan	
Republic ofKorea	Kazakhstan	Philippines	
New Zealand	Malaysia	Senegal	
Norway	Mexico	Tunisia	
Saudi Arabia	Peru	Ukraine	
Switzerland	Russian Federation	Vietnam	
United Kingdom	South Africa		
United States of America	Thailand		
	Turkey		