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Trade 4 Sustainable Development

Deliverable 2.1:
Report on the quantitative assessment of FTA contribution to SDGs

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Report on the quantitative assessment of FTA contribution to SDGs

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The Effect of Environmental Provisions in Preferential Trade Agreements on Sustainable Development Goals

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Abstract

Preferential Trade Agreements (PTAs) have increasingly been used to promote environmental protection and climate issues, as denoted by the increasing number and variety of specific environmental provisions included in the agreements. The effectiveness of these commitments in helping countries to make progress towards environmental targets is still unclear, however. In this paper we empirically estimate the effect of specific environmental provisions in PTAs on selected environmental targets as defined in the Sustainable Development Goals. We combine a detailed dataset on environmental norms in PTAs with data on a broad range of environmental outcomes and find heterogenous effects across the various outcomes. Provisions on the use of renewable energy, the reduction of greenhouse gas emissions, and the protection of fish stocks appear to be particularly effective.

JEL Classification: F18, Q56
Keywords: Preferential Trade Agreements, Sustainable Development Goals, Environment

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Table of Contents

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101000551 – TRADE4SD

List of Figures

List of Tables

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101000551 – TRADE4SD

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1 INTRODUCTION

Preferential Trade Agreements (PTAs) have progressively become more comprehensive in scope, both in terms of the number of policy areas covered, and the depth and detail of the provisions regulating a certain area (Mattoo et. al, 2020). Modern PTAs extend well beyond issues directly related to trade liberalisation such as tariffs, quotas and rules of origin, and feature chapters on regulatory issues, competition, intellectual property rights, among other areas. Furthermore, and especially over the last two decades, PTAs increasingly include provisions on non-trade issues such as environmental protection and labour standards, which are also issues addressed as part of the United Nations Sustainable Development Goals (UN-SDGs/ SDGs). This trend has also been well-documented, with a number of newly available data sources codifying the non-trade content of PTAs in great detail (Morin et. al., 2018; Raess & Sari, 2018; Mattoo et. al., 2020), and a fast-growing literature studying its effects (Brandi et al., 2020; Osnago et al., 2020; Carrère et al., 2021; Di Ubaldo and Gasiorek, 2022; Francois et al., 2022). The relationship between trade liberalisation and sustainable development is very complex, however, and strong and consistent evidence on the effects of non-trade provisions in PTAs on their intended non-trade outcomes is still missing.

In this paper, we contribute to the emerging literature on the impact of trade agreements on non-trade policy objectives with a focus on environmentally related United Nations Sustainable Development Goals. We do so by linking PTA provisions to a list of selected SDG-indicators, and estimating the causal impact of the former on the latter. More specifically, we assess whether PTA provisions on environmental protection and climate change have a direct effect on outcomes under SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 13 (Climate Action), SDG 14 (Life Below Water) and SDG 15 (Life on Land). Our headline findings are that the impact of PTA provisions on the SDG indicators is very heterogenous, with countries that signed PTAs with provisions on the reduction of green-house gas emissions, the use of renewable energy, against illegal fishing, and on the protection of parks and natural areas seeing an improvement of the related SDG outcome, relative to countries not party to such agreements. The heterogeneity of our findings is not unexpected,

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due to the complexity of the relationship between PTAs and the environmental goals that we analyse.

The increasing popularity of non-trade provisions in PTAs cannot be explained by a single factor, as multiple reasons can lead to include more or less binding non-trade provisions in trade agreements. On the one hand, there can be an attempt to remedy problematic situations of an economic or political nature, often advocated by human rights and environmental NGOs in developed economies. On the other hand, there can be the intention to create the conditions for fairer international competition, or to level the playing-field and avoid a race to the bottom (Lechner, 2016; Borchert et al., 2021).

Non-trade provisions in PTAs also address the concern that changes in trade can have both positive and negative implications for the achievement of the UN-SDGs. Countries can reap gains from trade, which include higher incomes, increased consumption choices, lower prices, and allocative and productive efficiency (among many others, Melitz and Trefler, 2012; Melitz and Redding, 2014; Fajgelbaum, and Khandelwal, 2016). These benefits have the potential to improve livelihoods, create more and better jobs, diffuse environmentally friendly technologies as well as transfer values such as democracy, gender equality and the respect for human rights. However, trade also has the potential to deter the attainment of certain SDGs. Specifically, for the case of the environment, trade can affect environmental outcomes through three main channels (Grossman & Kreuger, 1991; Antweiler & Copeland, 2001; Copeland & Taylor, 2004; Baghdadi et al., 2013). Firstly, economic growth that is associated with trade can lead to more demand for natural resources and increased pollution. Environmental standards might also deteriorate as firms seek to remain competitive and/or increase production to take advantage of access to a larger market. Conversely, as countries become wealthier through freer trade, awareness and concerns about environmental issues are also likely to increase (Frankel & Rose, 2005).[1] Secondly, trade can improve environmental outcomes through the transfer of greener technologies from countries with cleaner technologies to countries with more polluting methods of production (Baghdadi et al., 2013): as firms adopt cleaner technologies to comply with tighter environmental regulation, trade liberalisation could lead to

[1] This can result in an inverted-U relationship between economic growth and environmental quality, i.e. the relationship between trade and the environment is negative at lower levels of income and then turns positive as countries move to higher income levels. This relationship between trade and environment based on the level of income of a country is embodied in the Environmental Kuznets curve theory.

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a technological transfer. Finally, trade liberalization might result in certain countries exploiting their comparative advantage in pollution-intensive products: this can be due to either their resource endowments (Factor Endowment Hypothesis, see for instance Baghdadi et al., 2013; Zhou et al., 2017), or through the relocation of firms from stricter regulatory to looser regulatory environments (Pollution Haven Hypothesis; see for instance Dean et al., 2009). In sum, trade can affect the environment either positively or negatively depending on the net effects of these interrelated channels. The empirical literature confirms this heterogeneity with authors finding positive, negative and nil impacts of trade on the environment (Frankel & Rose, 2005; He and Wang, 2019; Abman & Lundberg, 2020; Apergis & Payne, 2020; Wu et. al 2021; Afesorgbor & Demena, 2022).

Environmental provisions in PTAs therefore also address the growing recognition that trade should play a beneficial role in the attainment of various developmental goals (Barros & Martínez-Zarzoso, 2022). These multiple objectives, often in conflict with the general aim of PTAs as instruments of economic integration, have led to a heterogenous design of non-trade provisions across agreements: some provisions in some PTAs are legally enforceable, with sanctions and recourses to legal arbitration included as part of the dispute settlement mechanisms in these PTAs; other provisions are directed at fostering cooperation, or more loosely refer to obligations already taken through international conventions (Lydgate, 2023). For instance, while the EU, Australia, Japan, New Zealand tend to opt for a more cooperative and consultative approach to implementation, the US and Canada prefer a more binding approach (Velut et. al, 2022). For this reason, in our analysis we differentiate between agreements with binding and non-binding provisions, as well as among agreements signed by the EU, the US and other countries. We find that, where the impact of PTA provisions on the SDG is statistically significant, this is not systematically driven by the use of binding provisions; on the contrary, the majority of the statistically significant effects appear to be driven by non-binding PTA provisions, suggesting that a cooperative approach could be more successful than one based on economic sanctions.

The impact of environmental provisions on environmental quality has previously been researched mainly with a focus on a single environmental outcome such as emissions (Baghdadi et al., 2013; Lundberg et al., 2023; Sorgho & Tharakan, 2020), deforestation (Abman et al., 2021) and air quality (Zhou et al., 2017; Martínez-Zarzoso & Oueslati, 2018). Our research takes a broader approach and considers eight indicators of environmental quality

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and environmental protection which are part of the UN-SDGs. The only paper to the best our knowledge that considers the impact of environmental provisions on multiple indicators of environmental quality is Francois et al. (2022). The main difference between our study and that of Francois et al. (2022) is the specific linkage between environmental provisions and UN-SDGs that we consider in our study. We consider a wide range of environmental SDG indicators and use a more detailed dataset on environmental norms in PTAs from Morin et al. (2018) that allows us to link specific provisions that address a specific environmental SDG indicator. Francois et al. (2022) use the World Bank Deep Trade Agreement Database as their source of data on non-trade provisions in PTAs, which is not as detailed on specific environmental issues as the dataset by Morin et al., (2018).

The high level of detail on the environmental provisions in PTAs that we use allows us to move away from a focus on single environmental quality indicators and general measures of environmental provisions as has been the case in previous studies. Sorgho & Tharakan (2020) use the same data on PTA provisions as we do (Morin et. al 2018) for their analysis on the impact of environmental provisions on greenhouse gas emissions (GHG). They show that for GHG emissions, only PTAs with specific climate related provisions have an effect in reducing emissions, unlike PTAs with general environmental provisions. This points to the importance of considering the specific linkage between provisions and environmental outcomes when analysing the impact of the former on the latter.

Studying these effects using a broad approach presents certain challenges, however. Our analysis includes all the PTAs we have information on from Morin et al. (2018) and is based on a differences-in-difference (DiD) set-up. The staggered nature of coming into force of PTAs, and the unequal performance in terms of SDGs of the countries party (or not) of such agreements, risk violating the 'parallel-trend assumption' necessary for the unbiasedness of DiD estimators. As PTAs are negotiated and applied in different years, to estimate their effect correctly we need to take into account that the 'treatment', i.e., the application of an environmental provision, occurred at different points in time for different countries (Callaway and Sant'Anna, 2021). Second, as PTAs are not negotiated with random partners and do not have random content, to estimate their impact we need to find a suitable counterfactual for the treated countries. In other words, we need to make sure our estimates are not affected by selection and reverse causality, which would occur if the content of PTAs were dictated by the

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realization of the SDGs. Third, in terms of research design, we need to choose how to model the frequent situation of countries being part of multiple agreements with specific provisions. Much of the existing literature has used quasi-experimental methods such as matching and difference in difference to estimate causal impacts (Baghdadi et al., 2013; Abman et al., 2021). To address the econometric issues mentioned above we follow Francois et al. (2022) and use a synthetic DiD (henceforth SDID) estimator developed by Arkhangelsky et al., (2021) which combines the desirable features of both synthetic control methods and DiD estimators. The SDID aims at satisfying the 'parallel trends assumption' by computing units and time-specific weights and assigns an appropriate counterfactual to the treated countries. This enables us to estimate the average treatment effect of having a PTA with a specific environmental provision in an unbiased way, and also to deal with the staggered treatment approach we employ in our analysis. Lastly, in order to be able to apply this method, we choose to consider a country as 'treated' from the moment its first PTA with a specific provision comes into force and to stay treated throughout the analysis.

Our paper fits into three strands of the literature on the impact of trade and trade policy on sustainable development related outcomes. Firstly, this research is related to the broad literature on the impact of trade liberalisation on various measures that fall under the domains of the three dimensions of economic, social and environmental sustainability. This includes studies that have looked at how trade affects poverty, education, employment outcomes, job creation, gender equality, and child labour, among other outcomes (e.g., Winters et al., 2004; Winters & Martuscelli, 2014; Edmonds et al., 2010; Atkin, 2016; Greenland & Lopresti 2016; Juhn et al., 2014; Kis-Katos & Sparrow, 2011, 2015). Secondly, we contribute to the extensive literature on the impact of trade and trade agreements on environmental outcomes (Grossman & Kreuger, 1991; Frankel & Rose, 2005; Antweiler & Copeland, 2001; Copeland & Taylor, 2004; He and Wang, 2019; Abman & Lundberg, 2020; Apergis & Payne, 2020; Wu et. al 2021; Afesorgbor & Demena, 2022). Finally, this paper most directly adds to the literature on the effects of non-trade provisions in deep trade agreements on various non-trade outcomes (Baghdadi et al., 2013; Sorgho & Tharakan 2022, Abman et. al 2021, Abman et al., 2023; Zhou et al., 2017, Hoekman et al.,2022; Martinez Zarzoso & Kruse, 2019).

The rest of the paper is structured as follows: In Section 2 we present the data and key descriptive features. Section 3 presents our empirical specification. Section 4 describes the

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empirical results. Section 5 presents some additional analysis on particular subsamples of our data. Section 6 concludes.

2 Data and Descriptive Analysis

This study estimates the effects of specific environmental provisions in PTAs on UN-SDG outcomes. For this purpose, we construct a country-level panel dataset on environmental provisions in PTAs combined with data on UN-SDG indicators. Details of the data and key descriptive features are described below.

2.1 Environmental Provisions in PTA – SDG-related Provisions

Data on the specific environmental provisions found in Preferential Trade Agreement (PTAs) are sourced from the Trade and Environment Database (TREND) by Morin et. al (2018). This dataset manually codes the environmental norms in 630 PTAs signed between 1948 and 2018. The list of PTAs is based on the compilation from the Design of Trade Agreements Database (Dür et al., 2014). PTAs are assigned a binary code based on the presence or absence of 308 environmental norms. These 308 norms fall under 14 broad categories that are related to the environment including law and policy making, specific trade-related measures, enforcement measures, implementation and, most importantly, provisions on specific environmental issues. This dataset is therefore extremely detailed and provides information on very specific environmental norms, which enables us to link the SDG indicators to these specific issues in the PTAs very closely.

Below are two examples of provisions identified in the text of PTAs that have specific norms on water efficiency and greenhouse reduction norms.

Provision/ Norm	Text from PTA
GHG Reduction	***Korea-Peru, art. 19.8(2):"*** *2. For promoting sustainable development, each Party, within its own capacities, shall adopt policies and measures on issues such as: (b) research, promotion, development, and use of […] technologies of carbon dioxide capture.*

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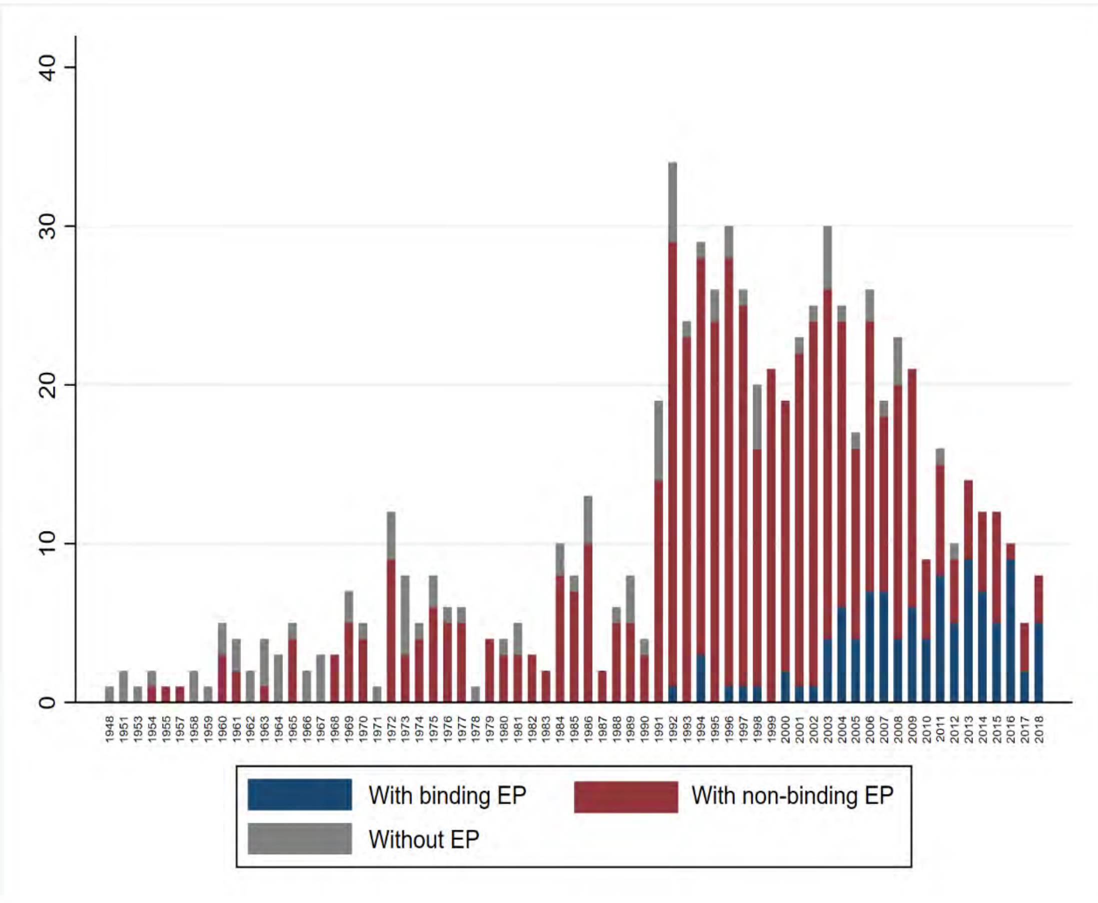
Water Efficiency	***CARIFORUM EC EPA**, art. 138(2)(a): "The Parties agree to cooperate […] in the following areas:* *(a) projects related to environmentally friendly products […], including those related to appropriate water-saving."*

Source : TREND (Morin et al, 2018).

A relevant dimension of our analysis concerns the differential impacts of binding and non-binding environmental provisions in PTAs. To be able to make this comparison, we define a PTA as having binding environmental provisions if it contains provisions that relate to active domestic enforcement of environmental norms or/ and contains punitive economic measures as part of its dispute settlement mechanism. These provisions must specifically refer to environmental commitments within the PTA for it to be classified as having binding environmental provisions.

Figure 1: Number of Trade Agreements with and without Environmental Provisions (EP)



Source: Authors' elaboration with data from TREND.

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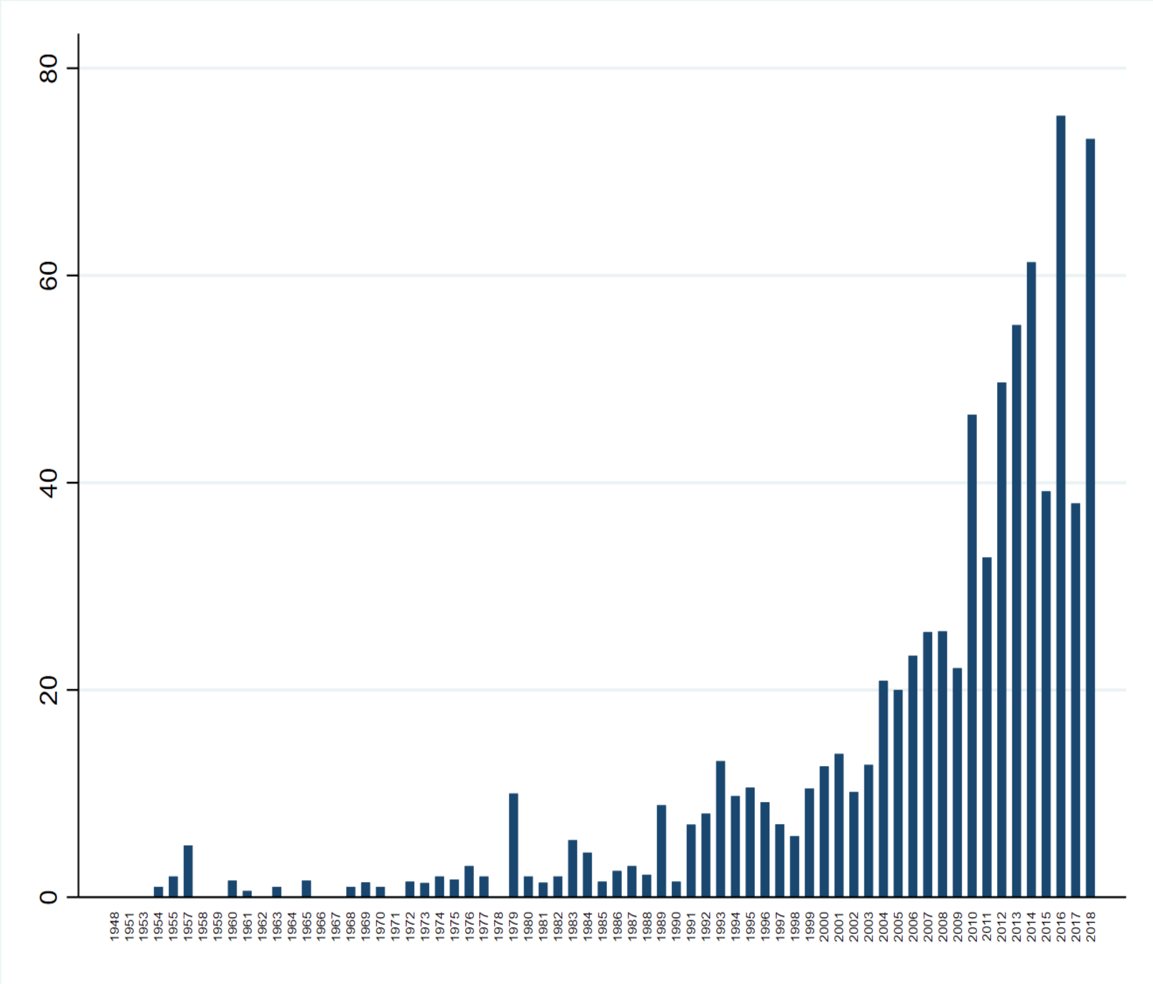
Figure 1 shows the number of PTAs that are included in our dataset over time. It differentiates between PTAs with binding and non-binding environmental provisions, and PTAs without any form of environmental provisions. Figure 2 presents the average number of environmental norms per trade agreement in each year.

Figure 2: Average number of Environmental Provisions per Trade Agreement



Source: Authors' elaboration with data from TREND.

Inspection of Figures 1 and 2 reveals four main features. The first is the rapid increase in the number of PTAs over time. After the year 1990, the number of PTAs that came into force annually saw a sharp increase, with more than 30 PTAs coming into force in 1992 alone. The number of PTAs signed after 1992 and until 2004 was (almost) always more than 20. Secondly,

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the increase in the number of PTAs coming into force is associated with the inclusion of environmental provisions in the majority of them. After 2008, all PTAs that came into force include environmental provisions (except for 2011 and 2012). Despite this recent trend, we note that PTAs have included some form of environmental provisions as far back as 1950s, although the share of PTAs without environmental provisions was clearly higher pre-1990 than after-1990. Third, note how PTAs started including binding environmental provisions only recently, in the early 1990s, but that since then the share of agreements with binding provisions has progressively grown, to the point that the majority of the most recent PTAs feature forms of enforcement of the environmental commitments in them.

The fourth and most relevant aspect for our research is the rapid increase in the average number of environmental provisions in PTAs since the early 2000s (depicted in Figure 2). This trend points to the move away from general clauses and provisions on the environment in PTAs, to more specific provisions that seek to address particular environmental concerns. This increase in the scope of environmental provisions in FTAs is also noted by Velut et al. (2022) in their comparative review of trade and sustainable development (TSD) provisions in trade agreements. They note that the range of specific environmental issues has increased, and now includes issues such as climate change, renewable energy, biodiversity, air pollution, and deforestation, among others.

2.2 Sustainable Development Goals (SDG) Indicators

The United Nations Sustainable Development Goals (SDG's) consist of 17 goals and 169 Targets. For the progress on the Goal/Targets to be measurable, the various targets are assigned indicator measures. For the purpose of our analysis, we focus on five SDGs and eight indicators that are related to environmental issues and for which data is available for a number of years adequate for our empirical approach.[2] We compiled data on SDG indicators from three main sources: the Food and Agricultural Organisation's (FAO), World Bank's World Development Indicators, and the 2018 Environmental Performance Index database.

[2] More details are provided in the section describing our empirical approach.

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Table 1: SDG indicators and linked specific environmental provision/norm

SDG	Indicators	Years	Specific Provision/ Norms
6 Clean Water and Sanitation	6.4.1 Total Water Efficiency	2000-2018	Promotion of water efficiency
	6.4.2 Water Stress	2000-2018	Management of rivers Transboundary waterways Management of aquifers and groundwater
7 Affordable and Clean Energy	7.2.1 Renewable Energy Share of Total Final Energy Consumption	1990-2018	Renewable energy production
	7.3.1 Energy Intensity Level of Primary Energy	2000-2018	Energy efficiency promotion
13 Climate Action	13.2.2 Total Greenhouse Gas Emissions	1990-2018	Greenhouse gas reduction
14 Life Below Water	14.4.1 Fish Stock Status	1990-2014	Combat illegal fishing Prevent pollution Conservation of fisheries
	14.5.1 Marine Protected Areas	2000-2017	On seas and oceans Protection of coastal areas On protected areas, parks and natural reserves
15 Life on Land	15.5.1 Species Protection Index	1990-2014	Endangered species Migratory species Shared species On protected areas, parks and natural reserves Biodiversity

Source: Authors' elaboration

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In selecting which SDG indicators to use for our analysis we take into consideration two main points. The first is that we focus on SDG indicators that can be directly linked to specific environmental provisions in PTAs. This required inspecting carefully both the descriptions and measurement of the various SDG indicators, as well as the rich Codebook of the TREND dataset. As an example, for SDG 7 which is concerned with affordable and clean energy, we consider indicator 7.2.1 (Renewable energy share of total final energy consumption), but not indicator 7.1.1 (Proportion of population with access to electricity), since the latter does not directly affect environmental quality and is not directly addressed in PTAs through specific provisions. The second criterion for the selection of only certain SDG indicators is data availability. We focus on indicators that have uninterrupted data series for a feasible period, i.e., a period which allows us to exploit our preferred estimation method.

Finally, we link the SDG outcome indicators we so identified with the specific provisions in PTAs that have the potential to directly influence a particular outcome. Table 1 provides a list of the SDGs we consider in our analysis, the years of data available and the specific provisions or norms in PTAs that we identified to have the potential to directly impact them. Certain SDGs indicators such as water efficiency and GHG reduction have only one related specific provision, while others such as water stress and Fish Stock Status have multiple related provisions. Our analysis ends in 2018 because of the time span of the environmental provision's dataset (1948-2018).

We present the main descriptive features of the final dataset in the next section, after detailing how the sample of analysis needed to be arranged for us to exploit the SDID estimator.

3 EMPIRICAL SPECIFICATION

The baseline empirical relationship between specific environment norms and UN-SDG outcomes is modelled by the following fixed effects specification.

$$SDG_{it} = \beta\, Provision_{it} + \delta\, X_{it} + \alpha_i + \gamma_t + \varepsilon_{it} \qquad (1)$$

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Equation (1) above models the environmental outcome of a country i at time t as a function of the presence of a specific provision related to the environmental indicator in a country's PTAs ($Provision_{it}$), various country-time specific characteristics (X_{it}), and country and time specific fixed effects α_i and γ_t . Our fixed effects variables capture time specific and country specific factors affecting the SDG outcomes that we cannot directly control for because we do not observe them. Other observable variables that we control for are the gross domestic product (GDP) of a country, level of openness to trade (a ratio of trade/GDP), population, per capita income, and the total number international environmental agreements a country is partner to at a certain point in time. These control variables could influence both the level of the environmental outcome in a country and its uptake or inclusion of certain specific provisions in its PTAs. GDP and GDP per capita are of relevance as higher levels of income can induce an improvement in the SDG indicator, and most certainly help matching treatment and control group countries more accurately. The level of trade openness is also a crucial control variable, as PTA membership can affect SDG outcomes through increased trade flows, as described in the introduction, other than through the effect of specific provisions. Finally, the number of international environmental agreements also deserves some more attention: non-trade provisions in PTAs could encourage the accession of countries to international agreements relevant to the specific non-trade issue, which can therefore be an indirect conduit whereby PTA provisions affect SDGs. This is known as the 'participation linkage' and was investigated by Lundberg et al. (2023), in the context of the Montreal protocol.

Our main coefficient of interest is β, which captures the average impact of having a specific provision in PTA on SDG outcomes.

$Provision$ is the treatment variable that takes the value 1 if a country has a preferential trade agreement which contains the specific norm. In essence, our baseline estimations compare the SDG outcomes of countries with a specific provision with that of countries without the provision, pre- and post-application of an environmental provision. We also define the treatment to differentiate between binding and non-binding provisions, to enable us to determine which types of provisions are driving the overall results.

Synthetic Difference-in-Differences (SDID)

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The empirical estimation of the causal effects of environmental provisions in PTAs on related SDG outcomes is potentially plagued with various concerns ranging from the non-random inclusion of provisions in PTAs, the staggered timing of the signing of PTAs, potential reverse causality, and data unavailability. More specifically, exploiting a standard difference-in-difference estimator to retrieve β in specification 1 risks yielding biased estimates due to a likely failure of the 'parallel trends assumption', i.e., the assumption that, in the absence of the treatment, average SDG outcomes for treated and control observations would have proceeded along parallel trends. To estimate a causal (and unbiased) impact of the PTA provisions, the issue boils down to being able to identify an appropriate counterfactual for the treated countries: for this reason, methods that generate synthetic control groups have become attractive in the literature.

To enable us to tackle the issues of endogeneity and identify a causal effect of environmental provisions on environmental indicators, we employ the synthetic difference-in-difference (SDID) estimator which was developed by Arkhangelsky et. al (2021). This method is attractive to use because it combines the features of the synthetic control methods and the difference-in-difference estimator. The SDID estimator assigns an appropriate counterfactual to treated groups (in this case countries that sign a PTA with the specific environmental provision) by computing units and time specific weights. In essence, for each treated unit, the SDID generates a synthetic version of that unit that was not treated or did not sign a PTA containing the specific provision, using the pool of untreated units. It assigns a synthetic version that replicates both the treated observation and time period over which the treatment occurred. The unit weight emphasises more similar control units, while the time weight balances pre- and post-treatment periods for control units. This enables the 'parallel trend assumption' of the difference-in-difference estimator to be satisfied. The method also allows for a staggered treatment approach, which is ideal for our setting of countries signing PTAs with environmental provisions at different points in time.

The SDID estimator computes parameters that minimises Equation (2) below.

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$$(\hat{\beta}^{sdid}, \hat{\alpha}, \hat{\gamma}, \hat{\mu}) = arg \min_{\beta,\alpha,\gamma,\mu} \left\{ \sum_{i=1}^{N} \sum_{t=1}^{T} (SDG_{it} - \beta\, Provision_{it} - \alpha_i - \gamma_t - \mu)^2 \; \hat{\omega}_i^{sdid} \; \hat{\tau}_t^{sdid} \right\} \quad (2)$$

where $\hat{\beta}^{sdid}$ is the average treatment effect of interest here, and $\hat{\omega}_i^{sdid}$ $\hat{\tau}_t^{sdid}$ are the unit and time weights, respectively. The SDID also allows us to use additional matching variables, to improve the match between the treated units and their synthetic untreated version. We use the vector of X_{it} variables from Equation (1) above as our matching variables. The SDID estimator also controls for time and unit fixed effects, α_i *and* γ_t .

The SDID estimator however necessitates a balanced panel featuring both pre- and post-treatment periods for the analysis. Based on the available years in the SDG outcome data, described in Table 1 above, we allocate pre-treatment and post-treatment periods of 5-years. For example: for an outcome variable with data over 1990-2018 (the observation period allowed by the SDG data) the analysis will be carried out using years from 1995 to 2013 as the treatment period, and therefore include PTAs signed over this period (treatment period). Countries that signed PTAs with relevant provisions over this period are considered treated; all the other countries, including those signing PTAs outside the treatment period, are used as control observations. We do not consider PTAs signed outside the treatment period and we drop countries that do not have information on SDG indicators. All this implies that a somewhat different sample is used in the estimation concerning different SDG outcomes.

Table 2 below presents key features of the PTAs that we include in the SDID estimations. It presents the number of PTAs we consider for the estimation for each specific environmental provision, the number that are either EU or US PTAs, the average age of the PTAs, the average depth (measured as the average number of all environmental provisions in the PTA) and the number of PTAs classified as having binding provisions. There exists a lot of heterogeneity in the PTAs containing different provisions. For instance, for a provision such as combatting illegal fishing, only one PTA is identified within our treatment period, while others such as renewable provisions are found in as many as 53 PTAs. EU agreements tend to be rather numerous for particular subsets of provisions, such as those on transboundary waterways (three out of four agreements featuring this provision), renewable energy production, energy

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efficiency promotion, GHG reduction, conservation of fisheries, and biodiversity. US agreements, conversely, are more numerous among PTAs featuring provisions on endangered species, migratory species, protection of parks and natural reserves, and notably only 1 PTA with GHG reduction provisions is among those signed by the US.

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Specific Provision	Number of PTAs with Provisions						
	Total	EU	US	Bilat.	Avg. Age	Avg. Depth	Bind.
Water efficiency	5	1	1	3	8.6	70.2	4
Management. of Rivers	5	1	0	3	8.8	74.4	4
Transboundary Waterways	4	3	0	4	9	40.75	1
Aquifers and groundwater	4	0	1	3	10.75	60	3
Renewable energy production	53	23	5	41	11.98	46.81	27
Energy efficiency promotion	26	9	1	16	8.85	51.73	18
GHG Reduction	22	8	1	17	9	55.59	14
Combat illegal fishing	1	0	0	1	9	47	0
Prevent pollution from fishing	2	1	0	1	18.5	38.5	0
Conservation of fisheries	33	12	4	27	14	47.09	15
Seas and Oceans	39	5	2	32	9.46	50.72	24
Protection of coastal areas	10	1	1	9	9.8	58.3	8
Protected areas, parks, and natural reserves (MPA)*	20	4	3	13	9	64.15	15
Endangered species	12	0	9	9	14	74.5	12
Migratory species	5	0	5	3	13	79	5
Shared Species	5	0	3	1	15	71.8	3
Protected areas, parks, and natural reserves (SPI)*	24	5	7	17	14.88	57.13	16
Biodiversity	42	11	6	32	14.1	52.12	22

Table 2: Characteristics of PTAs with Specific Provisions in Analysis

Notes: EU agreements are considered bilateral agreements. The average depth is computed as the average number of all environmental provisions in the agreements featuring a specific provision. *The provision on protected areas, parks and natural reserves is linked to two SDG indicators, Marine Protected Areas (MPA) and Species Protection Index (SPI). The number of PTAs used differ for both indicators because of data coverage.
Source: Authors' elaboration on TREND data matched with SDG outcome data.

In Table 3, we present summary statistics of the eight SDG indicators used in our analysis based on our final estimation samples. Again, note that the sample of analysis differs across the indicators, as a consequence of the uneven data availability, both across countries and over time.

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Table 3: Descriptive Statistics of SDG Indicators

SDG Indicators	Obs.	Mean	SD	Min	Max
6.4.1 Total Water Efficiency	1,140	35.011	44.872	0.310	261.84
6.4.2 Water Stress	1,444	44.601	112.683	0.200	992.833
7.2.1 Renewable Energy Share of Total Final Energy Consumption	3,277	36.992	30.980	0	98.304
7.3.1 Energy Intensity Level of Primary energy	2,204	5.193	2.825	1.350	26.910
13.2.2 Total Greenhouse Gas Emissions	3,306	10.415	2.123	3.689	16.339
14.4.1 Fish Stock Status	1,950	23.793	20.060	0	100
14.5.1 Marine Protected Areas	1,620	5.838	12.586	0	99.551
15.5.1 Species Protection Index	2,700	10.986	5.269	0	17

***Notes**: Total GHG Emissions is logged. Detailed description of variables in appendix.*

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4 Estimation Results

In Tables 2 to 11 we present the impact of specific PTA provisions on the various SDGs indicators. To show how results differ between a standard difference-in-difference or two-way fixed effects estimator and the SDID, columns (1) - (3) of each table presents the results from the standard estimator (Equation 2). In column (1) we present the estimate of being part of an FTA with a specific provision obtained on the aggregate sample; in column (2) and (3) we break down the estimation between the subsamples of PTAs where the provisions are binding and non-binding, respectively. In all three cases, the control or base group consists of countries that signed PTAs within the period under consideration that did not contain a specific provision.[3] Columns (4)-(6) present a similar structure, and present results obtained with the SDID. Given the properties of the SDID estimator described above, the differences between columns (1)-(3) and columns (4)-(6) are due to the corrections operated on the control group, to alleviate several endogeneity concerns. In case where the differences between the DiD and the SDID are very small, we can consider endogeneity to be less of an issue. Nonetheless, our preferred results are the average treatment effects reported in Column (4) to (6).

The impact of having a specific provision on SDG indicators varies across the SDG indicators under consideration and the nature of the provision. On the one hand, provisions on the promotion of renewable energy production, combatting illegal fishing, reducing greenhouse gas emissions, water stress, and the protection of parks and natural reserves are found to have a statistically significant impact on their related outcome. For many provisions, instead, we fail to find statistically significant effects, although in a number of cases we obtain coefficients that take the correct sign: this is the case for provision on transboundary waterways, energy efficiency, and provisions on migratory and endangered species. The effects also differ when we consider the heterogenous effects of binding vs non-binding provisions. Detailed elaborations for each SDG indicator follow below.

[3] This modelling choice restricts the sample of analysis to countries that have signed PTAs during the treatment period and excludes countries that did not enter into new PTAs. This is motivated by our intention to restrict the analysis to countries that all become part of PTAs (with/without specific environmental provisions), and are thereby similarly exposed to changes in trade, investment and economic activity that accompanies the signature of PTAs and could at the same time affect SDG outcomes.

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4.1 Results for SDG 6: Clean Water and Sanitation

Table 4 and 5 present the estimation results for the two outcome indicators that fall under SDG 6 (Clean Water and Sanitation): Total Water Efficiency (indicator 6.4.1) and Water Stress, (indicator 6.4.2) respectively.

Water Efficiency is defined as value added divided by the volume of water used. It is measured in dollars per cubic metre, and higher values denote a more efficient use of water. For this indicator, we obtain the counterintuitive result that countries in PTAs with specific provisions on water efficiency turn to be less water efficient. The sign of the estimates is consistent for both the standard DID (Column 1) and SDID (Column 4) estimators, with the SDID average effects being almost 5 times that of the DID estimates. The impact on the aggregate sample is not statistically significant, however. When we consider the differential impacts of binding vs. non-binding provision, we find the impact for non-binding provision to be weakly statistically significant at the 10% significance level. Having a non-binding specific provision on water efficiency reduces total water efficiency by 2.3 dollars per cubic meter on average. Binding provisions are instead to have no effect, with the size of the coefficient being close to that of the aggregate sample.

Table 4: Impact of Specific Provision on Promotion of Water Efficiency on Total Water Efficiency

SDG indicator	**Water Efficiency**					
Estimator	**Standard DID**			**Synthetic DID**		
Treatment	Prov.	Binding prov.	Non-Binding prov.	Prov.	Binding prov.	Non-Binding prov.
	(1)	(2)	(3)	(4)	(5)	(6)
Water Efficiency	-1.292	-0.828	-5.735***	-7.250	-7.708	**-2.334***
	(3.32)	(3.60)	(2.11)	(4.83)	(4.98)	(1.28)
Observations	1140	1120	924	1140	1102	760
Groups	60	60	60	60	58	40

Notes: All models include country FE and year FE, and a list of control variables (DID models), or matching variables (SDID models), which include: GDP, Population, GDP per Capita, Trade (% of GDP), and IEA. Standard errors in parentheses: the Standard DID standard errors are clustered at the

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country level; the SDID standard errors are bootstrapped with 50 repetitions. * p< 0.10, ** p<0.05, *** p< 0.01.

Table 5: Impact of Specific Provisions on Management of Rivers, Transboundary Waterways and Aquifers (Groundwater) on Water Stress

SDG indicator	Water stress					
Estimator	Standard DID			Synthetic DID		
Treatment	Prov.	Binding prov.	Non-Binding prov.	Prov.	Binding prov.	Non-Binding prov.
	(1)	(2)	(3)	(4)	(5)	(6)
Management of rivers	-2.867	-3.590	0.719	-0.960	**-1.460****	1.483
	(2.22)	(2.50)	(3.41)	(0.63)	(0.69)	(1.79)
Observations	1843	1793	1594	1843	1748	1216
Groups	97	97	97	97	92	64
Transboundary waterways	-4.225	-3.265*	-4.403	-1.620	-0.345	-1.668
	(2.64)	(1.80)	(2.82)	(1.40)	(0.86)	(1.12)
Observations	1843	1520	1831	1843	1330	1805
Groups	97	97	97	97	70	95
Management of Aquifers & groundwater	2.802	2.487	2.760	4.073	4.868	2.850*
	(3.56)	(5.15)	(3.53)	(3.00)	(4.64)	(1.54)
Observations	1843	1813	1793	1843	1786	1767
Groups	97	97	97	97	94	93

Notes: All models include country FE and year FE, and a list of control variables (DID models), or matching variables (SDID models), which include: GDP, Population, GDP per Capita, Trade (% of GDP), and IEA. Standard errors in parentheses: the Standard DID standard errors are clustered at the country level; the SDID standard errors are bootstrapped with 50 repetitions. * p< 0.10, ** p<0.05, *** p< 0.01.

Table 5 presents the results for Water Stress. This indicator is measured as freshwater withdrawals as a proportion of available freshwater resources, and is a measure of the demand for water relative to its supply. We therefore expect a negative effect from PTA provisions. The result in Column (5) of Table 5 suggest that only binding provisions on management of rivers seem to be effective in reducing water stress, on average. Specific provisions on the management of transboundary waterways have no statistically significant impact, although the sign of the effects is in the desired direction. Non-binding specific provision on the management of aquifers and groundwater seem to be increasing the pressure on water sources, rather than reducing it, although again binding provisions are found to have no statistically significant effect.

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Taken together, for the outcomes related to SDG 6, only the provisions on the management of rivers appear to lead to an improvement in their related SDG outcome indicators. We also obtain some counterintuitive results, with provisions having the opposite effect as expected, although only for non-binding provisions: a more benign interpretation of this latter finding could be that binding provisions at least prevent a deterioration of SDG 6 outcomes, unlike non-binding provisions.

4.2 Results for SDG 7: Affordable and Clean Energy

Tables 6 and 7 present the estimation results for SDG 7 (Affordable and Clean Energy). The two indicators considered are Renewable Energy Share of Total Final Energy Consumption (indicator 7.2.1) and Energy Intensity (indicator 7.3.1).

The renewable energy share in total final consumption is the percentage of final consumption of energy that is derived from renewable resources, therefore a positive impact of specific PTA provisions is expected.

Table 6: Impact of Specific Provisions on Renewable Energy Production on Renewable Energy in Energy mix

SDG indicator	**Renewable Energy Share of Total Energy Consumption**					
Estimator	**Standard DID**			**Synthetic DID**		
Treatment	Prov.	Binding prov.	Non-Binding prov.	Prov.	Binding prov.	Non-Binding prov.
	(1)	(2)	(3)	(4)	(5)	(6)
Renewable energy	1.241	3.249*	1.744	2.926*	1.442	0.886
	(1.10)	(1.71)	(1.38)	(1.73)	(0.98)	(2.38)
Observations	3277	2139	2788	3277	1131	2001
Groups	113	113	113	113	39	69

Notes: All models include country FE and year FE, and a list of control variables (DID models), or matching variables (SDID models), which include: GDP, Population, GDP per Capita, Trade (% of GDP), and IEA. Standard errors in parentheses: the Standard DID standard errors are clustered at the country level; the SDID standard errors are bootstrapped with 50 repetitions. * $p< 0.10$, ** $p<0.05$, *** $p< 0.01$.

Countries that are partners of PTAs which feature a specific provision on renewable energy production have a higher share of renewable energy in their final energy consumption, on

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average. More specifically, the presence of renewable energy provisions in PTAs results in an increase of approximately 2.9 percentage points in the share of renewable energy out of the total. This result brings support to the use of trade policy as a tool to promote cleaner energy, although the effects that we estimate are somewhat imprecise, possibly due to a rather small sample. When we separate the effects (and the sample) by PTAs with binding and non-binding provisions, we fail to estimate a statistically significant effect on either of the subsamples. The coefficient on subsample of PTAs with binding provisions (column 5) is, however, closer to that of the aggregate sample, and likely to drive the results in column 4.

Table 7 presents the results for Energy Intensity, an indicator of the Energy Efficiency SDG target. This indicator is calculated by dividing energy consumption by Gross Value Added and represents how much energy is used to produce one unit of economic output. So, we expect PTA provisions to have a positive effect on this indicator.

Table 7: Impact of Specific Provision on Promoting Energy Efficiency on Energy Intensity of Primary Energy

SDG Indicator	**Energy Efficiency of Primary Energy**					
Estimator	**Standard DID**			**Synthetic DID**		
Treatment	Prov.	Binding prov.	Non-Binding prov.	Prov.	Binding prov.	Non-Binding prov.
	(1)	(2)	(3)	(4)	(5)	(6)
Energy Efficiency	0.495**	0.577**	0.084	0.039	0.199	-0.184
	(0.20)	(0.25)	(0.16)	(0.21)	(0.15)	(0.46)
Observations	2204	2082	1646	2204	1596	1197
Groups	116	116	116	116	84	63

Notes: All models include country FE and year FE, and a list of control variables (DID models), or matching variables (SDID models), which include: GDP, Population, GDP per Capita, Trade (% of GDP), and IEA. Standard errors in parentheses: the Standard DID standard errors are clustered at the country level; the SDID standard errors are bootstrapped with 50 repetitions. * $p< 0.10$, ** $p<0.05$, *** $p< 0.01$.

Energy efficiency provisions show a positive and statistically significant impact on energy efficiency when we consider the standard DID estimates in column (1) and (2). However, for our preferred SDID estimator that accounts for endogeneity issues we do not find any statistically significant impact of having energy efficiency provisions in PTAs on the level of

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a country's energy intensity. Albeit insignificant, the coefficient in column (5) estimated for PTAs with binding provisions exhibits a positive coefficient, in line with our expectation.

4.3 Results for SDG 13: Climate action

Table 8 presents the results for Total Greenhouse Gas (GHG) Emissions (SDG 13.2.2) which is an indicator under SDG 13 (Climate Action). This indicator is measured as kilo-tonnes of CO_2 equivalents, and comprises CO_2 (Carbon Dioxide), CH4 (Methane), Nitrous Oxide (N_2O) and Fluorinated Gases (F-Gases). We therefore expect a negative impact of PTA provisions on GHG emissions reduction.

Table 8: Impact of Specific Provision on Reduction of Greenhouse Gas Emissions on Total GHG Emissions

SDG indicator	**Total GHG emissions**					
Estimator	**Standard DID**			**Synthetic DID**		
Treatment	Prov.	Binding prov.	Non-Binding prov.	Prov.	Binding prov.	Non-Binding prov.
	(1)	(2)	(3)	(4)	(5)	(6)
GHG reduction	-0.083**	-0.195***	-0.030	-0.221***	-0.077**	-0.118
	(0.04)	(0.05)	(0.04)	(0.04)	(0.03)	(0.09)
Observations	3306	3072	2895	3306	2610	2088
Groups	114	114	114	114	90	72

Notes: All models include country FE and year FE, and a list of control variables (DID models), or matching variables (SDID models), which include: GDP, Population, GDP per Capita, Trade (% of GDP), and IEA. Standard errors in parentheses: the Standard DID standard errors are clustered at the country level; the SDID standard errors are bootstrapped with 50 repetitions. * $p< 0.10$, ** $p<0.05$, *** $p< 0.01$.

For this indicator we find the most robust impact of PTA provisions: under both the standard DID and the SDID, we find a large, negative, and very precisely estimated impact of provisions on GHG reduction on GHG emissions. For this indicator we have expressed the dependent variable in logs which implies that, on average, being part of a PTAs with provisions on GHG reduction leads to 22% less total GHG emissions (coefficient in column 4). For the SDID estimator, the result is again negative and significant for the subsample of PTAs with binding provisions; the coefficient estimated on the subsample of PTAs with non-binding provisions is larger and marginally closer to that obtained on the aggregate sample, although not significant at the conventional levels.

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For this SDG, which has been subject of analysis in previous studies, our findings are in line with those of Baghdadi et al. (2013) and Sorgho & Tharakan (2022).

4.4 Results for SDG 14: Life below water

Tables 9 and 10 presents the results for SDG 14 (Life Below Water). Here we inspect the impact of PTAs on two indicators: Fish stock status (indicator 14.4.1) and Marine Protected Areas (indicator 14.5.1). The fish stock status measures the percentage of a country's total catch that come from overexploited or collapsed stocks. We therefore expect negative impact of PTA provisions.

Table 9: Impact of Specific Provisions on Combating Illegal Fishing, Preventing Pollution and Conservation of Fisheries on Fish Stock Status

SDG indicator	**Fish stock status**					
Estimator	**Standard DID**			**Synthetic DID**		
Treatment	Prov.	Binding prov.	Non-Binding prov.	Prov.	Binding prov.	Non-Binding prov.
	(1)	(2)	(3)	(4)	(5)	(6)
Combat illegal fishing			-9.916*			**-5.899*****
			(5.85)			(2.14)
Observations			1950			1950
Groups			78			78
Prevent Pollution			0.456			3.537
			(4.87)			(4.15)
Observations			1950			1950
Groups			78			78
Conservation of fisheries	-2.503	1.763	-3.349	0.858	4.044	-6.157*
	(2.26)	(3.77)	(2.53)	(2.52)	(3.96)	(3.61)
Observations	1950	1387	1707	1950	800	1225
Groups	78	78	78	78	32	49

Notes: All models include country FE and year FE, and a list of control variables (DID models), or matching variables (SDID models), which include: GDP, Population, GDP per Capita, Trade (% of GDP), and IEA. Standard errors in parentheses: the Standard DID standard errors are clustered at the country level; the SDID standard errors are bootstrapped with 50 repetitions. * $p < 0.10$, ** $p<0.05$, *** $p< 0.01$.

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We identify three provisions in the TRENDS data that can be directly linked to this indicator, on Combatting illegal fishing, Preventing pollution, and on the Conservation of fisheries. For the first two provisions we do not find PTAs where they can be considered legally binding.

The estimation results are similar between the standard and the synthetic estimators and suggest a negative and significant effect of provisions on Combatting illegal fishing and the Conservation of fisheries. Importantly, the effect comes from PTAs where the provisions are non-binding. This result in encouraging, as it suggests a positive role for PTAs to play in the conservation of fish stocks, possibly achieved through a cooperative approach.

The effect of PTA provisions on Marine Protected Areas is shown in Table 10. This indicator is measured as the percentage of a country's Economic Exclusion Zones (EEZ) that are set aside as marine protected areas. Therefore, we expect a positive impact of PTA provisions related to this indicator.

Table 10: Impact of Specific Provisions on Seas and Oceans, Protection of Coastal Areas and Protected Areas on Marine Protected Areas

SDG indicator	**Marine Protected Areas**					
Estimator	**Standard DID**			**Synthetic DID**		
Treatment	Prov.	Binding prov.	Non-Binding prov.	Prov.	Binding prov.	Non-Binding prov.
	(1)	(2)	(3)	(4)	(5)	(6)
Seas and Oceans	1.299	1.540	-1.421*	-4.986	-6.413	-0.670
	(0.83)	(1.01)	(0.81)	(3.99)	(4.79)	(1.81)
Observations	1620	1548	1110	1620	1422	702
Groups	90	90	90	90	79	39
Protection of coastal areas	1.587*	1.573	-5.163	-10.039	-11.264	-1.075
	(0.93)	(0.97)	(3.72)	(7.38)	(6.97)	(3.64)
Observations	1620	1606	1372	1620	1584	990
Groups	90	90	90	90	88	55
Protected areas, parks, natural reserves	2.895***	2.700***	11.406**	2.901**	2.710**	18.240***
	(0.93)	(0.93)	(4.73)	(1.23)	(1.31)	(0.98)
Observations	1620	1607	1157	1620	1566	774
Groups	90	90	90	90	87	43

Notes: All models include country FE and year FE, and a list of control variables (DID models), or matching variables (SDID models), which include: GDP, Population, GDP per Capita, Trade (% of GDP), and IEA. Standard errors in parentheses: the Standard DID standard errors are clustered at the

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country level; the SDID standard errors are bootstrapped with 50 repetitions. * p< 0.10, ** p<0.05, *** p< 0.01.

Out of the three provisions that we consider can be linked directly to this outcome, we find that only provisions on Protected areas, parks and natural reserves have a positive and statistically significant effect. On the aggregate sample, we find that being a member of a PTA with this provision leads to a 2.9 percentage point higher share of EEZs set aside as marine protected areas. The effect is also significant for the subsample of PTAs with binding provisions, and of a similar magnitude. On the subsample of PTAs with non-binding provision we again find a positive and significant effect, but the magnitude is a great deal larger. Note, however, that the sample on which we estimate the latter coefficient is smaller than that for binding provisions.

4.5 Results for SDG 15: Life on land

Table 11 presents the estimation for SDG 15 (Life on Land), and the indicator we use in our analysis is the Species protection index (indicator 15.5.1).

This indicator measures how well a country's terrestrial protected areas overlap with the ranges of its vertebrate, invertebrate, and plant species, so we would expect a positive impact of PTA provisions. We have selected five specific provisions to relate to this indicator, but for none of them we find a statistically significant and positive impact.

Table 11: Impact of Specific Provisions on Endangered Species, Migratory Species, Shared Species, Protected areas, and Biodiversity on Species Protection Index

SDG indicator	Species Protection Index					
Estimator	Standard DID			Synthetic DID		
Treatment	Prov.	Binding prov.	Non-Binding prov.	Prov.	Binding prov.	Non-Binding prov.
	(1)	(2)	(3)	(4)	(5)	(6)
Endangered Species		-0.695			0.346	
		(0.76)			(0.71)	
Observations		2700			2700	
Groups		108			108	

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Migratory Species		-0.665			0.657	
		(0.94)			(0.99)	
Observations		2700			2700	
Groups		108			108	
Shared Species	-0.893	-0.752	-1.110	0.066	0.704	-0.548
	(0.78)	(1.15)	(0.89)	(0.70)	(1.15)	(0.99)
Observations	2700	2610	2615	2700	2550	2500
Groups	108	108	108	108	102	100
Protected areas, parks and natural reserves	0.202	-0.245	0.316	0.615	-0.000	-1.136***
	(0.46)	(0.59)	(0.58)	(0.54)	(0.56)	(0.30)
Observations	2700	2435	2355	2700	2150	1725
Groups	108	108	108	108	86	69
Biodiversity	-0.011	-0.679	-0.141	0.245	0.159	0.068
	(0.37)	(0.58)	(0.44)	(0.51)	(0.47)	(0.54)
Observations	2700	1886	2347	2700	1150	1675
Groups	108	108	108	108	46	67

Notes: All models include country FE and year FE, and a list of control variables (DID models), or matching variables (SDID models), which include: GDP, Population, GDP per Capita, Trade (% of GDP), and IEA. Standard errors in parentheses: the Standard DID standard errors are clustered at the country level; the SDID standard errors are bootstrapped with 50 repetitions. * p< 0.10, ** p<0.05, *** p< 0.01.

5 Further Analysis - Mechanisms

The results in section 4 suggest that specific SDG-related provisions in PTAs have a very heterogenous effect on their specific environmental SDG outcomes. Some provisions are found to have their intended (positive or negative) effect, other provisions are found to have no statistically significant effect, and in a small number of cases we find counterintuitive results pointing in a direction which is opposite to the expected one. Similarly, the breakdown of the impacts depending on the legal enforceability of the provisions, i.e., what we refer to as binding or non-binding provisions, did not suggest that one approach is always superior to the other. Perhaps contrary to expectations, we find that non-binding provisions are those more often driving the statistically significant results obtained in the aggregate sample.

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Trying to summarize these findings and condense them into policy recommendations is therefore rather challenging. To shed some light on mechanisms or channels that could tie these heterogeneous results together, we perform a number of additional exercises and present the results in this section.

In a nutshell, we repeat the main estimations using the SDID estimators for various subsamples of PTAs, in the attempt to determine if there are any special features of the PTAs in terms of membership, age and assistance provisions of the agreements that can help explain why certain provisions have an effect on the SDGs while others do not. We perform this analysis by considering the age of PTAs that contain specific provisions, if PTAs have been negotiated by the EU, the US or other third countries, or if the effects depend on the presence of technical or financial assistance provisions related to environment matters.

For conciseness, we focus here on the three provisions that are found to have an effect on their respective SDG indicators in the aggregate sample: 'Promotion of renewable energy production', 'Reduction of total greenhouse gas emissions', and 'Protected areas, parks, and natural reserves'. We exclude the provision on combatting illegal fishing for which we found to influence the fish stock status because there is only one PTA with this provision for the period we consider in our analysis.

5.1 Age of PTAs

The age of the agreements is potentially an interesting dimension for two reasons. On the one hand, as we define countries as treated as soon as the first PTA of a certain kind (i.e. with a specific SDG-related provision) enters into force, it could be that older agreements show larger effects, as these countries took commitments towards a certain outcome before countries that are members of newer agreements. On the other hand, newer agreements tend be much deeper and more likely to include binding provisions. So, it is not a-prior clear whether older or younger agreements might affect SDG outcomes more.

Our research design, involving the use of the SDID estimator requiring both pre- and post-treatment windows, together with the relatively short and unequal time series of SDG outcome indicators data (see Table 1 above), significantly constrained our options for how to split the estimation sample along the PTA age dimension. We therefore opted for a criterion that would

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allow us to make a similar sample split across the various provisions and opted for estimating our models separately for PTAs that are more or less than 10 years old. This implies that, for the various indicators, the sample split occurred around 2008.[4] Table 12 presents the results for the three provisions we focus on in this section.

Table 12: Effect by Older and Newer PTAs

	(1)	(2)
PTAs in force over:	**1995-2008**	**2009-2013**
SDG indicator: Renewable energy in energy mix		
Renewable Energy	2.617*	2.804***
	(1.36)	(0.69)
Observations	3277	1798
Groups	113	62
PTAs in force over:	**1995-2008**	**2009-2013**
SDG indicator: Total GHG emissions		
GHG Reduction	-0.244***	-0.104***
	(0.04)	(0.03)
Observations	3306	1798
Groups	114	62
PTAs in force over:	**2005-2007**	**2008-2012**
SDG indicator: Marine protected areas		
Protected areas, parks, natural reserves	2.806	2.485**
	(3.74)	(1.15)
Observations	1242	1476
Groups	69	82

Notes: All models are estimated via SDID. All models include country FE and year FE, and a list of matching variables which include: GDP, Population, GDP per Capita, Trade (% of GDP), and IEA. Standard errors (in parentheses) are bootstrapped with 50 repetitions. * p< 0.10, ** p<0.05, *** p< 0.01.

Overall, the effects estimated for the two subsamples of older and newer agreements display similar patterns as the baseline estimations presented in Section 4. For provisions on

[4] For provisions on the reduction of GHG emissions and the promotion of renewable energy production, this is defined as pre-2008, while for the provision on protected areas, parks, and natural reserves this is pre-2007.

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'Renewable energy' and ', we observe that the impacts are more significant on the subsample of PTAs that are less than a decade old. Specifically, for 'Protected areas', the impact of older PTAs is statistically insignificant, while the effect of the Renewable energy' provisions is larger and more statistically significant in the more recent PTAs.

Provisions on the 'GHG emissions reduction' show a different pattern, as the effect is significant for both groups of agreements, but the magnitude is twice as large for older PTAs than for newer PTAs. In sum, our results do not point in a unique direction. Provisions on the reduction GHGs are numerous and it is plausible that, due to the visibility of this target, countries that took these commitments started acting on them early on. Younger PTAs seem to be more effective concerning targets in renewable energy and marine protected areas.

5.2 EU, US, and Other Countries PTAs

Another dimension that might be of relevance is the membership of the PTAs. Big economies such as the EU and the US are notoriously demanding in terms of non-trade provisions they negotiate in their PTAs (Lechner, 2018). For this reason, we inspect whether, for the provisions we found to be affecting their related SDG outcome, EU or US agreements are particularly effective. Estimation results are presented in Table 13.

The effect for the specific provision on 'Renewable energy' is driven entirely by other countries PTAs, while the average treatment effect for EU and US is found to be insignificant effect. Note, however, that while the coefficient for EU agreements is similar to that of the aggregate sample, the coefficient for US agreements is negative.

For 'GHG reduction', while all three sets of agreements are found to have the expected negative and significant effect, EU PTAs are clearly driving the baseline result obtained in the aggregate sample (table 8 above).

Finally, we find that the impact of US PTAs with provisions on 'Protected areas, parks and natural reserves' have a very large and strongly significant effect on the Marine protected areas outcome. US PTAs featuring this provision improve the Marine Protected Areas index of a treated country by as much as 12.2%, in comparison to 2.7% and 2.8% for EU and other third countries, respectively.

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Taken together, results in Table 13 confirm that, in two out three of the provisions we analyse, PTAs having either the EU or the US among their member are more effective at achieving their non-trade target.

Table 13: Effect by Member Countries

	(1)	(2)	(3)
Key member countries	EU	US	Others
SDG indicator: Renewable energy in energy mix			
Renewable Energy	2.738	-1.180	2.000**
	(1.84)	(2.59)	(0.92)
Observations	2610	754	1189
Groups	90	26	41
SDG indicator: Total GHG emissions			
GHG Reduction	-0.261***	-0.125*	-0.063**
	(0.04)	(0.07)	(0.02)
Observations	2842	2030	2378
Groups	98	70	82
SDG indicator: Marine protected areas			
Protected areas, parks, natural reserves	2.713*	12.217***	2.823***
	(1.40)	(0.43)	(0.39)
Observations	1314	774	1044
Groups	73	43	58

Notes: All models are estimated via SDID. All models include country FE and year FE, and a list of matching variables which include: GDP, Population, GDP per Capita, Trade (% of GDP), and IEA. Standard errors (in parentheses) are bootstrapped with 50 repetitions. * p< 0.10, ** p<0.05, *** p< 0.01.

5.3 Technical and Financial Assistance Provisions Related to the Environment

Lastly, we compare outcomes for countries that signed PTAs containing either financial or technical assistance provisions, as well as the specific SDG-related provisions, with outcomes of countries that signed PTAs that did not contain the specific SDG-related provision.

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Technical and financial assistance could be relevant conduits to enable countries to make tangible progress on environmental outcomes, and therefore complement the effect of non-trade provisions. We classify a PTA is as having a technical provision if it contains norms related to technical assistance, capacity building and technology transfer in environmental issues. Similarly, we classify a PTA as having a financial provision if it contains norms that speak to funding capacity building, training, technical assistance, other co-operation activities and providing financial assistance to other non-state actors, in environmental issues. We present the effects in Table 14 below.

Table 14: Effects by PTAs With or Without Financial and Technical Assistance Provisions

	(1)	(2)	(3)	(4)
Type of assistance	Financial		Technical	
	Yes	No	Yes	No
SDG indicator: Renewable Energy in energy mix				
Renewable Energy	1.852	0.938	2.795	1.781
	(1.19)	(2.19)	(1.82)	(1.58)
Observations	1102	2059	2842	783
Groups	38	71	98	27
SDG indicator: Total GHG emissions				
GHG Reduction	-0.064	-0.057*	-0.065*	-0.102
	(0.04)	(0.03)	(0.03)	(0.07)
Observations	2436	2233	2639	2059
Groups	84	77	91	71
SDG indicator: Marine protected areas				
Protected areas, parks, natural reserves	2.687**	5.611***	2.716	4.404***
	(1.34)	(0.47)	(1.67)	(0.45)

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Observations	1476	828	1386	936
Groups	82	46	77	52

Notes: All models are estimated via SDID. All models include country FE and year FE, and a list of matching variables which include: GDP, Population, GDP per Capita, Trade (% of GDP), and IEA. Standard errors (in parentheses) are bootstrapped with 50 repetitions. * p< 0.10, ** p<0.05, *** p< 0.01.

Columns 1 and 2 display results for PTAs with and without financial provisions, respectively. Columns 3 and 4 show the effects of PTAs with and without technical provisions, respectively. We do not find much evidence of technical or financial provisions related to environmental issues driving the effects we observe in our baseline estimations. For financial provisions, the effects are statistically significant for the provision on 'Protected areas, parks and natural reserves'. Likewise, we only find weak effects for the inclusion of technical assistance provisions for the case of the reduction of GHG emissions.

6 CONCLUSION

In this paper we perform a rigorous empirical investigation of the effect of including SDG-related provisions in PTAs on their intended outcomes. Unlike the majority of the literature focusing on a particular outcome (e.g. deforestation), we take a broad approach and study impacts on several SDG indicators, but with an overall focus on environmental issues.

We match detailed information on the environmental content of PTAs with data on specific SDG indicators, in the attempt to relate PTA provisions with their direct non-trade outcome as closely as possible. We also address several econometric concerns that affect the empirical estimation exploiting a Synthetic Difference-in-Difference estimator, as recently done by the related work of Francois et al., (2022).

We find very heterogeneous results across the various PTA provisions and SDG outcomes, which do not allow us to come to general conclusions about the effectiveness of trade agreements in pursuing environmental outcomes.

The strongest and most consistent results across several specifications are those obtained for the impact of provisions on the reduction of Greenhouse Gases (GHG): for these, we find large,

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negative, and statistically significant effects on the level of total GHG emissions. This result is estimated more precisely for the subsample of PTAs that contain legal enforcement mechanisms (e.g. binding provisions), although similar effects are found for PTA with non-binding provisions. The effect on GHG reduction is driven by PTAs negotiated by the EU, older PTAs, and PTAs that include provisions on technical assistance in environmental issues. Also, provisions on the production of renewable energy, the sustainability of fish stocks, and the protection of parks and natural areas are found to have a significant impact on their related SDG outcomes, but results are less consistent across specifications.

The models that distinguish between PTAs that make environmental provisions binding or non-binding are, again, not entirely uniform in suggesting that one strategy (e.g. binding provisions) is superior to the other in achieving its objective. However, we find that the majority of the statistically significant effects arise on the subsamples of PTAs with non-binding provisions: this result is potentially of relevance as it suggests that, in environmental matters, a cooperative approach is likely to be more successful in order to make progress towards the attainment of SDGs.

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APPENDIX

SDG Indicators

- **Total Water Use Efficiency** is measured as dollars per cubic meter ($/m3). Higher values denote more efficient use of water. Data obtained from FAO.
- **Water stress** is when demand for safe usable water exceeds its supply. It is measured as freshwater withdrawal as a proportion of available freshwater resources. Water is mainly demanded for agriculture, industrial and domestic use. Sources of supply include rivers, lakes, and aquifers. Data obtained from FAO.
- **Renewable energy** consumption as a percentage of total final energy consumption. Data is from the World Bank (WDI).
- **Energy Intensity Level of Primary Energy** is a measure of energy efficiency. It is obtained by dividing total primary energy supply over GDP and captures how much energy is used in the production of a unit of output. Its unit of measurement is Mega Joules per $ (MJ/$). GDP is measured at purchasing power parity in constant 2017 dollars. Data is from the World Bank (WDI).
- **Total greenhouse gas emissions** are measured in kilo tonnes of CO_2. It composes of CO_2, CH_4, N_2O and F-gases (HFCs, PFCs and SF_6). Data is from the World Bank (WDI).
- **Fish Stock Status** measures the percentage of a country's total catch that come from taxa that are classified as either over-exploited or collapsed. Data obtained from 2018 Environmental Protection Index. This measure is used in place of the official SDG measure "Proportion of fish stocks within biologically sustainable level" due to data unavailability.
- **Marine Protected Areas** measures the percentage of a country's Economic Exclusion Zone (EEZ) set aside as a marine protected area. Data obtained from 2018 Environmental Protection Index. This measure is used in place of the official SDG measure "Coverage of protected areas in relation to marine areas" due to data unavailability.

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- **Species Protection Index** measures protected areas in relation to species distributions in a country. Data obtained from 2018 Environmental Protection Index. This measure is used in place of the official SDG measure "Red List Index" due to data unavailability.

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