Environmental Policy and Services Trade*

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Cosimo Beverelli† Martin Breitkopf‡ Matteo Fiorini‡ Enxhi Tresa‡

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Abstract

Do more stringent environmental policies induce higher services imports relative to domestic sourcing? In a sample of 40 importing countries and 8 services sectors between 2005 and 2023, we show a positive impact of more stringent environmental policies on services imports. Using a LASSO-based estimator to select the most relevant variables, we further show that most policy types matter for at least some sectors, with maintenance and repair and telecommunications having the highest differential impact on international relative to domestic sourcing. Beyond such differential effect, stringent environmental policies also have a positive impact on trade in absolute terms.

Keywords: Services trade, environmental policy, gravity.

JEL Classification: F14; F18; F64.

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†University of Modena and Reggio Emilia; Robert Schuman Centre for Advanced Studies, European University Institute. Email: cosimo.beverelli@unimore.it.

‡OECD. E-mails: martin.breitkopf@oecd.org, matteo.fiorini@oecd.org, enxhi.tresa@oecd.org.

1 Introduction

Services trade can play an important role for environmental sustainability, by allowing firms, governments, and consumers to access those services that facilitate the development, implementation, adoption, and diffusion of more climate-friendly solutions. In this paper, we investigate whether environmental policy leads to higher imports of services. In particular, we test the impact of more stringent environmental regulations on incentives for economic actors to disproportionately rely on international markets rather than domestic suppliers when sourcing services required to meet higher sustainability standards.

We make use of a database covering multiple dimensions of environmental policy potentially affecting services trade. Given the large number of environmental stringency indicators employed, and the fact that some have more explanatory power than others, the LASSO method is employed to select variables with the largest direct causal impact on services imports relative to domestic sourcing. Moreover, we complement this exercise with estimations that go beyond the differential effect, and provide insights on the absolute trade effect of environmental regulations.

Our work directly contributes to the literature on the impact of environmental policy on trade flows. The pollution haven *effect* (Copeland and Taylor, 2004) posits that more stringent environmental standards reduce exports (or increase imports) of pollution-intensive goods. There is evidence for pollution haven effects. Levinson and Taylor (2008) use industry-level data and find that increases in pollution abatement costs are a significant component of increased US net imports from Canada and Mexico. More recently, Cherniwchan and Najjar (2022) use firm-level data and find that the Canadian air quality standards reduce export volumes and increase the likelihood to stop exporting. According to the Porter hypothesis (Porter and van der Linde, 1995), environmental policies improve incentives for innovation, thereby increasing exports of goods most affected by such regulations. In line with this idea, Wang et al. (2016) provide evidence that in most sectors in China between 1985 and 2010, stricter environmental regulation reduced trade in primary (pollution-intensive) products and encouraged trade in high value-added green products. Similarly, it has been found that environmental policies in the European Union increase export competitiveness, particularly in the "green exports" sector (Costantini and Mazzanti, 2012; Sauvage, 2014).

While this literature focuses on goods trade, we consider the impact of environmental regulation on services trade. Employing a structural gravity framework, we show that environmental policy stringency increases services imports, both relative to domestic sourcing and in absolute terms.

We also contribute to the literature on the environmental impact of trade. In the canonical theoretical framework, trade affects the environment through three channels: scale, composition, and technique

(Grossman, 1991). Although this framework was originally developed for trade in goods, it equally applies to trade in services, providing further justification for our focus on services. Consider gross domestic production of goods and services as the economic activity of interest. First, increased imports of services (e.g. financial, engineering, transport, and logistics) could enable firms to access higher quality-to-price ratio services from international markets, thereby reducing firms' design, operational, and distribution costs, and scaling up production. All else being equal (including the relative contribution of each sector to total output and the production techniques used across sectors), a higher scale of production would increase its environmental footprint as measured, for example, by production-based emissions. This negative effect of services trade on the environment operates via the scale channel.

Second, services trade may affect the production of goods differently than the production of services, thereby shaping the composition of total output. For example, if services trade disproportionally favors the expansion of services output compared to goods, and if the emission intensity of production is lower in services than in goods, then (assuming the overall scale and technique of production remain constant) the environmental footprint of gross domestic product will decrease with higher services trade through a composition channel.

Third, increased services trade – for instance higher imports of state-of-the-art engineering and consulting services – may lead to the development and adoption of more energy efficient production methods across sectors, thereby lowering the environmental footprint of production for a given scale and composition. This technique channels points to a positive effect of services trade on the environment.

By potentially affecting the scale, the composition, and the technique of production, environmental policy can influence the relationship between trade and environmental sustainability. A number of studies explore how environmental policy shapes the composition channel of the environmental effect of trade by influencing comparative advantage in clean or polluting industries (Copeland and Taylor, 2004). As summarized by Copeland et al. (2022), the overall message from these studies is that such composition effects are small, and if anything they tend to raise pollution in countries with more stringent environmental regulation, and lower pollution in countries with less stringent environmental regulation.[1]

Environmental policy can drive economic actors to seek international markets for services that are crucial for designing or adopting environmental solutions and implementing technical changes needed to meet more stringent environmental standards. This, in turn, can trigger or amplify the technique channel of trade's effect on the environment. This was the case for many of the signatory

[1] This runs contrary to the pollution havens *hypothesis*, which envisions a shift of polluting firms or industries to countries with weaker environmental policies triggered by reductions of trade costs or barriers.

countries of the Kyoto protocol, which increased imports from countries with higher environmental standards to achieve greener production processes (Aichele and Felbermayr, 2012). Evidence from the United States shows that, while environmental policies result in production outsourcing, they also induce imports of greener technologies and intermediate inputs, leading to a large amount of emission reductions through the technique effect (Levinson, 2009). In line with this research, we show that more stringent environmental regulation increases services imports relative to domestic sourcing, which can improve environmental outcomes through a technique channel.

The rest of the paper is organized as follows. Section 2 describes the data employed. Section 3 explains the benchmark empirical strategy applied, gravity with internal trade, and shows the first available estimations. Sections 4 , 5 and 6 present the LASSO, the robust estimation and the absolute effect estimation methodologies, alongside with their results. Then, section 7 concludes.

2 Data

2.1 Environmental policy stringency

The measures of environmental policy stringency come from the OECD Climate Actions and Policies Measurement Framework (CAPMF) database (Nachtigall et al. (2022)). The CAPMF project collects data on 130 individual policy measures across 50 countries over the 1990-2023 period. Building on information at the level of individual policy measures, CAPMF environmental policy stringency indicators are constructed following different levels of aggregation. While the data has up to four categories or “levels” of variables depending on the level of aggregation, data availability decreases with less aggregated indicators. In this study we focus on the most aggregate level, level 1 and an aggregation by “policy types”, which holds the same complexity level as level 2 in the original framework.

Level 1 is the most aggregate and consists of three environmental policy stringency indicators varying at the country-time level, corresponding to three clusters of policies: sectoral, cross-sectoral, and international policies. These variables are all available for all countries and years in the database, and an unweighted average of the three is the closest measure of a country-level average stringency. Policy type indicators provide a more disaggregated detail. Contrary to the “benchmark” aggregation proposed in the database, they focus on the level of stringency by type of policy instrument rather than the areas affected. These are the variables used for most estimations, given level 2 (or its policy type equivalent) is the largest level of detail at which most of the variables are available for all countries and years. Overall, there are 11 policy type indicators in the CAPMF database, which are listed in Table A-1 alongside a set of examples of policies included in each category.

The database provides indicators taking values from 0 to 10 that measure the level of stringency in a given environmental policy dimension, with 0 representing very low or no stringency, and 10 its maximum level.

2.2 Services trade

The services trade data used in our estimations is sourced from the OECD's Balanced Trade in Services (BaTiS) database (Liberatore and WTO (2021)). BaTiS provides yearly values for bilateral services trade in current USD. The data is available for total services trade as well as for 12 main services categories.[2]

Since our estimation strategy requires estimates of internal trade, which are not included in BaTiS, these are built and integrated into the BaTiS data using the OECD National Accounts (NA) database and the OECD Structural Analysis (STAN) database (Horvát and Webb (2020)). The national accounts data from STAN and NA provides information on services production at the level of ISIC Rev.4 sectoral categories. To integrate internal trade measures, we establish a correspondence between the services sectors in the production and services trade datasets. It must be noted, however, that the correspondence is not perfect, and therefore we can only provide internal trade estimates for 6 out of the 12 sectors in BaTiS.[3]

2.3 Additional control variables

Finally, for certain estimations some additional controls are required. The World Bank's Deep Trade Agreements (DTA) database (Hofmann et al. (2017)) is used for the inclusion of a control for the presence of a Free Trade Agreement (FTA) in all our estimations. In particular, we use the detailed information this database provides in terms of trade agreement content to only control for those trade agreements that cover services.[4] Additionally, variables such as GDP or GDP per capita are also used in the estimations of the marginal effect on services trade, as controls for country-time varying variables, sourced from the CEPII gravity database (Conte et al. (2022)). Other additional sources are Our World in Data for manufacturing value-added as a share of GDP and UNCTAD for inward FDI flows, both also used as controls in the last estimation of the paper.

[2]Which correspond to the 12 main services categories of the e Extended Balance of Payments Services Classification (EBOPS) 2010. The database also provides further disaggregation of some of these categories, as well as different multi-sector aggregations.

[3]A possible alternative source could be the International Trade and Production Database for Estimation (ITPD-E) database (Borchert et al. (2021)). This database already includes internal trade estimates, using production data from the UN National Accounts database. Similarly to BaTIS, the internal trade matching also forces to exclude certain sectors that would be available for international trade only. The main difference between the two databases lies in the different availability of sectoral data. While some sectors are shared, BaTIS includes sectors such as Maintenance and Repair services, which ITPD-E does not. The temporal coverage is also different, since ITPD-E does not include estimates for 2022 and 2023.

[4]This includes agreements covering only services, or both goods and services.

Table 1: Summary statistics of key variables

Variable	Source	Mean	Median	Std Dev	Min	Max
Total exports	BaTiS/STAN	6307.19	0.00	257521.78	0.00	33521224.00
SFTA	WB DTA	0.22	0.00	0.42	0.00	1.00
CAPMF Average	CAPMF	3.23	3.03	1.61	0.32	7.34
Subsidies	CAPMF	3.14	3.10	2.40	0.00	8.23
Trading systems	CAPMF	2.27	2.16	1.60	0.00	7.72
Taxes and fees	CAPMF	2.71	3.21	1.83	0.00	6.43
Tech. Standards	CAPMF	0.69	0.00	1.24	0.00	6.54
Other NMBI	CAPMF	2.95	2.80	1.76	0.00	7.60
Performance standards	CAPMF	5.70	6.00	2.65	0.00	9.60
Information instruments	CAPMF	8.35	10.00	2.63	0.00	10.00
Targets	CAPMF	2.46	0.00	3.29	0.00	9.38
Climate governance	CAPMF	1.14	0.00	2.48	0.00	9.80
International coordination	CAPMF	5.43	4.17	2.58	0.00	10.00
Climate data	CAPMF	4.02	3.00	2.70	0.00	10.00

Notes: This table includes the main descriptive statistics for all variables used in the augmented gravity framework exercise. The estimation sample consists of 105,377 observations, covering 40 importing countries for which CAPMF indicators of environmental policy are observed, 250 exporting countries, for the period 2005-2023. Exports include internal trade (production) values needed for the estimation. Exports and production are expressed in current USD. SFTA is a dummy variable and the CAPMF variables are expressed on a 1 to 10 scale, where 0 (10) indicates minimum (maximum) environmental policy stringency. Trade data typically includes a high number of zeros, which explains the relatively low values of the mean and median with respect to the SD. Total exports include internal trade estimates.

Source: Authors' elaboration based on BaTIS, CAPMF, STAN and WB-DTA.

3 Structural gravity with internal trade

The hypothesis of a positive differential effect of environmental policy stringency on services imports with respect to domestic sourcing is first tested empirically using a structural gravity framework with domestic trade flows.This methodology allows to estimate the linkages between measures of bilateral services trade and environmental policy in the importing country. It is an extension of the gravity model (Tinbergen (1962)) that, accounting for the latest developments in the literature in terms of identification strategy and structural interpretation of the estimated parameters (Anderson and Van Wincoop (2003); Head and Mayer (2014)), allows to gain insights on the trade effects of variables that vary only at the level of a single trade partner. In particular, all our specifications of the panel gravity framework include exporter-time and importer-time fixed effects, which allow to control for multilateral resistance terms and any observed and unobserved country-specific covariates that may vary across time (productivity shocks, exchange rate fluctuations, terms of trade changes) (Baier et al. (2019)). Additionally, we also introduce country-pair fixed effects. This allows to control for all time-invariant bilateral explanatory variables normally included in gravity analysis (distance, common language, common border, etc.). Including country-pair fixed effects allows to identify the coefficients in the gravity specification using only variation over time and within country pairs. Moreover, this approach controls for endogeneity of policies depending on bilateral relationships, allowing for a more robust causal interpretation of the coefficients (Baier and Bergstrand (2007)).

However, in a standard structural gravity framework with the three-way fixed effects described above it would be impossible to estimate the coefficient of environmental policy stringency in the importing country. If included directly into the equation, such variable would be perfectly collinear with the importer-time fixed effects, and its coefficient would not be identified. The extension of the panel gravity setting with the inclusion of internal trade flows allows to solve this problem. More precisely, adding internal trade flows allows to define an international border (IB) dummy variable, that takes value 1 when trade is international, i.e. when it happens between two countries separated by an international border. The BD dummy can then be interacted with the measure of domestic environmental policy stringency in the importing country. This interaction term varies at the importer-exporter-time level and is therefore not absorbed by the three-way fixed effects. Its coefficient can then be estimated, allowing the us to identify the differential effect of environmental policy in the importing country on international trade in services with respect to domestic flows.

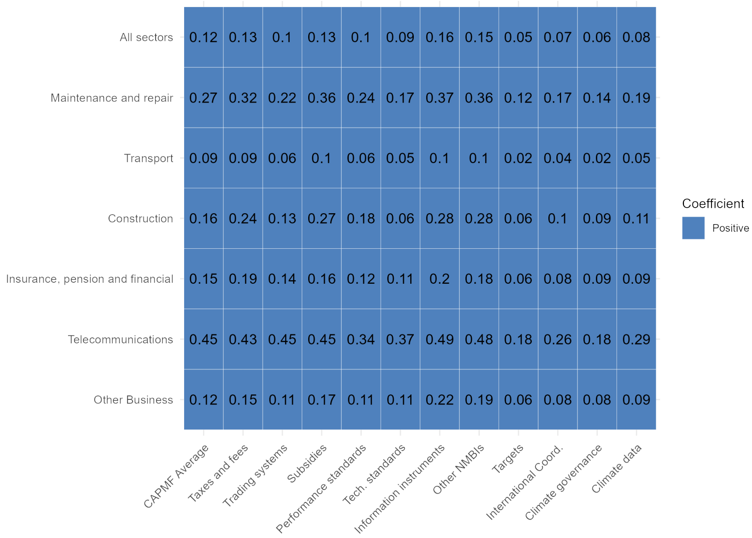
Our estimation of the panel gravity equation with internal trade is based on the Poisson Pseudo Maximum Likelihood (PPML) technique introduced by Santos Silva and Tenreyro (2006). This is the common approach for the estimation of gravity models, as it allows retaining zeros in trade data due to its functional form, as well as being robust to different patterns of heteroscedasticity. The estimating specification is given by the following equation:

$$EXP_{ijt} = exp(\beta CAPMF_{jt} BD_{ij} + \gamma FTA_{ijt} + \sigma_{it} + \delta_{jt} + \theta_{ij}) + \epsilon_{ijt} \tag{1}$$

where EXP_{ijt} represents services exports from exporter i to importer j at time t. $CAPMF_{jt}$ is a CAPMF indicator measuring environmental policy stringency in the importer country j on a given year. BD_{ij} is the international border dummy, which is country-pair specific. $SFTA_{ijt}$ is a dummy that takes value 1 when there is a trade agreement that covers services in place between the two countries at a given year. This is a bilateral, time-varying covariate that can affect simultaneously services trade and environmental policy, and a standard control variable in gravity settings. σ_{it}, δ_{jt} and θ_{ij} are exporter-time, importer-time, and country-pair fixed effects, respectively. Following (Egger and Tarlea (2015)) and (Larch et al. (2019)), errors are clustered by country pair and year, to avoid for potential autocorrelation of standard errors across all three dimensions of the panel.

We use the specification in equation 1 to estimate 84 regressions, each of them defined by a combination of the 7 sectoral categories in the BaTiS-STAN services trade database with internal flows, and the 12 CAPMF indicators (all 11 policy type variables and the average of the three level 1 indicators). The estimation sample consists of 105,377 observations, covering 40 importing countries for which CAPMF indicators of environmental policy are observed, up to 250 exporting countries, for the period 2005-2023. Table 1 provides summary statistics for the main variables in the estimation sample.

Figure 1: Estimated differential effect of CAPMF indicators on services imports with respect to domestic sourcing



Notes: Each cell of the matrix in the figure shows, for a given sector and CAPMF variable, the estimated coefficient of the interaction between environmental policy stringency and the international border dummy from the regression including trade in the specified services sector as dependent variable and using the selected CAPMF indicator as the measure of environmental policy stringency. Colour codes identify statistically significant (at least at the 95% confidence level) positive (blue) and negative (dark grey) estimates, as well as estimates that do not meet that significance level of 95% (light grey). These estimates are interpreted as the differential effect of environmental policy stringency, as captured by CAPMF indicators, on services imports in a specific sectoral category, with respect to domestic sourcing of the same services.

Source: Authors' elaboration based on BaTIS, CAPMF, STAN and WB-DTA.

Overall, these estimates confirm the hypothesis of a positive differential effect of higher environmental policy stringency on services trade with respect to the use of domestic services, both across different policy dimensions and services sectors. The magnitude of the estimates suggests economically meaningful effects. Consider, for example, the differential effect of environmental policy stringency in climate governance policies on total services imports with respect to domestic trade. The estimation results imply that an increase of policy stringency by roughly half of a standard deviation of the CAPMF indicator, leads to a percentage change in total services imports which is 6 percentage points higher than the percentage change in domestic sourcing. In other words, assuming that the more stringent policy measures on climate governance would lead to an increase of 1% in services provided by domestic suppliers for domestic demand, then imports of services would increase by 7%.

All services sectors have all of their corresponding coefficients show a positive differential effect. Sectors like maintenance and repair or telecommunication services have the largest coefficients, while transport or other business services show the lowest differential effects.

For illustrative purposes, Table A-2 in the annex displays more detailed estimation results from the gravity equation with total services trade (covering all sectors) as a dependent variable and the CAPMF indicator in climate governance policies as measure of environmental policy stringency.[5]

[5] Regressions for all combinations of policy variables and services sectors are estimated and summarized in figure 1. However, the remaining specific regression results are not shown.

The estimated coefficient for the interaction between environmental policy stringency and the international border dummy is positive and statistically significant at the 99% confidence level. As all the other estimated coefficients presented in Figure 1, it can be interpreted roughly as a semi-elasticity. More precisely, the estimated coefficient equal to 0.0597 reported in Table A-2 implies that a one unit increase in the indicator of environmental policy stringency in the area of climate governance (corresponding to roughly half of a sample standard deviation) is associated to a change in total services imports which is $100 \times (e^{0.0597} - 1) = 6.15$ percentage points higher than the change in domestic sourcing. Assuming for example that the environmental policies determining a one unit increase in the CAPMF indicator on climate governance would lead to an increase of 1% in domestic services performed for domestic demand, then the increase in services imports associated to the same policies would be of 1+6.15=7.15%.

4 Plug-in and Iceberg LASSO

While providing a first estimate of the differential effect of environmental policy stringency on services trade with respect to internal trade, the main limitation of the methodology used in the previous section is the assumption that different dimensions of environmental policy stringency impact trade in isolation. This assumption is inherent in the approach of including only one CAPMF indicator (interacted with the IB dummy) in each gravity equation. While identifying the empirical interdependencies between granular dimensions of environmental policies in incentivising the recourse to international services markets is beyond the scope of this report, a robust empirical analysis of the differential effect of environmental policy on trade should account for the possibility that multiple dimensions of environmental policy stringency may simultaneously influence trade.

This exercise addresses this challenge by proposing a machine-learning based approach to gravity estimation that allows to identify, among many variables of interest, those that appear with higher predictive power. This method, first introduced by Breinlich et al. (2022) to single out the most important provisions of deep trade agreements from a trade generating perspective, can be adapted directly to the problem of selecting dimensions of environmental policy stringency in the gravity framework with domestic trade flows illustrated above.

The approach consists of two steps. First, the LASSO (Least Absolute Shrinkage and Selection Operator) method for variable selection is applied to the PPML-based estimation of the gravity equation with internal trade augmented with all 11 policy type CAPMF indicators, each of them interacted with the IB dummy. In this application, a regressor specific penalty is associated to the coefficients of these 11 interaction terms, giving more weight to the coefficients of those variables with a better predictive power and penalizing coefficients of variables with little predictive power. This forces some of the coefficients with higher penalties to go to zero, ending up with only a subset of the initial interactions. It is important to note that fixed effects coefficients are exempt from the penalty, so they will always be present in the regression.

Following Breinlich et al. (2022), this first LASSO estimation is implemented using the 'plug-in' approach to determine the tuning parameter, and is therefore labeled 'plug-in PPML-LASSO'. The key difference between plug-in LASSO and other similar methodologies consists of a penalty chosen following statistical theory (Belloni et al. (2016)). Intuitively, this procedure sets the coefficient of each of the variables to zero, and assigns a penalty based on how much the fit of the model improves without that variable. This approach differs from the more standard approach of choosing the penalty parameters based on cross-validation, where penalties are determined by predictive power on a within-sample calibration. Breinlich et al. (2022) show that the plug-in LASSO tends to be more parsimonious and restrictive when compared to cross-validation methods, resulting in less variables being selected.

For an analysis that aims to shed light on the most important dimensions of environmental policy as causal determinants of services imports patterns, the set of indicators identified by the plug-in PPML-LASSO might be just the tip of the iceberg. The LASSO solution to the variable selection model in fact tends to pick only one "winner" among those variables that play a similar predictive role. Therefore, among the interactions between environmental policy indicators and the international border dummy excluded for their collinearity with the selected ones, there might be other good candidates for exerting a causal effect on services trade.[6]

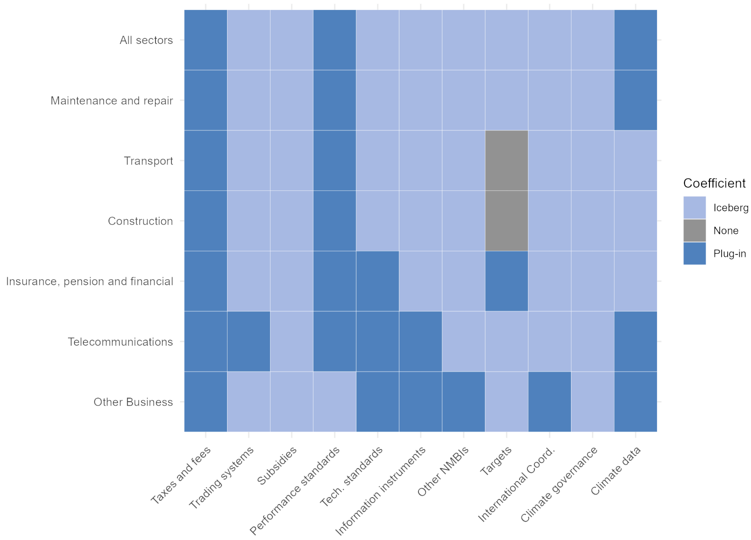
The iceberg lasso is introduced precisely to identify those potentially relevant causal factors missed by the plug-in PPML-lasso. All the CAPMF indicators featuring in the interaction terms that were not selected by the plug-in LASSO are included on the right-hand side of these new iceberg LASSO regressions. Those variables retained by the iceberg LASSO estimations, are likely to have a similar explanatory power as the ones captured by the plug-in LASSO. Therefore, we cannot claim that these variables do not exert any differential effect on services trade.

Taken together, the environmental policy indicators appearing in the interactions selected by the plug-in PPML-lasso first, and by the iceberg lasso in the second stage, constitute a group of variables that is likely to include the dimensions of environmental policy stringency most relevant to predict the differential changes in services imports with respect to domestic trade.

Overall, the results summarized in figure 2 suggest that almost all 11 CAPMF policy type indicators can exert a differential effect on services imports across most of sectoral categories. While the plug-in lasso significantly reduces the number of relevant dimensions of environmental policy stringency in the first step, the iceberg lasso estimations in the second step tend to reintroduce almost all CAPMF

[6]Plug-in LASSO results are shown more in depth for total services imports in table A-3.

Figure 2: Relevant dimensions of environmental policy stringency across sectoral categories of services trade



Notes: The heatmap indicates, for each sectoral category of services trade (listed across the rows of the matrix), if a CAPMF indicator (listed across the columns of the matrix) is selected as relevant by the plug-in LASSO estimation (dark blue), the iceberg LASSO (light blue), or by none of them (grey).

Source: Authors' elaboration based on BaTIS, CAPMF, STAN and WB-DTA.

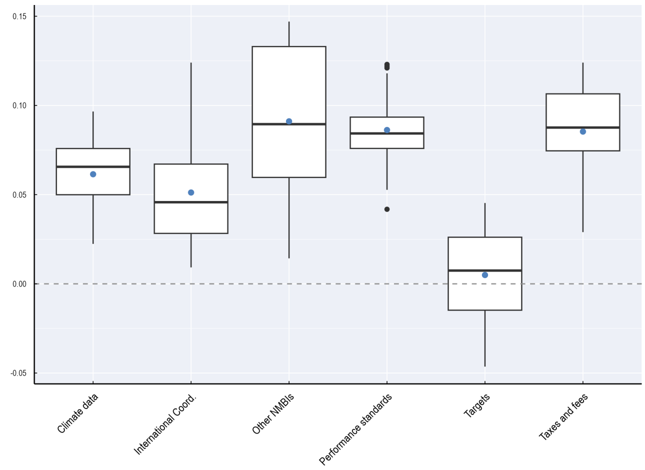
indicators in the pool of relevant candidates. This reinforces the conclusions drawn from the results in figure 1.

5 Towards a robust assessment of the differential effect of environmental policy on services imports

After introducing a model to identify the differential effect of environmental policy on services imports, and a methodology to select those indicators that are most fit to the model, the final step in the analysis could consist in running the internal trade-augmented gravity regressions for services trade including simultaneously all the interactions between environmental policy indicators and the international border dummy provided in the list of indicators. However, the utilized LASSO-based variable-selection algorithm identifies and rewards predictive power rather than causal impact, and, as such, it does not offer any guarantee that the list of selected indicators coincides with the list of causal factors behind the differential effect of interest.

As an alternative more robust approach to assess the causal differential effect of various dimensions of environmental policy on services imports, the next exercise proposes to estimate, for total services trade as well as for the seven sector-specific services trade variables, the parameters of a large but tractable number of gravity regressions, each of them featuring a different combination of the selected interactions between environmental policy indicators and the international border dummy. This approach delivers for each services trade variable and environmental policy indicator a large number of estimated differential effects of the latter on the former. Studying the distribution of these estimated effects and their statistical significance leads to the most robust and preferred answers to

Figure 3: Distribution of estimated differential effect of CAPMF indicators for total services imports



Notes: For each CAPMF indicator listed horizontally, the figure shows the box plot of the distribution of all estimated differential effects of the CAPMF indicator on total services imports. These estimates correspond to the estimated coefficient of the interaction term between the international border dummy and the CAPMF indicator in the following gravity specifications: one where the interaction term of interest is included in isolation; all regressions where the interaction term is included in all possible combinations with another interaction term from the list of those selected by either plug-in or iceberg lasso as relevant predictors of services trade; and all regressions where the interaction term is included in all possible combinations with two other interaction terms from the list. Only those CAPMF variables with more than 90% of coefficients significant at the 95% confidence level are included. The plot also includes the mean value of all significant coefficients, represented in blue.

Source: Authors' elaboration based on BaTIS, CAPMF, STAN and WB-DTA.

the research questions tackled in this section.[7]

More specifically, for each interaction term in the list of those selected by either plug-in or iceberg lasso as relevant predictors of a services trade variable, the following coefficients are estimated: (a) the coefficient of the interaction term included in isolation; (b) the coefficients of the interaction term in all possible combinations with another interaction from the list; (c) the coefficient of the interaction term in all possible combinations with two other interactions from the list. If, for example, a list includes all 11 interactions between CAPMF indicators and the international border dummy, this approach will produce 91 ((a)+(b)+(c) = 1+10+45 = 56) estimates of the differential effect on services trade for each indicator of environmental policy stringency.[8] Figure 3 reports the box plots describing the distribution of the estimated differential effects on total services imports for the CAPMF indicators (listed on the horizontal axis).[9]

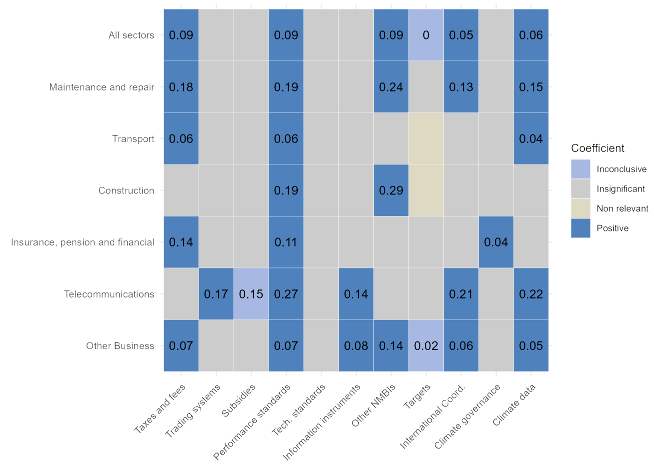
The robust assessment of the differential effect of a specific dimension of environmental policy stringency for total services imports is built as follows. First, the differential effect of a CAPMF indicator is considered *insignificant* if more than 10% of its estimated differential effects have statistical signifi-

[7]A similar is employed by Levine and Renelt (1992) to identify robust determinants of long-run average growth rates in cross-country growth regression settings.

[8]Estimating the coefficients of an interaction term in all possible combinations with a larger amount of combinations would become exponentially more burdensome both in terms of time and computational power. Given this burdensome timing and computing requirement the preferred approach is that of limiting the analysis to all possible combinations of the variable of interest with two other interactions.

[9]We take the results for total services as the more representative set of results. Results for each services sector are available on figure A-1 in the annex.

Figure 4: Summary of the robust assessment of the differential effects of environmental policy stringency on services imports with respect to domestic sourcing



Notes: The matrix plotted in the figure characterizes each combination of a sectoral category of services imports (row dimension of the matrix) and a dimension of environmental policy (column dimension) with a robust assessment of the estimated differential effect of the latter on the former. This robust assessment is performed by analyzing a large but tractable number of estimated differential effects. If less than 90% of these coefficients are significant at the 95% confidence level the cell is labeled as insignificant. Color-codes corresponding to positive and negative labels are assigned when all coefficients are either positive or negative. If the significance requirement is met, and at least two significant coefficients have a different sign, the cell is labeled as inconclusive. When the effect is considered not insignificant, the cell reports the mean estimated effect. In those cases where a CAPMF indicator is not selected as relevant for a services trade variable by the two-step variable selection algorithm, the respective cell is labeled non relevant.

Source: Authors' elaboration based on BaTIS, CAPMF, STAN and WB-DTA.

cance lower than a 95% confidence level. Second, the differential effect of each CAPMF indicator that satisfies the significance requirement is considered *positive* if all the statistically significant (at a 95% level) estimated differential effects are strictly greater than zero. This corresponds to the box plot lying completely above the horizontal line set at 0 in Figure 3. In the figure, environmental stringency indicators from five policy types satisfy this condition: Climate data; International coordination policies; Other non-market based policies; Performance standards; Taxes and fees. Symmetrically, it is considered *negative* if all statistically significant estimates are strictly lower than zero, with the boxplot lying completely below the horizontal line instead. Finally, the assessment of a CAPMF indicator that satisfies the significance requirement is considered *inconclusive* if the vector of estimated differential effect associated to the indicator contains statistically significant positive and negative estimates. In figure 3, this would be the case for the Targets indicator.

Results for the robust estimation of the differential effect are shown in figure 4. When the effect is considered significant, the figure reports the mean estimated effect. In those cases where a CAPMF indicator is not selected as relevant for a services trade variable by the two-step lasso algorithm described above, the respective cell is labeled as non-relevant.

Figure 4 offers a rich set of robust empirical findings on the differential effects of environmental policy stringency on services imports. First, most of the significant relationships point to a positive effect. For total services imports, this is the case for five dimensions of environmental policy stringency. Results for individual services sectors reveal that this pattern is driven by other business services (showing a positive differential effect from six CAPMF indicators), maintenance and repair and telecommunications (both showing a positive effect from five indicators, plus an indicator labeled as inconclusive but with a positive average in the case of telecommunications). Looking at areas of environmental policies, those that tend to exert a positive effect for the highest number of sectoral categories of services imports are performance standards (impacting all sectoral categories), taxes and fees (impacting 5 sectoral categories); as well as climate data policies (also affecting 5 categories of services imports). The pattern follows the variables selected by the plug-in LASSO in the previous exercise, showing robustness in variable selection across both methodologies.

Secondly, Figure 4 shows that in many more cases than those suggested by a less robust empirical assessment, environmental policy stringency does not disproportionally affect services imports with respect to domestic sourcing. This lack of a differential effect is particularly pronounced for construction services, transport services and financial, insurance and pension services, where only a few dimensions of environmental policy stringency (two and three, respectively) seem to call for more services sourced from international markets than from domestic suppliers. The dimensions of environmental policy which generate fewer differential effects across sectoral categories of services imports are technology standards (which has no significant coefficient across all sectoral categories), subsidies (for which only telecommunication services are affected, but inconclusively), and trading systems (affecting only telecommunications significantly). While target-based policies seem to affect two different sectoral categories, in both cases they do so in an inconclusive manner.

Third, the magnitudes of the mean estimated differential effects reported in Figure 4 indicate that the strongest response to more stringent environmental policies can be expected for imports of telecommunication services. For this sector, the highest estimated differential effect is that from information instruments, equal to 0.27. This estimate implies that an increase of policy stringency by roughly half of a standard deviation (1.31) of the corresponding CAPMF indicator, leads to a percentage change in imports of telecommunication services which is 40 percentage points higher than the percentage change in domestic sourcing.[10] If, for example, the hypothesized increase in environmental policy stringency leads to a 10% increase in domestic sourcing of maintenance and repair services, imports of these services would increase by 50%. This is a very large effect, significantly higher than those associated to the typical positive estimate reported in Figure 4. The average positive differential effect for total services imports is equal to 0.055, which implies that a one-unit variation in a CAPMF indicator leads to a percentage change in total services imports which is 5.65 percentage points higher than

[10]The formula used for the economic quantification of the 0.27 estimate is the following. For a one unit increase in the CAPMF indicator, services imports would increase by $100 \times (e^{0.27} - 1) = 57$ percentage points more than the percentage change in domestic sourcing. Half of a standard deviation in the CAPMF indicator is equal to 1.31, which implies that the associated percentage increase in services imports would be 40 percentage points higher than the percentage change in domestic sourcing.

the percentage change in domestic sourcing.Do we need such a complex quantification strategy?

Finally, one caveat of the analysis conducted to estimate the differential effect of environmental policy on services imports with respect to domestic sourcing is that services trade flows do not capture services imported through commercial presence, or mode 3 services imports. These are actually partly embedded in the measure of internal trade, which does not distinguish between the domestic or foreign ownership of firms that supply services domestically. While this represents a limitation for the analysis it does not jeopardize the robustness of the findings. These must be interpreted as differential effects of environmental policy on services imported through the modes of supply captured by the balance of payments framework, which forms the statistical basis of the BaTiS data.[11] The exercise to extend the analysis to mode 3 services imports is left for further research.

6 Beyond the differential effect

The overall assessment of a positive differential effect of environmental policy on services imports with respect to domestic sourcing does not provide any evidence on whether higher environmental standards increase services imports in absolute terms. For instance, a positive differential effect would be estimated even if higher standards lead to a reduction in the use of all services, but a smaller decrease for those sourced internationally. This scenario would contradict evidence highlighting the crucial role of services as key elements in many processes and solutions to achieve more ambitious environmental sustainability goals.

The empirical assessment of the absolute effect of environmental policy on services imports cannot rely on the structural gravity framework utilized so far. The reason for that is a technical one: the importer-time specific indicators of environmental policy would be perfectly collinear with and subsumed by the importer-time fixed effects, required by any structural gravity equation to account for the idiosyncratic pull factors characterizing a specific importer at any given point in time. However, an econometrically sound correlation between environmental policy stringency and services imports can be estimated by fitting a panel regression model with data varying at the country and year level. While not allowing for a causal interpretation, this setting would contribute to shed some light on the relationship between environmental policy stringency and services imports, beyond the differential effect with respect to internal trade investigated so far.[12]

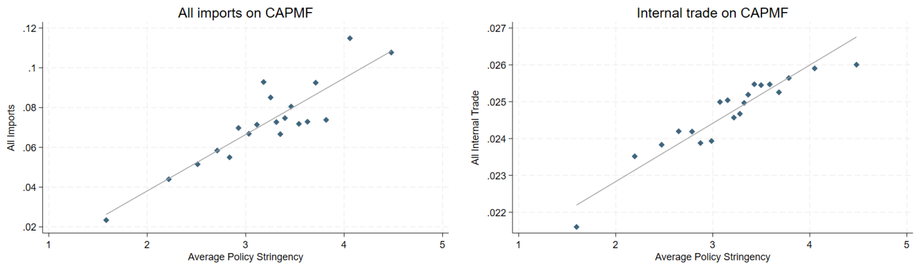
The preferred specification chosen for this exercise takes (unilateral) total services imports as the dependent variable.[13] and the most aggregate CAPMF indicator of environmental policy stringency

[11]For most of the sectors analyzed, these are notably mode 1 or cross border services trade, and mode 4 or trade by temporary movement of persons.

[12]Regression results and summary statistics for the used variables are available in tables A-5 and A-4 in the annex.

[13]The choice for using only total services imports as the dependent variable is based mainly on data availability: Using specific sectors would not allow for statistically robust results on this estimation.

Figure 5: Effect of CAPMF on internal trade and total imports



Notes: These two scatter plots show the results of regressions between the total amount of internal trade (left panel) and imports (right panel) on the country average CAPMF index. The dependent variable was rescaled on both cases for comparability, and it ranges between 0 and 1. Both regressions include year fixed effects, and controls for the main country-time macroeconomic variables (GDP, GDP per capita, share of manufacturing sector GDP, inward FDI flows). The dots represent the bins generated from clustering of residuals to account for all relevant controls. For internal trade, the CAPMF coefficient was found insignificant, while it is significant at the 99% level for imports.

Source: Authors' elaboration based on BaTIS, CAPMF, STAN and WB-DTA.

as the key regressor of interest. Identification relies on cross country variation after controlling for several country-year characteristics, including the size the economy (proxied by GDP), the level of economic development (GDP per capita), the share of manufacturing sector over GDP, inward FDI flows, as well as year-specific shocks common across countries. The same specification can be replicated with the measure of internal services trade as dependent variable, to complement the analysis with an estimate of the empirical linkages between environmental policy stringency and the use of services sourced from the domestic market.

The empirical relationship between environmental policy stringency and total services imports is positive and statistically significant (left panel in Figure 5). It remains positive and significant when services imports are replaced by the measure of internal trade (right panel). However, the relationship is stronger in the case of imports (the coefficient is roughly 18 times larger than the one corresponding to internal trade). Overall, these findings suggest that countries facing higher environmental policy stringency tend to import more services from international markets rather than showing stronger patterns of domestic sourcing. This aligns well with the positive effect of higher environmental standards on services imports compared to domestic sourcing and confirms that trade is a key channel for accessing services required to tackle more ambitious environmental sustainability objectives.

7 Conclusion

In this study, we study whether environmental policy stringency drives higher demand for services imports using a robust, multi-method approach. By combining the use of a structural gravity model augmented with internal trade and a machine-learning based method for algorithmic selection, the paper identifies the most influential environmental stringency variables and estimates their differential and absolute effects across service sectors. The findings reveal a predominantly positive relationship both across sectors and policies, with certain sectors such as other business services, maintenance and repair or telecommunications showing the most sizable increases with respect to internal trade. Results also point at a positive absolute effect of environmental stringency on services trade. While non-conclusive evidence, this supports the theory that higher environmental policy stringency has an overall positive effect on services trade, thus underscoring the role of environmental policies in shaping sustainable trade dynamics.

Future research could expand these insights by exploring the heterogeneity of effects across modes of service supply and variations by different exporting country characteristics, such as their level of development or environmental standards. Such analyses would deepen understanding of the mechanisms through which environmental policies influence trade, particularly in the context of global value chains and cross-border digital services. Examining these aspects would provide a more comprehensive picture of how trade and environmental goals can align across diverse economic and regulatory landscapes.

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A Appendix

Table A-1: CAPMF Policy Categories and Examples

CAPMF Policy Type	Policy Examples
Taxes and fees	Carbon taxes; Fossil fuel subsidy reforms;Fossil fuel excise taxes
Trading systems	Renewable energy certificates; ETS; Emission pricing
Subsidies	Feed-in tariffs; Renewable energy auctions; Financing mechanisms; RD&D expenditure
Performance standards	Air emission standards; MEPS; Building energy codes
Technology standards	Ban and phase outs of fossil fuels (use, support, product expansions)
Information instruments	Mandatory energy labels for appliances; Labels for vehicles
Other non-market-based instruments	Planning for renewables expansion; Energy efficiency mandates; Speed limits on motorways; Methane abatement policies; Share of rail or transport public expenditure
Targets	Nationally determined contributions; Net zero targets
International coordination	Ratification of key international climate treaties; Participation in international climate initiatives
Climate governance	Independent climate advisory bodies
Climate data	GHG Emissions reporting and accounting; UNFCCC evaluation of reports; Submission of UNFCCC documents

Notes: Authors' elaboration based on Nachtigall et al. (2022).

Table A-2: Example PPML regression: All services trade on Climate governance

	All sectors
Int Border X Climate Governance	0.060***
	(0.003)
SFTA	0.183***
	(0.027)
Observations	105,377
Country-pair FEs	YES
Importer-time FEs	YES
Exporter-time FEs	YES

Notes: The coefficient of interest should be interpreted as the differential effect with respect to internal trade. Robust standard errors clustered by exporter-importer-time are reported in parentheses. *p<0.10, **p<0.05,***p<0.01.

Source: Authors' elaboration based on BaTIS, CAPMF, STAN and WB-DTA.

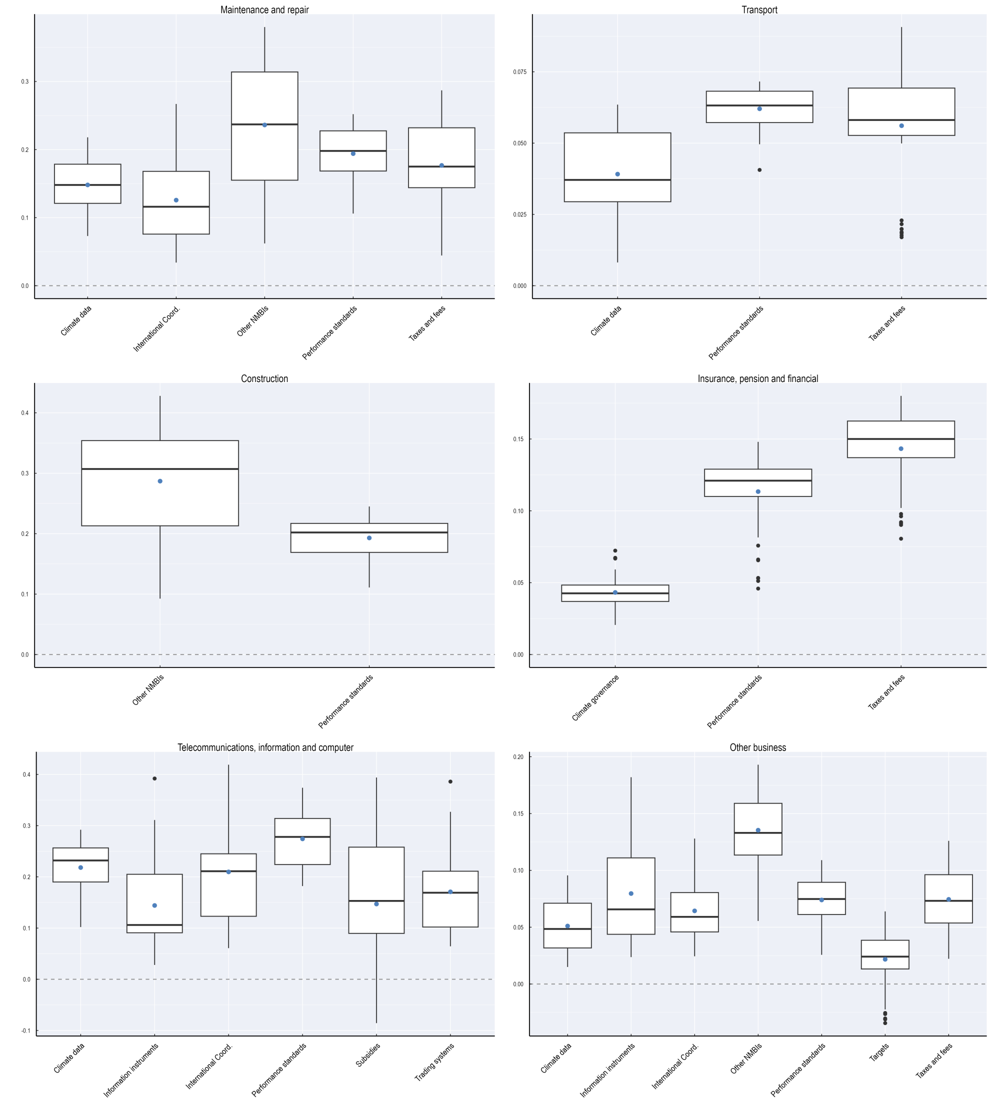
Table A-3: Differential effect of CAPMF indicators selected by the plug-in LASSO

	All sectors	Maintenance and repair	Transport	Construction	Insurance, pension and financial	Telecommunications	Other Business
Taxes and fees	0.043***	0.076**	0.019	0.045	0.109***	0.035	0.057***
	(0.009)	(0.031)	(0.012)	(0.031)	(0.019)	(0.032)	(0.013)
Trading systems						0.069*	
						(0.041)	
Subsidies							
Performance standards	0.042***	0.106***	0.052***	0.154***	0.045**	0.178***	
	(0.009)	(0.027)	(0.011)	(0.023)	(0.019)	(0.028)	
Tech. Standards					0.032**	0.052	0.013
					(0.014)	(0.035)	(0.009)
Information instruments						0.024	0.029**
						(0.016)	(0.014)
Other NMBIs							0.049*
							(0.029)
Targets					0.009*		
					(0.004)		
International coord.							0.035***
							(0.013)
Climate governance							
Climate data	0.032***	0.093***				0.103***	0.001
	(0.005)	(0.013)				(0.014)	(0.011)

Notes: This table shows the results of eight different post-LASSO regressions, one per sectoral category of services trade. Coefficients estimated only for the interaction terms selected by the plug-in LASSO procedure. Standard errors are shown in parenthesis. The estimation sample for each of these 8 regressions is the same as in the corresponding regression with only one interaction. *p<0.10, **p<0.05,***p<0.01.

Source: Authors' elaboration based on BaTiS, CAPMF, STAN and ITPD-E.

Figure A-1: Distribution of estimated differential effect of CAPMF indicators for services imports by sectoral category



Notes: For each CAPMF indicator listed horizontally, the figure shows the box plot of the distribution of all estimated differential effects of the CAPMF indicator on total services imports. These estimates correspond to the estimated coefficient of the interaction term between the international border dummy and the CAPMF indicator in the following gravity specifications: one where the interaction term of interest is included in isolation; all regressions where the interaction term is included in all possible combinations with another interaction term from the list of those selected by either plug-in or iceberg lasso as relevant predictors of services trade; and all regressions where the interaction term is included in all possible combinations with two other interaction terms from the list. Only those CAPMF variables with more than 90% of coefficients significant at the 95% confidence level are included. The plot also includes the mean value of all significant coefficients, represented in blue.

Source: Authors' elaboration based on BaTiS, CAPMF and STAN.

Table A-4: Summary Statistics for the absolute effect estimations

	Mean	**Median**	**Standard Dev.**	**Min**	**Max**
Internal trade (rescaled)	0.0636	0.0130	0.1514	0.0000	1.0000
Total imports (rescaled)	0.1102	0.0530	0.1530	0.0000	1.0000
CAPMF Average	2.7999	2.4905	1.4055	0.3885	6.9581
GDP	1251977007.8809	378305511.4240	2886551921.1300	12823849.9840	22996100000.0000
GDP per capita	36.8731	35.9010	23.4250	3.3930	135.6830
Inward FDI flow	22558.7465	9347.8296	50432.2593	-101147.6719	467625.0000
Proportion of manufacturing value added of GDP	14.3352	13.5705	5.0892	4.5544	34.6510

Notes: The estimation sample consists of 678 observations, covering 40 countries for which CAPMF indicators of environmental policy are observed, for the period 2005-2023. Imports and production are expressed in current USD. CAPMF Country average consists of the average of the four country-level CAPMF stringency indexes with the highest aggregation level. Both internal trade and imports per country were scaled between 0 and 1 for comparability of results. *p<0.10, **p<0.05,***p<0.01.

Source: Authors' elaboration based on CAPMF, STAN, BaTIS and CEPII.

Table A-5: Absolute effect of CAPMF on trade: regression results

	All imports	Internal trade
CAPMF Average	0.0283***	0.001582***
	(0.00348)	(0.000148)
GDP	0.00004***	0.00003***
	(2.10e-06)	(8.88e-08)
GDP per capita	7.82e-07***	-6.02e-09
	(1.20e-07)	(5.12e-09)
Inward FDI flow	4.00e-07***	-1.11e-08***
	(6.97e-08)	(2.94e-09)
Manufacturing value added of GDP	0.00066	-0.0001586***
	(0.000474)	(0.00002)
Observations	678	678
R-squared	0.648	0.995
Year FEs	YES	YES
Country FEs	NO	NO

Notes: Regression results for all imports and internal trade on average policy stringency (the average of the three level 1 CAPMF indicators). Both regressions include only year FEs, to exploit across country variation. Standard errors in parentheses. *p<0.10, **p<0.05,***p<0.01.

Source: Authors' elaboration based on BaTiS, CAPMF, STAN, CEPII, Our world in data and UNCTAD.