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Environmental outcomes in agriculture: the effects of environment-related provisions in regional trade agreements

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Abbreviations

Ag-ERP	ERP related to the agriculture, forestry and fishery sectors
bc	black carbon
CBD	Convention on Biological Diversity
CFIF	FAO Latin America and the Caribbean Service
COMESA	Common Market for Eastern and Southern Africa
COP	Conference of the Parties
CPTPP	Comprehensive and Progressive Agreement for Trans-Pacific Partnership
EPI	Yale University's Environmental Performance Index
ERP	environment-related provision
EST	FAO Markets and Trade Division
FAO	Food and Agriculture Organization of the United Nations
FOAG	Federal Office for Agriculture of Switzerland
FDI	foreign direct investment
GBF	Kunming-Montreal Global Biodiversity Framework
GDP	gross domestic product
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
MPA	marine protected areas
NMVOC	non-methane volatile organic compounds
OC	organic carbon
OECD	Organisation for Economic Co-operation and Development
RTA	regional trade agreement
R2	coefficient of determination
SFS	sustainable food systems
TPA	terrestrial protected areas
TREND	TRade & ENvironment Database
USMCA	The United States–Mexico–Canada Agreement
PM	particulate matter
PTPA	United States-Peru Trade Promotion Agreement
WTO	World Trade Organization

Chemical formulae

CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CO_2eq	CO_2 equivalents
NH_3	ammonia
N_2O	nitrous oxide
SO_2	sulfur oxide

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Executive summary

The agriculture sector contributes to global greenhouse gas (GHG) emissions and is affected by trade policies. International trade and trade policies have a significant impact on agriculture, which in turn can drive climate change and other environmental issues.

As more and more regional trade agreements (RTAs) include environment-related provisions (ERPs), this study explores whether agriculture-related ERPs in RTAs are associated with reduced GHG emissions from agriculture. A novel dataset is used on ERPs related to the agriculture, forestry and fishery sectors (Ag-ERPs) to construct the exposure of Ag-ERPs for countries over time through RTAs that have been enforced between 1995 and 2019. This is combined with data on GHG emissions in agriculture and other environmental outcomes to analyse how these outcomes are related in 191 countries and territories over the same period.

This study thus aims to contribute to the existing literature by examining the association between Ag-ERPs and the subsequent reduction agriculture-related GHG emissions, the establishment of protected areas, deforestation outcomes, and fishery intensity.

The findings show that there is indeed a significant reduction of agriculture-related GHG emissions in countries that enter into RTAs with more Ag-ERPs with their relevant trading partners in agricultural products. There are two potential channels for this emissions-reducing effect. On the one hand, the reduction of GHG emissions could in theory be driven by Ag-ERPs generally hindering trade in agricultural products, thereby reducing agricultural production and agricultural land use. On the other hand, the reduction of GHG emissions could be associated with more environmental-friendly agricultural production at given levels of land use. The latter could be either driven by domestic regulation induced by Ag-ERPs in RTAs or by a direct effect of these Ag-ERPs.

A mediation analysis reveals that 13 percent of all GHG emission reductions in agriculture can be explained by stricter domestic environmental regulations associated with including more Ag-ERPs in countries' RTAs. About 24 percent can be explained by reduced agricultural land use linked to RTAs with Ag-ERPs. The remaining 63 percent are unexplained by these two channels, suggesting that even at given levels of domestic regulation and agricultural land use, agricultural production becomes less emission-intensive in countries with more Ag-ERPs in their relevant RTAs. This finding is in line with qualitative evidence that ERPs, in general, are effective through several channels beyond enforceable ERPs or decreasing trade flows. Key channels include civil society dialogue and other cooperative mechanisms including technical assistance and capacity building. Besides the effects on GHG emissions, Ag-ERPs in relevant RTAs are also associated with subsequent reductions in other air pollutants. There is no strong evidence for effects on other environmental outcomes, however, such as levels of deforestation or catch of fish.

Finally, the study also explores whether the association between Ag-ERPs and GHG emissions from agriculture differs by the income levels of the countries signing the pertinent RTAs. The estimation results show that the overall association between Ag-ERPs and agricultural GHG emissions is stronger in high-income countries but also visible in low- and middle-income countries. All results also hold when selection into RTAs with Ag-ERPs by countries based on income level and agricultural trade dependency is controlled for.

Many provisions have been incorporated into RTAs only more recently, which is why their actual effects might be difficult to detect at this point in time. The broader overview in this study suggests that while the impact of Ag-ERPs may differ across environmental outcomes, its potential effects can be substantial. From a policy perspective, this study confirms that the design of trade agreements matters.

Chapter 1.

Introduction

Agriculture is an important contributor to global greenhouse gas (GHG) emissions. According to the Intergovernmental Panel on Climate Change (IPCC), more than 20 percent of all global GHGs are emitted in the agriculture sector (IPCC, 2019). Agriculture is thus the second largest sector to contribute to global warming after the energy sector. Moreover, agriculture contributes to several other key environmental challenges, including the biodiversity loss.

At the same time, agricultural products are traded across the globe, with their embodied emissions. In fact, between 29 and 39 percent of deforestation-related emissions are driven by international trade, above all in beef and oilseeds like palm oil (Pendrill *et al*., 2019). Abman and Lundberg (2020) find that trade agreements increase agricultural land use and deforestation in their signatory countries. Trade is thus highly relevant from an environmental perspective, in agriculture-related sectors and beyond them, and international trade policy can be a key instrument to address GHG emissions.

Since regional trade agreements (RTAs) include increasingly diverse and far-reaching environment-related provisions (ERPs), they can be important tools to promote environmental protection and tackle emissions in the agriculture sector. In recent decades, trade agreements have included more and more ERPs (Morin, Dür and Lechner, 2018). Between 2015 and 2020, each new RTA had an average of 48 ERPs and recent RTAs frequently included more than 100 ERPs. In 2019, the agreement between the United States of America, Mexico, and Canada (USMCA) set a new record by including 153 ERPs. ERPs in RTAs can, for example, address domestic environmental protection, promote the implementation of environmental agreements, foster civil society participation or require the transfer of environmental technologies to developing countries. They can cover a wide range of environmental issues, such as deforestation, fish stocks or CO_2 emissions.

The increasing inclusion of ERPs in RTAs might be driven by "green" protectionism but also in response to electoral pressures for greater environmental protection, to better safeguard policy space for domestic environmental regulations in light of environmental trade disputes and to promote environmental governance in the context of trade negotiations by using trade agreements to leverage environmental policies abroad (Brandi and Morin, 2023).

So far, only a limited number of studies have assessed the effects of including ERPs in RTAs. Existing studies find positive effects of ERPs on environmental outcomes (see, e.g., Baghadi, Martínez-Zarzoso and Zitouna, 2013; Bastiaens and Postnikov, 2017; Martínez-Zarzoso and Oueslati, 2018; Abman, Lundberg and Ruta, 2021; Sorgho and Tharakan, 2022; see also a more detailed discussion of the literature below). But to date, there has not been an extensive analysis of agriculture-related environmental effects of ERPs in RTAs.

This study utilizes novel data on ERPs that are particularly related to the agriculture, forestry and fisheries sectors (Ag-ERPs) in RTAs. The underlying database is constructed by FAO (Avesani *et al*., 2024), and is based on the Trade and Environment Database (TREND) by Morin, Dür and Lechne (2018). This data is used to construct the exposure of Ag-ERPs for countries over time through their RTAs. This data is combined with panel data on GHG emissions in agriculture and other environmental outcomes to analyse how these outcomes are related to the Ag-ERPs.

The results suggest that Ag-ERPs in RTAs are associated with a subsequent reduction in agriculture-related GHG emissions. There are two potential channels for this emissions-reducing effect. On the one hand, the reduction of GHG emissions could in theory be driven by Ag-ERPs generally hindering trade in agricultural products, thereby reducing agricultural production and agricultural land use. On the other hand, the reduction of GHG emissions could be associated with more environmental-friendly agricultural production at given levels of land use. The latter could be either driven by domestic regulation induced by Ag-ERPs in RTAs or by a direct effect of these Ag-ERPs. As there is no direct data on different methods of agricultural production available, agricultural land use is considered, and the depth of domestic environmental regulation and the direct effect of Ag-ERPs not explained by the two former as potential channels for how ERPs may affect GHG emissions. A mediation analysis reveals that 13 percent of all GHG emission reductions in agriculture can be explained by stricter domestic environmental regulations associated with including more Ag-ERPs in countries' RTAs. About 24 percent can be explained by a reduction of agricultural land use that is linked to RTAs with Ag-ERPs. The remaining 63 percent are unexplained by these two channels, suggesting that even at given levels of domestic regulation and agricultural land use, agricultural production becomes less emission-intensive in countries with more Ag-ERPs in their relevant RTAs. This could be due to low-emission climate-smart production methods in signatory-exporting countries.

In order to address questions concerning reverse causality between the different variables, a two-stage regression estimate in which only those Ag-ERPs that cannot be explained by underlying observable country characteristics are used as explanatory variables. This, to some degree, supports the notion that the direction of causality goes from Ag-ERPs to GHG emission reductions, but due to the limitations of the empirical analysis, it is best to refrain from explicitly interpreting the identified relationships in a causal way.

GHG emission reductions are only one relevant environmental effect of including Ag-ERPs in RTAs. This study, therefore, also analyses the association between Ag-ERPs and the subsequent reduction of emissions beyond GHGs, the establishment of protected areas, deforestation outcomes, and fishery intensity. The empirical analysis indicates that emissions of other pollutants are also reduced in countries with more Ag-ERPs in their RTAs, but the results show no substantial or significant effects on any of the other potential environmental outcomes.

The remainder of this report is structured as follows: **Chapter 2** presents and discusses the relevant existing literature on the topic. **Chapter 3** provides an overview over the data used. **Chapter 4** introduces the estimation methodology for the baseline estimation, and **Chapter 5** presents the baseline results. **Chapter 6**, introduces the mediation analysis to elicit the channels of the overall relationship between Ag-ERPs and GHG emissions originating in agriculture and discuss the relevant results. **Chapter 7** includes the two-stage estimation and other robustness test results, and **Chapter 8** investigates the association of ERPs with other environmental outcomes. **Chapter 9** concludes.

Chapter 2.

Related literature

The existing literature on the effects of ERPs is not extensive, but there a few studies that have analysed different implications of including ERPs in RTAs.[1] Regarding economic outcomes, Brandi *et al*. (2020) show that ERPs in RTAs decrease trade in environmentally harmful products but increase trade in green products. However the overall trade flows are not affected. The estimation uses data from the TREND database (Morin, Dür and Lechner, 2018), and is conducted at a bilateral level through a gravity equation. The results support the notion that the outcomes of ERPs in RTAs may be affected through the channel of evolving trade patterns. Using less detailed data with regard to the character of the ERPs (but analysing a broader set of outcomes and considering the enforceability of the provisions), Hoekman, Santi and Shingal (2023) show that the inclusion of ERPs in RTAs is associated with increased exports of environment-intensive goods from high-income member states. This finding is consistent with arguments that environmental provisions mirror the commercial interests of high-income countries since their inclusion in RTAs may raise trade costs for low- and middle-income countries.

Regarding environmental outcomes, several studies suggest that ERPs in RTAs can have positive environmental implications. Baghdadi *et al*. (2013) find that ERPs in RTAs lead to convergence in levels of CO_2 emissions between partnering countries. The estimation is conducted at a bilateral level; the authors coded ERPs as a dummy variable, and therefore much cruder than is possible with data that is available now. Bastiaens and Postnikov (2017) show that developing countries in RTAs with the United States of America or the European Union increase their level of environmental performance, again using a dummy variable for whether RTAs incorporate ERPs. Martínez-Zarzoso and Oueslati (2018) and Zhou, Tian and Zhou (2017) show that countries with RTAs with ERPs reduce their levels of air pollution. Their estimations are restricted to OECD countries, due to data availability. They use data on ERPs in RTAs from the WTO RTAs database, which includes more RTAs than previous research had assessed but still less than covered by the TREND database. Moreover, the information on ERPs used by Martínez-Zarzoso and Oueslati (2018) and Zhou, Tian and Zhou (2017) is still restricted to binary information whether or not the RTAs include ERPs.

Using satellite imagery of deforestation, Peinhardt, Kim and Pavon-Harr (2019) find that despite the 2009 United States-Peru Trade Promotion Agreement (PTPA), in the context of which the Peruvian government agreed to reduce illegal logging and improve forest sector governance, deforestation has increased since the PTPA entered into force. Rickard (2022) shows that for signatories of the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), which incorporates stringent provisions on the reduction of environmentally harmful fishery subsidies, is correlated with a 20 percent increase in environmentally friendly subsidies compared to the more harmful subsidies of non-signatories. The recent analysis by Bayramoglu and co-authors (2023), based on TREND, on the impact of ERPs in RTAs on the decline of marine fisheries resources, suggests that while RTAs are likely to have a negative effect on the status of fish stocks, the incorporation of fisheries-related ERPs offsets this negative effect. Furthermore, existing research suggests that ERPs in RTAs have heterogeneous effects on foreign direct investment (FDI) across sectors in the United States of America, with a reduction in FDI in polluting sectors but an increase in environmentally clean sectors (Lechner, 2018). However, the effects of environmental provisions on FDI across countries are unclear. One recent study found that non-trade provisions, including environmental provisions, have a negative effect on FDI flows, particularly in middle- and low-income countries (Di Ubaldo

[1] For a recent overview of the drivers and effects of ERPs in RTAs, see also Brandi and Morin (2023).

and Gasiorek, 2022). Another study found no empirical evidence that adding environmental provisions to an RTA decreases bilateral FDI (see Rojas-Romagosa, 2020). Therefore, the literature provides inconclusive findings on the effects of environmental provisions in RTAs on FDI.

The three studies most closely related to this study are Abman, Lundberg and Ruta (2021), Francois *et al*. (2023), and Sorgho and Tharakan (2022). Abman, Lundberg and Ruta (2021) analyse whether and through which channels ERPs in RTAs affect deforestation in signatory countries. Their estimation is undertaken at the agreement level, which allows to better control for (unobservable) agreement characteristics compared with this study's approach, but allows to account less well for (unobservable) country characteristics. The authors find that ERPs limit the increase of deforestation in signatory countries and that this is due to a minor increase in agricultural land use. Francois *et al*. (2023) also look at a panel of countries, and analyse the effects of non-trade provisions (environmental provisions but also labour standards and civil and political rights) in RTAs on a number of environmental outcomes (among other non-trade outcomes). They find a significant effect of these provisions for only some of the outcome indicators they investigate, GHG emissions being one of them. Both studies use information from the World Bank Deep Trade Agreement Database (based on the WTO RTAs database), which includes information on specific types of provision in 279 RTAs. This database includes less RTAs than TREND and is less granular (i.e. the types of specifically environment-related provisions are limited to two different types while TREND distinguishes between nearly 300 different types of ERPs). Sorgho and Tharakan (2022) use information from TREND in order to analyse the effect of ERPs on GHG emissions and find that RTAs with environmental (and climate-related) provisions are associated with reductions in GHG emissions. While their analysis assesses the implications for GHG emissions more generally, this study puts a spotlight on the agriculture sector to examine the role of ERPs in this important sector.

This study thus aims to contribute to the existing literature by adding a traceable approach to analyse environmental outcomes in agriculture, using a novel, extensive, and detailed dataset on agriculture-related ERPs in RTAs. The study assesses different types of environmental outcomes but specifically focuses on agriculture-related GHG emissions. Much of the anthropogenic GHG emissions are not from the well-known CO_2, but from methane (CH_4) and the, often overlooked, nitrous oxide (N_2O). Nitrous oxide comprises approximately 6 percent of GHG emissions and about three-quarters of those N_2O emissions originate from agriculture, especially because of the heavy use of synthetic nitrogen fertilizer. Methane in turn is responsible for around 30 percent of the rise in global temperatures. Agriculture is the most important anthropogenic source, generating around one quarter of methane emissions. In addition, this study assesses also several additional environmental outcome indicators that have not been examined in detail yet, including protected environmental areas, in which the exploitation of natural resources (e.g. firewood, non-timber forest products, water) is limited to achieve the long term conservation of nature.

Chapter 3.

Data

In order to analyse the relationship between ERPs in RTAs and GHG emissions from agriculture and the channels through which this relationship is realized, the study combines country-year panel data from different sources. Data on GHG emissions in agriculture are taken from FAOSTAT (FAO, 2024). They include overall GHG emissions in terms of CO_2-equivalents while at the same time distinguishing them from methane (CH_4) and nitrous oxide (N_2O). Emissions of other air pollutants are drawn from the EDGAR database (JRC, 2023). Data on countries' forest areas and fish catch is also drawn from FAOSTAT. Data on protected areas derive from Yale University's Environmental Performance Index (Yale University, 2023).

To generate country-year variables for Ag-ERPs included in a country's RTAs, the study uses novel data on Ag-ERPs constructed by FAO. This data is based on the 2022 update of the TREND database (Morin, Dür and Lechner, 2018).[2] The novel database on Ag-ERPs covers 318 RTAs notified to the WTO between 1995 and 2022. It identifies and classifies 142 types of provisions in these RTAs that have direct or indirect agricultural objectives and/or consequences. These provisions include a subset of the nearly 300 environmental provisions found in TREND, and some new types, such as provisions on "sustainable management of vegetable oils", "sustainable food systems" (SFS), "animal welfare", "antimicrobial resistance", and "agricultural biotechnology". The dataset is described in an accompanying publication to this study (Avesani *et al.,* 2024). It does not include information on the enforceability of the individual provisions but only on the enforceability of the agreements through different mechanisms, such as dispute resolution mechanisms.

As Ag-ERPs in RTAs apply bilaterally between parties to the RTAs, the agreement-related content has to be broken down to the country level in order to be able to attribute effects within the signatory countries to the treatment of the ERPs. To this end, the country-level variable *ERP* for country *c* in year *t* will be constructed so that the number of ERPs in RTAs is weighted by the relative importance of the respective RTA signatories in total agricultural exports. The variable is thus defined as:

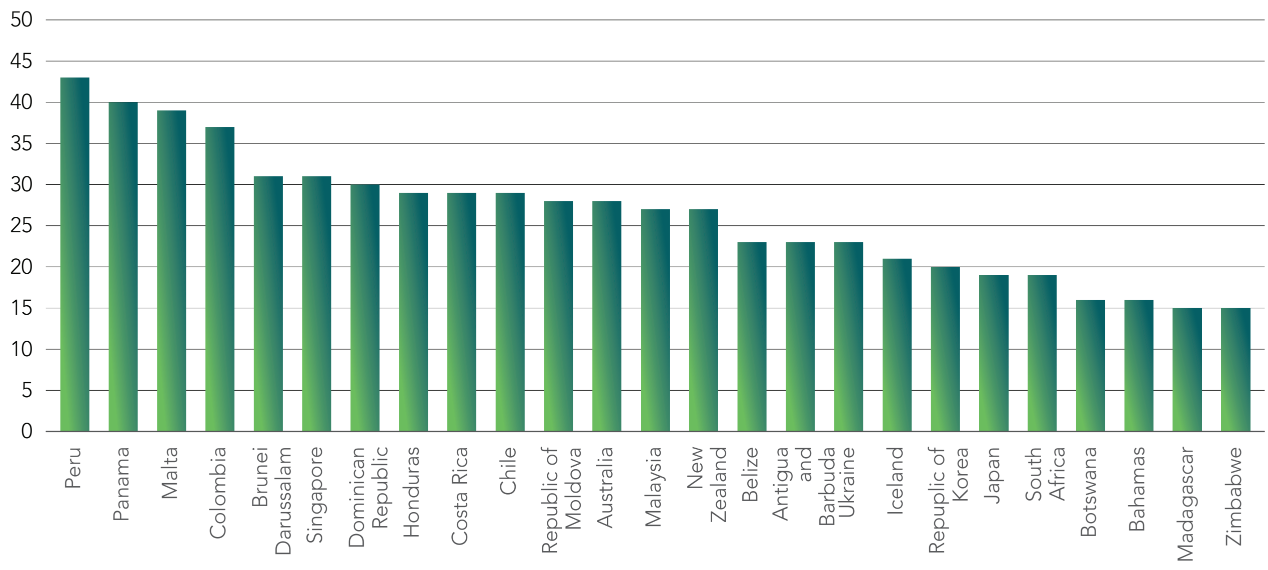
$$ERP_{c,t} = \frac{\sum_p EX_{c,p,t} * ERP_{c,p,t}}{\sum_p EX_{c,p,t}} \quad (1)$$

Where p denotes the respective partner country. $EX_{c,p,t}$ denotes the agricultural exports from country c to partner country p. Bilateral sectoral trade flows are drawn from the latest 2023 update of the BACI trade database by CEPII (Gaulier and Zignago, 2010). Agricultural trade flows are defined according to the Uruguay Round Agreement on Agriculture of the WTO (Annex I), which covers HS chapters 1 to 24, excluding fish and fish products. For further analysis, Ag-ERPs are also weighted by the countries' importance in the exports of fish and forestry products. For the baseline and weighting according to agricultural exports between signatories, Figure 1 depicts the countries with the highest number of Ag-ERPs included in all RTAs signed and weighted by the relative importance of the respective co-signatories in total agricultural exports since 1995. Note that the variation in this variable derives both from the number of Ag-ERPs in

[2] The updated TREND dataset can be found here: https://www.chaire-epi.ulaval.ca/en/trend

RTAs, and the importance of the respective partners in the RTAs in total agricultural exports.[3] The graph shows that countries that included the most Ag-ERPs in RTAs with their most relevant agricultural export destinations within the sample period are not predominantly from one region or level of development, but entail vast yet diverse countries.

Figure 1. Ag-ERPs, 1995-2019 (weighted by agricultural exports)



Notes: This figure shows the cumulative average number of Ag-ERPs in countries' RTAs that entered into force between 1995 and 2019, weighted by relative importance of the respective RTA partners as the countries' export destinations in agricultural products.
Source: Authors' own elaboration based on Avesani, C., Dervisholli, E., Schéré, E. and Solórzano López, J. 2024. *Ag-ERPs database: a novel repository of environment-related provisions for agriculture, fisheries and forestry in regional trade agreements*. Rome, FAO.

In order to analyse the channels of the association between Ag-ERPs and GHG emissions in agriculture, data on environmental regulation and agricultural land use are also incorporated into the panel data. Data on environmental regulation was provided by FAOLEX (FAO, 2023). It counts data on the number of legislations passed in a certain year related to the environment. The study cumulates this data over time to obtain the number of environmental laws implemented over the sample period. While this data does not include any information about the stringency of the respective regulation, the number (and the fact that there is considerable variation) makes this the best proxy available. Data on agricultural land use is also taken from FAOSTAT and denoted as the area in use for agricultural purposes. Additional country-specific information used to relate country characteristics to expected Ag-ERPs is drawn from the World Bank World Development Indicators (World Bank, 2023).

[3] This also explains the fact that countries that have only concluded the same RTAs in this time period, such as the countries of the European Union, may still differ in the number of trade-weighted Ag-ERPs, because the respective partners may be differently important to them as export destinations.

Data on the relevant environmental outcomes is only available until 2019. The resulting overall country-level sample spans 4 748 observations across 191 countries and territories in a (unbalanced) panel from 1995 to 2019. Summary statistics are provided in Table A 1 in the Appendix.

Chapter 4.

Estimation methodology

In order to estimate the relationship between GHG emissions in agriculture and Ag-ERPs in RTAs, this study runs an ordinary least square (OLS) panel regression at the country level with country and time-fixed effects. Then it compares how environmental outcomes (on average) develop differently after countries enter RTAs that include more Ag-ERPs compared to countries that have included fewer or have not entered these RTAs at all. Denoting countries by *c*, and time (in years) by *t*, the baseline regression equation is as follows:

$$Emissions_{c,t} = \alpha_c + \beta * ERP_{c,t} + \rho * RTA_{c,t} + \alpha_t + \varepsilon_{c,t} \quad (2)$$

where *Emissions* are the CO_2 equivalents of the respective GHG emission type, *ERP* is the number of Ag-ERPs included in a country's RTAs as defined above, and *RTA* is a control variable for how many RTAs a country has signed with its relevant trading partners. α_c and α_t are country- and time- fixed effects.

As Ag-ERPs only apply whenever an RTA is in place and are thus correlated with the presence of RTAs, the number of RTAs itself has to be controlled for in order not to capture the effect of RTAs themselves in the estimation of β. The variable *RTA* is defined analogously to *ERP*, that is, weighted by relative agricultural exports to co-signatories.

Country-fixed effects control for all time-invariant characteristics of countries that are potentially correlated with environmental outcomes and can determine selection into RTAs with Ag-ERPs. Time-fixed effects control for common global time trends in both variables.

For all outcome variables, including *Emissions*, the study uses the absolute values in the respective scales (metric tons) in order to capture absolute changes. This does give greater weight to countries with high emission intensities (and thus likely larger absolute changes) than using values relative to individual country sample averages. Because absolute changes (that is, relative changes in countries with high intensities) are more important and also more likely to be affected by the respective RTA regulations, this appears to be the more relevant metric. At the same time, the study runs robustness tests to the baseline estimation with relative values after discussing the baseline results.

Chapter 5.

Baseline results

The study estimates Equation (2) to elicit the relationship between Ag-ERPs in RTAs and GHG emissions in agriculture. The results are depicted in Table 1. Column 1 reports the results for overall emissions from agriculture in CO_2-equivalents, and columns 2 and 3 report the results separately for methane and nitrous oxide emissions, respectively.

Table 1. Baseline estimation results ERPs on GHG emissions in agriculture

	(1)	(2)	(3)
	Aggregate		
	CO_2eq.	**CH_4**	**N_2O**
ERPs	-141.5***	-88.65**	-52.85***
	(52.12)	(36.78)	(18.08)
RTAs	90.56	-165.3	255.9
	(738.9)	(523.8)	(291.6)
Constant	29 084.0***	19 452.2***	9 631.8***
	(199.9)	(134.4)	(74.87)
Countries	191	191	191
Observations	4 748	4 748	4 748
R^2	0.994	0.994	0.990

Notes: This table shows the results from estimating Equation (2), with aggregate CO_2eq. and those from CO_2eq. from CH_4 and N_2O in agriculture separately as dependent variables. ERPs are the Ag-ERPs, and RTAs the number of RTAs, both weighted by trading partner in agricultural products. Country and Year fixed effects are used. Robust standard errors clustered at the country level are reported in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.
Source: Authors' own elaboration.

The results show that countries that signed RTAs with more Ag-ERPs emitted less agriculture-relevant CO_2-equivalents and fewer emissions from methane and nitrous oxide in agriculture after the signature of these agreements than countries with less Ag-ERPs in their RTAs. This effect is also substantial: in 2019, the average country had 6.6 agriculture-trade weighted Ag-ERPs. The point estimates from Table 1, imply a relative reduction of agriculture-related GHG emissions of approximately 3 percent associated with Ag-ERPs in RTAs. This is an important finding, as rapid methane emissions reductions are key to limiting climate change and improving air quality.

VI

Chapter 6.

Channels

There could be different mechanisms through which Ag-ERPs in RTAs influence GHG emissions in agriculture. First, Ag-ERPs may lead to stricter domestic environmental regulations, which in turn reduce emissions. Existing evidence indicates that environmental provisions in RTAs do promote domestic environmental legislation (Brandi, Blümer and Morin, 2019). Second, either due to this or independently, Ag-ERPs may lead to pressure on agricultural production such that agricultural production is reduced and emissions are thereby decreased. Third, other mechanisms, such as increased demand for lower-emission agricultural production outputs by trading partner countries or preferred market access for lower-emission agricultural products, may influence production methods without reducing agricultural output. As there is data available on domestic environmental regulation and agricultural land use, the study considers these two mechanisms explicitly as possible channels for the overall effect in the utilized model, while allowing for a direct effect of Ag-ERPs on agriculture-related GHG emissions independent of these.

Methodology

The mediation analysis is conducted in three steps. First, to be relevant, a potential channel variable must be associated with the number of Ag-ERPs in RTAs in countries. The study tests for this relationship by the following regression:

$$Channel_{m,c,t} = \alpha_{m,c} + \gamma_m * ERP_{c,t} + \rho_m * RTA_{c,t} + \alpha_{m,t} + \varepsilon_{m,c,t} \quad (3)$$

In this equation, $Channel_{m,c,t}$, $m \in \{Environmental\ Regulation, Agricultural\ Land\}$, is either the cumulative number of environmental regulation in a country c in year t or the area used for agricultural production, and all other variables are identical to their definition in Equation (2). This equation is estimated for both channels independently. The relationship between the channel variables and Ag-ERPs in RTAs is then given by γ_m , m $\in \{Environmental\ Regulation, Agricultural\ Land\}$.

After having estimated the relationship between Ag-ERPs and the channel variables, in order to qualify as a channel, a variable also has to be associated with the outcome of interest, that is, GHG emissions in agriculture. Therefore, the study estimates this relationship as follows:

$$Emissions_{c,t} = \alpha_{2,c} + \sum_m \delta_m Channel_{m,c,t} + \eta * ERP_{c,t} + \rho_2 * RTA_{c,t} + \alpha_{2,t} + \varepsilon_{2,c,t} \quad (4)$$

In this equation, the δ_m , m $\in \{Environmental\ Regulation, Agricultural\ Land\}$ denote the relationship between the channel variables and GHG emissions, and η captures the direct effect of Ag-ERPs on these, controlling for (and thus independent of) the channel variables.

In order to see how these two estimations can provide a share of the overall relationship between Ag-ERPs and GHG emissions, the following is inserted from Equation (3) into (4) to arrive at:

$$Emissions_{c,t} = \alpha_{2,c} + \sum_m \delta_m (\alpha_{m,c} + \alpha_{m,t}) + \left(\sum_m \delta_m \gamma_m + \eta \right) ERP_{c,t} + \left(\sum_m \delta_m \rho_m + \rho_2 \right) RTA_{c,t} + \alpha_{2,t} + \varepsilon_{2,c,t} + \sum_m \delta_m \varepsilon_{m,c,t} \quad (5)$$

This equation is identical to Equation (1), considering a number of identities. Most importantly, the overall association between GHG emissions and Ag-ERPs is accordingly given by $\sum_m \delta_m \gamma_m + \eta = \beta$, where η is the direct effect of Ag-ERPs on GHG emissions, and the $\delta_m \gamma_m$ are the association that is mediated by each of the two channels, with m ∊ {*Environmental Regulation, Agricultural Land*}. The share that each channel contributes to the overall association is thus given by $\frac{\delta_m \gamma_m}{\beta}$, and the share of the direct effect by $\frac{\eta}{\beta}$.

The respective products are computed from the estimates of Equations (3) and (4), and the statistical significance of the products is tested by bootstrapping standard errors with 1 000 replications.

Results

The mediation analysis hence combines two steps: a) the effect of Ag-ERPs on the potential mediators and b) their effect on GHG emissions. Appendix B shows the results for each of the respective steps separately. Taken together, they constitute a full decomposition of the overall association of ERPs with GHG emissions in agriculture. Following Equation (5), it can be estimated that the mediated effects of ERPs through both channels, and their respective shares in the overall effect, β. The result is depicted in Table 2. Columns 1–3 show the components of the association of Ag-ERPs and agricultural GHG emissions, $\delta_m \gamma_m$, while Columns 4-6 translate these into the shares of the overall β.

Table 2. Decomposition of association of ERPs with GHG emissions in agriculture

	(1)	(2)	(3)	(4)	(5)	(6)
		Decomposition			Percent of β	
	Aggregate CO_2eq.	CH_4	N_2O	Aggregate CO_2eq.	CH_4	N_2O
Total β	-141.5***	-88.65***	-52.85***			
	(21.08)	(14.67)	(7.583)			
Environmental regulation	-18.48***	-12.96***	-5.520***	0.131**	0.146**	0.104**
	(4.917)	(3.485)	(1.466)	(0.0459)	(0.0546)	(0.0353)
Agricultural land	-34.01**	-21.18**	-12.83**	0.240***	0.239***	0.243***
	(11.63)	(7.020)	(4.689)	(0.0623)	(0.0615)	(0.0698)
Explained component of β (mediated effect)	-52.50***	-34.14***	-18.35***	0.371***	0.385***	0.347***
	(11.43)	(7.013)	(4.540)	(0.0685)	(0.0773)	(0.0679)
Unexplained component of β (direct effect)	-89.00***	-54.50***	-34.50***	0.629***	0.615***	0.653***
	(16.90)	(12.66)	(5.639)	(0.0685)	(0.0773)	(0.0679)
Observations	4 748	4 748	4 748	4 748	4 748	4 748

Notes: This table shows the results from a mediation analysis following Equation (5), with aggregate CO_2eq. and those from CO_2eq. from CH_4 and N_2O in agriculture separately as dependent variables, where the estimations combine those of Equations (3) and (4). ERPs are the Ag-ERPs, and RTAs the number of RTAs, both weighted by trading partners in agricultural products. Environmental regulation is a count variable for the cumulative number of domestic environmental regulation in a country up to year t, and Agricultural land is the area of agricultural land use in a country. Total β is derived from the Equation (2). Country and Year fixed effects are used. Columns 1–3 show the absolute components of the direct effect of ERPs on the dependent variables and that mediated by the two channels, and Columns 4–6 show them relative to the overall β. Bootstrapped standard errors are reported in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Source: Authors' own elaboration.

The results of the mediation analysis show that 13.1 percent of the overall association of ERPs with GHG emissions in agriculture can be explained by the increase in domestic environmental regulation that comes with more Ag-ERPs in countries' RTAs.[4] An even greater share can also be explained by the reduced agricultural land use that is associated with Ag-ERPs, amounting to 24 percent of the overall relationship between Ag-ERPs and agricultural GHG emissions. Consequently, both channels together can explain 37.1 percent of the overall relationship. Thus, a direct effect of 62.9 percent of the overall association is driven by other channels (such as increased relative demand for lower-emission products).

Overall, the analysis shows that there is a large part of the association of Ag-ERPs with agricultural GHG emissions that is independent of agricultural land or domestic environmental regulation in partner countries. This finding is in line with qualitative evidence that ERPs, in general, are effective through several channels beyond enforceable ERPs or decreasing trade flows. Key channels include civil society dialogue and other cooperative mechanisms including technical assistance and capacity building (LSE, 2022; Brandi and Morin, 2023).[5] The result also suggests that Ag-ERPs foster more sustainable production methods at given levels of agricultural production. This, in turn, might be driven by the transfer of environmental technology.

[4] It has to be noted that the proxy for domestic environmental regulation is a simple count variable which can naturally not capture all variations in domestic regulatory intensity.

[5] Today, around 14 percent of RTAs include provisions on technical assistance and capacity-building and 10 percent also include financial or technology transfer commitments (Brandi and Morin, 2023), for example, training in resource management and environmental enforcement, the transfer of environmentally friendly technologies, assistance for the creation of protected areas, and legal advice on new environmental laws (Morin, Chaudhuri and Gauquelin, 2018).

VII

Chapter 7.

Robustness and extensions

Although the use of panel data estimation methods can exclude some form of reverse causality between ERPs and environmental outcomes by controlling for common forms of selection as described above, it may still be the case that the decision to join an RTA with Ag-ERPs is endogenous in a dynamic way. For example, countries that expect their policies to reduce GHG emissions are more likely to enter an RTA or accept more (or more stringent) ERPs in their trade agreements. To explore this issue further, the study uses time-varying country-level characteristics to predict whether a country is likely to enter RTAs with more ERPs, and consider only unexpected ERPs as a treatment variable. The explanatory variables considered include levels of gross domestic product (GDP) and GDP per capita, population, levels of liberal democracy (Coppedge *et al*., 2023), rural population, arable and agricultural land area, agricultural production, trade openness, and natural resource dependence. The result of the first stage of this two-step estimation of the determinants of ERPs is depicted in Table 3.

Table 3. Two-stage estimation – first stage: determinants of ERPs

	ERPs
GDP	0.000 (0.000)
GDP p.c.	-0.000 (0.000)
Population	-0.000 (0.000)
Liberal democracy	0.330 (1.362)
Rural population (%)	-0.021 (0.018)
Arable land (%)	-0.049** (0.020)
Agricultural land (%)	0.004 (0.013)
Agri fish forestry (% of value added)	-0.030 (0.022)
Trade (% of GDP)	-0.003 (0.005)
Natural resource rents (% of GDP)	-0.067*** (0.018)

	ERPs
Constant	5.695***
	(1.510)
Observations	4 193
R^2	0.035

Notes: This table shows the results from regressing the number of Ag-ERPs (ERPs) in a country on a number of time-varying country characteristics. The predictions of this estimation are used to derive the number of Ag-ERPs that cannot be explained by the included characteristics. Robust standard errors clustered at the country level are reported in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.
Source: Authors' own elaboration.

When jointly included, only some of the incorporated variables explain the inclusion of ERPs in countries' RTAs, which includes arable land in a given country and its dependence on natural resources. The prediction of this first stage regression is the number of (agricultural exports weighted) Ag-ERPs that would be expected based on the country characteristics such as, arable land and natural resource dependence. The difference between the actual number of (agricultural exports weighted) Ag-ERPs and this predicted number is the unexpected number of relevant Ag-ERPs. This unexpected number of Ag-ERPs is then used as the explanatory variable to estimate Equation (2). The results are shown in Table 4.

Table 4. Two-stage estimation – second stage: unpredicted ERPs

	(1) Aggregate CO_2eq.	(2) CH_4	(3) N_2O
ERPs (unpredicted)	-179.1***	-111.4**	-67.76***
	(65.09)	(45.94)	(22.56)
RTAs	-162.6	-349.8	187.2
	(822.4)	(581.8)	(322.3)
Constant	33 348.2***	22 302.3***	11 046.0***
	(224.2)	(159.3)	(87.89)
Countries	167	167	167
Observations	3 985	3 985	3 985
R^2	0.994	0.994	0.990

Notes: This table shows the results from estimating Equation (1), with aggregate CO_2eq. and those from CO_2eq. from CH_4 and N_2O in agriculture separately as dependent variables. RTAs are the number of RTAs weighted by trading partner in agricultural products. ERPs (unpredicted) are the residual from a first stage estimation of the number of Ag-ERPs (agricultural trade weighted) on time varying country

characteristics (results in Table 3). Country and Year fixed effects are used. Robust standard errors clustered at the country level are reported in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.
Source: Authors' own elaboration.

The estimation results address, at least to some extent, concerns about potential reverse causality. The findings show that when using only Ag-ERPs as explanatory variables that are unpredicted by a country's observable characteristics, these are significantly associated with reduced agricultural GHG emissions. At the same time, for the interpretation of the findings, it has to be noted that this regression does not exclude endogeneity due to the unobservable characteristics of a country, and the overall findings should be interpreted with caution regarding the direction of causality.

The estimations were conducted with absolute levels of agricultural GHG emissions as the relevant outcome variable. While this is reasonable, countries with little emissions may not contribute to variation in terms of both explanatory and outcome variables, this ensures that not only some outliers are driving the overall result. To do so, the study conducts an additional robustness check with a focus on relative GHG emissions. Table 13 in Appendix B shows the results on agricultural GHG emissions relative to countries' average over the sample period. They show the same picture as the baseline results using absolute levels.

Finally, the study explores whether the association between Ag-ERPs and GHG emissions from agriculture differs by the development status of the countries signing the pertinent RTAs. It divides the sample into high-income countries and low- and middle-income countries. Furthermore, to capture the fixed-effects, it interacts the explanatory variables with the respective dummy for development status (instead of looking at subsamples). In classifying high-income countries, the study utilizes the World Bank definition of 2018 to exclude issues with countries switching between income classification groups. The results are depicted in Table 5.

Table 5. Income classification

	(1)	(2)	(3)
	Aggregate		
	CO_2eq.	CH_4	N_2O
ERPs			
low- and middle-income countries	-92.85**	-57.95*	-34.90**
	(44.70)	(33.63)	(15.12)
high-income countries	-227.7**	-149.5**	-78.12**
	(110.0)	(73.00)	(38.94)
RTAs			
low- and middle-income countries	459.8	-25.73	485.5
	(903.0)	(629.1)	(386.4)
high-income countries	-2 128.1**	-1 100.2*	-1 027.9***
	(925.5)	(624.7)	(360.0)

	(1) Aggregate $CO_2eq.$	(2) CH_4	(3) N_2O
Constant	29 605.0***	19 788.7***	9 816.3***
	(208.1)	(138.0)	(78.52)
Countries	188	188	188
Observations	4 673	4 673	4 673
R^2	0.994	0.994	0.990

Notes: This table shows the results from estimating Equation (2) with interacting the explanatory variables with the countries' development status. Aggregate CO2eq. and those from $CO_2eq.$ from CH_4 and N_2O in agriculture are separately used as dependent variables. ERPs are the Ag-ERPs, and RTAs the number of RTAs, both weighted by trading partner in agricultural products, both included in their interaction term with a dummy variable for high-income and non-high-income countries. Country and Year fixed effects are used. Robust standard errors clustered at the country level are reported in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.
Source: Authors' own elaboration.

The estimation results show that the overall association between Ag-ERPs and agricultural GHG emissions is stronger in high-income countries but also visible in low- and middle-income countries. This is despite high-income countries exhibiting lower absolute and relative aggregate values of GHG emissions from agriculture on average.

Chapter 8.

Other environmental outcome indicators

In order to complete the picture, the study also analyses a number of additional environmental outcomes that can potentially be influenced by the inclusion of Ag-ERPs in RTAs. It conducts the analysis by replacing *Emissions* in Equation (2) with the respective outcome variable of interest.

To achieve this, the study examines a number of air pollutants aside from GHGs. While they are not directly related to agriculture, analysing their association with Ag-ERPs in countries' RTAs provides further relevant insights into the environmental effectiveness of Ag-ERPs in RTAs. Several of these outcome variables, including protected environmental areas, have not been investigated yet while making use of the comprehensive and detailed TREND data on environmental provisions in RTAs. The results are depicted in Table 6.

Table 6. Other pollutants

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	PM_{25}	PM_{10}	bc	Co	NH_3	NVOC	NO_x	OC	SO_2
ERPs	-1.150**	-1.806***	-0.136**	-14.63*	-0.777*	-2.657	-4.260*	-0.235**	-4.038
	(0.487)	(0.675)	(0.0606)	(7.420)	(0.422)	(1.687)	(2.555)	(0.0972)	(2.447)
RTAs	13.99	15.81	1.611	333.0*	5.754	60.55	125.6*	1.890	138.9**
	(10.21)	(14.28)	(1.125)	(179.8)	(9.596)	(39.49)	(64.06)	(2.058)	(63.03)
Constant	167.2***	273.1***	22.40***	2254.0***	255.7***	611.8***	497.4***	54.62***	471.6***
	(1.919)	(2.995)	(0.222)	(31.77)	(2.027)	(6.481)	(9.900)	(0.514)	(10.04)
Countries	189	189	187	187	189	190	189	187	187
Obs.	4 509	4 509	4 461	4 461	4 509	4 533	4 509	4 461	4 461
R^2	0.979	0.985	0.971	0.962	0.991	0.965	0.929	0.992	0.957

Notes: This table shows the results from estimating Equation (2), with several air pollutants other than GHG emissions as dependent variables. ERPs are the Ag-ERPs, and RTAs the number of RTAs, both weighted by trading partner in agricultural products. Country and Year fixed effects are used. Robust standard errors clustered at the country level are reported in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.
Source: Authors' own elaboration.

The estimation results show that a large number of other pollutants are emitted less when countries sign RTAs with ERPs. This holds for particulate matter ($PM_{2.5}$, PM_{10}), black carbon (bc), carbon monoxide (CO), ammonia (NH_3), organic carbon content (OC) and sulfur dioxide (SO_2). The point estimates for non-methane volatile organic compounds (NMVOC) and all nitrogen oxides (NO_x) are also negative but insignificant.

Furthermore, the inclusion of Ag-ERPs may incline countries to expand their protected environmental areas as agreed upon in the context of the Convention on Biological Diversity (CBD) and its regularly updated goals and framework programs. The Kunming-Montreal Global Biodiversity Framework (GBF), which was adopted during the CBD Conference of the Parties (COP 15) in 2022, includes a number of ambitious goals, including a commitment to designate at least 30 percent of global land and sea as protected areas. The implementation of this so-called "30 by 30" initiative is key to tackling the biodiversity loss.

To investigate the potential expansion of protected environmental areas, *Emissions* is replaced in Equation (2) with the protected areas in countries from Yale's EPI data. The data can be divided by terrestrial (TPA) and marine protected areas (MPA), as shares of a country's relevant biomes. Table 7 shows the results.

Table 7. Protected areas

	(4)	(5)
	TPA	**MPA**
ERPs	0.139	0.619**
	(0.144)	(0.258)
RTAs	-2.829	-7.017**
	(1.729)	(3.539)
Constant	54.42***	16.74***
	(0.421)	(0.686)
Countries	191	146
Observations	4 748	3 628
R^2	0.897	0.770

Notes: This table shows the results from estimating Equation (2), with the area of terrestrial (Column 1) and marine (Column 2) protected areas as dependent variables. ERPs are the Ag-ERPs, and RTAs the number of RTAs, both weighted by trading partner in agricultural products. Country and Year fixed effects are used. Robust standard errors clustered at the country level are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.
Source: Authors' own elaboration.

The results indicate that Ag-ERPs are not associated with an expansion in terrestrial protected areas, but they are indeed associated with an expansion in marine protected areas. To some extent, this offsets the overall negative association that RTAs exhibit with terrestrial and marine protected areas.

Finally, the study also examines environmental outcomes that are directly associated with agricultural production. First, it analyses whether the slight reduction in (the change of) agricultural land use related to ERPs that was noted above also translates into a (relative) increase in forest areas in countries. According to FAO estimates, between 2000 and 2018 nearly 90 percent of global deforestation was a result of agricultural expansion (FAO, 2021). However, deforestation (or its reversal) might also be affected by Ag-ERPs as some of the provisions require agricultural production not to be based on deforestation. Deforestation might also be affected, in particular by forestry-related provisions in RTAs. For example, the Common Market for Eastern and Southern Africa (COMESA) (1993) states that the "Member States agree to take necessary measures to conserve and manage forests."

To assess the role of forestry-related ERPs, the study uses the FAO database's distinct classification for forestry-related Ag-ERPs as a subset of all Ag-ERPs. These forestry-related Ag-ERPs need not necessarily be effective due to their inclusion in RTAs with relevant trading partners in agricultural products but due to their inclusion in RTAs with relevant trading partners in forestry products. All three possibilities are considered when replacing Emissions in Equation (2) with the forest area in countries. The results are depicted in Table 8. Column 1 shows the results using the overall number of Ag-ERPs weighted by the importance of agricultural trading partners. Column 2 depicts the results with only forestry-related Ag-ERPs, but weighted by agricultural trading partners. Column 3 shows the results of forestry-related Ag-ERPs, weighted by trading partners of forestry-related products.

Table 8. Forest area

	(1)	(2)	(3)
	Forest area	**Forest area**	**Forest area**
ERPs (Agricultural trade weighted)	7.517		
	(14.34)		
Forest ERPs (Agricultural trade weighted)		-228.3	
		(319.1)	
RTAs (Agricultural trade weighted)	355.9*	452.2*	
	(209.0)	(232.5)	
Forest ERPs (Forestry trade weighted)			-46.64
			(604.5)
RTAs (Forestry trade weighted)			91.92
			(89.79)
Constant	21 654.6***	21 669.4***	25 807.8***
	(71.21)	(70.63)	(23.42)
Countries	189	189	187
Observations	4 698	4 698	2 581
R^2	0.999	0.999	0.999

Notes: This table shows the results from estimating Equation (2), with countries' forest area as dependent variable. ERPs are the overall number of Ag-ERPs, Forest ERPs only those that are concerned with forestry, and RTAs the number of RTAs, all weighted by trading partner either in agricultural products (Columns 1 and 2) or forestry products (Column 3). Country and Year fixed effects are used. Robust standard errors clustered at the country level are reported in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.
Source: Authors' own elaboration.

The results show that in neither case, a significant association between (overall or forestry-related) Ag-ERPs and deforestation can be observed. The point estimate is positive (indicating a reduction in deforestation) for all Ag-ERPs, but is statistically insignificant. The results suggest that including forest-related ERPs in RTAs have yet to be successful in reducing deforestation. This somewhat contrasts Abman, Lundberg and Ruta (2021) findings when analysing a greater set of RTAs and more fine-grained information on (Ag-)ERPs in RTAs. However, most of these specific forest-related provisions are only included in rather recently signed RTAs, such that their effects may not yet have materialized, and the above results may change down the road. More generally, the findings do not imply that forestry-related ERPs in trade agreements do not already make a difference in certain contexts. How positive forest-related impacts can be achieved is hotly debated, for example, during the negotiations for the European Union-Mercosur trade agreement, especially concerning deforestation in the Brazilian Amazon due to agriculture-related land use change.

In the next step, and using the same logic as in the case of forest-related questions, the study also analyses the relationship between Ag-ERPs and the amount of caught fish. As (other than for forests) it is implausible that other Ag-ERPs than those specifically concerning fisheries affect the catch of fish, the study only uses the subset of these as explanatory variables, and weigh them by the importance of trading partners in fish and fish products.

Table 9. Fish catch

	(1)
	Fish catch
Fishery ERPs (Fish trade weighted)	-196 304.0
	(191 827.1)
RTAs (Fish trade weighted)	63 864.0
	(75 922.0)
Constant	713 445.1***
	(8 451.6)
Countries	166
Observations	1 686
R^2	0.968

Notes: This table shows the results from estimating Equation (2), with countries tonnes of fish catch as dependent variable. Fishery ERPs are those Ag-ERPs that are concerned with fisheries in particular, and RTAs the number of RTAs, both weighted by trading partner in fish products. Country and Year fixed effects are used. Robust standard errors clustered at the country level are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.
Source: Authors' own elaboration.

The results show that fishery-related Ag-ERPs are not (in a statistically significant way) associated with a reduction in fish catch (Table 9). The expansion of marine protected areas that fall under Ag-ERPs, in general, does not imply a reduction of fish catch, even when considering the effect of fishery-related Ag-ERPs. Like in the case of forestry-related provisions, most of these specific Ag-ERPs have only been included in recent RTAs, which means that it might be too early to detect their potential effects. At the same time, even if the effect of Ag-ERPs on fish catch is limited, this does not mean that the expansion of marine protected areas associated with Ag-ERPs does not contribute to environmental protection. Even if larger marine protected areas do not translate into a reduction of fish catch, they might generate positive effects on the environment, for example, by improving fisheries, and thus biodiversity, in these protected areas (Ban *et al*., 2017).

To summarize, the strong association of Ag-ERPs with agriculture-related GHG emissions cannot be found for other agriculture-related environmental outcomes, except for other air pollutants. At the same time, the findings do not necessarily imply that ERPs do not have positive implications for the environment beyond agriculture-related GHG emissions. For example, while there might not be any effect on fish catch due to the expansion of protected areas, there might well be positive consequences for fisheries, for instance, in protected areas, and thus for biodiversity. In addition, there might be other channels for fishery-related environmental improvements beyond marine protected areas, including the reduction of harmful fishery subsidies.

Chapter 9.

Conclusion

Agriculture is a significant driver of climate change and other environmental challenges, such as the biodiversity loss, and since agriculture is also substantially shaped by international trade and trade policies, it is key to assess whether and how the toolbox of trade policies can help to tackle agriculture-related GHG emissions. This study finds that RTAs with Ag-ERPs can play a vital role.

The study finds a significant reduction of agriculture-related GHG emissions in countries that enter into RTAs with more Ag-ERPs with their relevant trading partners. This finding is more pronounced in high-income countries but also significant in low- and middle-income countries. The association between Ag-ERPs and agricultural GHG emissions is stronger in high-income countries. However, on average, these countries exhibit lower absolute and relative aggregate values of GHG emissions from agriculture. The fact that the finding holds in high-income as well as low- and middle-income countries indicate that Ag-ERPs are linked to a significant reduction of agriculture-related GHG emissions across different income levels.

The association between Ag-ERPs and agricultural GHG emissions is, to some extent driven, by stricter domestic environmental regulations in the respective countries. An even greater share of the emission-reducing effect can be explained by a reduction in agricultural land use in countries with more Ag-ERPs in their relevant RTAs. A large part of the overall association, however, is still unexplained by these two channels, suggesting that lower GHG emission production methods, for example driven by technological innovation, are implemented at given levels of domestic environmental regulation and agricultural land use in countries with more ERPs in their relevant RTAs. This finding suggests that domestic environmental regulation and land use policies can be important levers to reduce agriculture-related GHG emissions. Moreover, this finding can be regarded as underlining the key role of technology transfer for strengthening environmental protection, which in turn could also be further promoted by focusing attention on those types of ERPs in RTAs that aim at furthering the transfer of environmental technology to developing countries. Lower GHG emission production methods might also be driven by higher consumer demand for green products. Raising awareness about the importance of lower GHG emission production methods might contribute to further strengthening this channel.

Other environmental outcomes are not as much affected by Ag-ERPs in RTAs with relevant RTAs. The study finds that Ag-ERPs are associated with an expansion of marine protected areas. They can thus partially offset the overall negative effect of RTAs on the size of protected areas, thereby contributing to the implementation of the Kunming-Montreal Global Biodiversity Framework (GBF) and the protection of marine biodiversity. While there is a strong association between Ag-ERPs in RTAs and other air pollutants, no effects on deforestation or fish catch levels can be established, even for the specific Ag-ERPs related with these environmental issue areas, and considering the trade weights accordingly. At the same time, many relevant provisions have been incorporated into RTAs only more recently, which is why their actual effects might be challenging to detect at this point. Overall, due to limited data availability, the study only investigated a subset of potential effects and underlying mechanisms in this context. Other positive environmental consequences might be difficult to uncover based on the limits of existing data on possibly relevant environmental outcomes.

While this study examined the direct effects of Ag-ERPs in RTAs, there might be more indirect effects of including Ag-ERPs in RTA that are challenging to investigate with a large-n analysis of environmental outcomes but that might still have important positive implications for the environment. For instance, Ag-

ERPs in RTAs can promote progress in the WTO and thus contribute to environmental protection via the multilateral route (Brandi and Morin, 2023). The CPTPP, which became effective in 2018 and includes several major fishing nations, contains innovative provisions on fishery subsidies that helped pave the way for the eventual conclusion of the WTO Agreement on Fisheries Subsidies, which was adopted in 2022 after very lengthy multilateral negotiations (Rickard, 2022).

Future research could go into more depth concerning the different types and topical distinctions of the novel data on Ag-ERPs, and consider even more specific channels regarding the potential causal mechanisms behind them. For example, it could spotlight the private sector's role as a potential driver of improved environmental outcomes due to higher demand for green products. There is also scope for more research into the role of environmental non-governmental organizations in this context. Qualitative research can complement existing quantitative insights, help uncover the indirect effects of Ag-ERPs and shed new light on potential channels behind their effects on the environment and other relevant outcomes. The broader overview in this study suggests that while the impact of Ag-ERPs may differ across environmental outcomes, its potential effects can be substantial. Further delving into the various dimensions and mechanisms of enforceability of RTAs and their Ag-ERPs is a promising avenue for future research which could be relevant for policymaking, by informing the specific design of RTAs that include Ag-ERPs.

From a policy perspective, this study confirms that the design of trade agreements matters. Given the urgency of the climate crisis and other environmental problems and the important role of agriculture in this context, RTAs should be designed to help contribute to tackling these challenges. Looking ahead, there are several additional policy recommendations for decision-makers (see also Brandi and Morin, 2023). For example, to further boost the effectiveness of ERPs in RTAs, it is important to foster compliance, enforcement and to strengthen cooperation with civil society, from shaping RTAs to monitoring the implications of these trade agreements. Moreover, decision makers in high-income countries should focus on assistance for demand-driven capacity-building on environmental issues and future RTAs should provide more stringent commitments on environmental aid. Last but not least, policymakers should conduct regular ex-post environmental assessments of agreements to provide better learning opportunities for future RTAs that can tackle environmental challenges in the agriculture sector and beyond.

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Appendix A

Summary statistics

Table A1. Summary statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Agggregate CO_2 eq.	4 748	28 749.76	85 489.07	0	757 149.4
CH_4	4 748	19 190.13	57 873.46	0	560 244.1
N_20	4 748	9 559.624	29 289.03	0	318 134.5
ERPs	4 748	2.513709	5.482342	0	43.18766
RTAs	4 748	0.237291	0.429368	0	3.834458
Environmental regulations	4 748	494.7489	1 069.749	0	7 833
Agricultural land	4 748	24 725.52	65 488.96	0.4	528 217.6

Source: Authors' own elaboration.

Appendix B

Mediation analysis

The mediation analysis laid out in the main text combines two steps: a) elicit the association Ag-ERPs with the potential mediators – domestic environmental regulation and agricultural land use –, and b) the association of the mediators with the outcome variable – GHG emissions from agriculture.

The study first tests step a) whether the two considered channels are in fact associated with Ag-ERPs that a country includes in its RTAs. Then it regresses these channel variables on ERPs, following Equation (3). The results are depicted in Table A2.

Table A2. Effect of ERPs on channels

	(1)	(2)
	Environmental regulation	**Agricultural land**
ERPs	12.65	-70.13
	(11.25)	(70.65)
RTAs	-335.5***	543.7*
	(99.76)	(311.7)
Constant	542.6***	24 772.8***
	(28.10)	(163.8)
Countries	191	191
Observations	4 748	4 748
R^2	0.682	0.998

Notes: This table shows the results from the first step of a mediation analysis, given by Equation (3), with the potential channels, Environmental regulation as a count variable for the cumulative number of domestic environmental regulation in a country up to year t (Column 1), and Agricultural land as the area of agricultural land use in a country (Column 2), as dependent variables. ERPs are the Ag-ERPs, and RTAs the number of RTAs, both weighted by trading partner in agricultural products. Country and Year fixed effects are used. Robust standard errors clustered at the country level are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.
Source: Authors' own elaboration.

The estimation results show that both, domestic environmental regulation, as well as agricultural land are related to ERPs of a country in the expected directions, but the relationships are not statistically significant at conventional levels. While this may indicate that both channels are not at all significant for the overall association, the fact that the point estimates point in the right direction and are only marginally insignificant requires looking at whether the impact of the mediators on the outcome is so strong as to make an actual mediating relationship likely nonetheless.

In the next step, the study looks at whether GHG emissions are related to each channel, i.e., step b). To this end, Equation (4) is estimated. The results are depicted in Table A3.

Table A3. Effect of channels on GHG emissions

	(1)	(2)	(3)
	Aggregate CO_2eq.	CH_4	N_2O
ERPs	-89.00**	-54.50*	-34.50**
	(42.78)	(31.97)	(13.80)
RTAs	-663.2	-673.3	10.03
	(756.4)	(552.4)	(278.9)
Environmental regulation	-1.461***	-1.025***	-0.436***
	(0.344)	(0.253)	(0.121)
Agricultural land	0.485***	0.302***	0.183***
	(0.104)	(0.0625)	(0.0512)
Constant	17 861.3***	12 526.4***	5 334.9***
	(2 488.3)	(1 488.6)	(1 251.5)
Countries	191	191	191
Observations	4 748	4 748	4 748
R^2	0.994	0.994	0.991

Notes: This table shows the results from the second step of a mediation analysis, given by Equation (4), with aggregate CO_2eq. and those from CO_2eq. from CH_4 and N_2O in agriculture separately as dependent variables. ERPs are the Ag-ERPs, and RTAs the number of RTAs, both weighted by trading partner in agricultural products. Environmental regulation is a count variable for the cumulative number of domestic environmental regulation in a country up to year t, and Agricultural land is the area of agricultural land use in a country. Country and Year fixed effects are used Robust standard errors clustered at the country level are reported in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.
Source: Authors' own elaboration.

The results show that GHG emissions are significantly related to both channels considered, domestic environmental regulation and agricultural land use. However, even when both are included (and thus controlled for), ERPs direct effect on GHG emissions remains.

The results of the second step, combined with marginally significant results of the first step, combine into an overall statistically significant result for both mediators in the mediation analysis, displayed in the main text.

Appendix C

Relative emissions

Table A4. Relative emissions

	(1) Aggregate CO_2eq. (relative)	(2) CH_4 (relative)	(3) N_2O (relative)
ERPs	-0.00678***	-0.00603**	-0.00667***
	(0.00226)	(0.00233)	(0.00228)
RTAs	0.0388	0.0347	0.0656**
	(0.0282)	(0.0267)	(0.0325)
Constant	1.008***	1.007***	1.001***
	(0.00679)	(0.00618)	(0.00737)
Countries	188	188	188
Observations	4 673	4 673	4 673
R^2	0.109	0.0694	0.143

Notes: This table shows the results from estimating Equation (2), with aggregate CO_2eq. and those from CO_2eq. from CH_4 and N_2O in agriculture separately as dependent variables, all relative to the respective country means over the sample. ERPs are the Ag-ERPs, and RTAs the number of RTAs, both weighted by trading partner in agricultural products. Country and Year fixed effects are used. Robust standard errors clustered at the country level are reported in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

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