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Assessing the Effectiveness
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in Regional Trade
Agreements: An Empirical
Analysis

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Zarzoso**

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Abstract

ASSESSING THE EFFECTIVENESS OF ENVIRONMENTAL PROVISIONS IN REGIONAL TRADE AGREEMENTS: AN EMPIRICAL ANALYSIS

Inmaculada Martínez-Zarzoso

While governments increasingly commit to incorporating environmental objectives in Regional Trade Agreements (RTAs), the evidence on the impact of including environmental provisions in RTAs on environmental outcomes is still very scarce. Only a few studies are known to address the relationship between RTAs and environmental quality to date.

In this context, this report aims to test whether the inclusion of environmental provisions in RTAs has contributed to the improvement of environmental quality among the Parties to these agreements through empirical modelling and analysis. Three indicators are considered as a proxy for environmental quality: concentrations of suspended particulate matter less than 2.5 microns (PM_{2.5}), sulphur dioxide (SO₂) and nitrogen oxide (NO_x).

The analysis identifies a statistically significant and positive relationship between membership in RTAs, either with or without environmental provisions, and improved environmental quality for two out of three pollutants investigated. However, the extent to which RTAs with environmental provisions makes an additional difference on emissions in comparison to those without environmental provisions could not be concluded with enough statistical certainty under the current empirical framework. While the analysis faces a number of challenges such as: (i) correctly measuring the environmental end points; (ii) separating the impact of RTAs from other factors; and (iii) potential endogeneity and reverse causality issues, future analysis could benefit from better information on the channels of effects and the further developed environmental indicators on both policy and output.

JEL classification: F13, F18, R11, Q56, Q58

Keywords: Regional trade agreements, free trade agreements, environmental provisions, trade and environment, environment policy, trade policy.

Résumé

Alors que les gouvernements s'engagent de plus en plus à intégrer les objectifs environnementaux dans les accords commerciaux régionaux (ACR), les analyses de l'impact de l'inclusion de dispositions environnementales dans les ACR sur l'environnement sont encore très rares. La relation entre les ACR et la qualité de l'environnement a ainsi été peu étudiée à ce jour.

Dans ce contexte, ce rapport vise à déterminer si l'inclusion de dispositions environnementales dans les ACR a contribué à l'amélioration de la qualité de l'environnement pour les Parties de ces accords à l'aide d'une analyse empirique. Trois indicateurs sont considérés comme un indicateur de la qualité de l'environnement: les concentrations de particules en suspension inférieures à 2,5 microns (PM 2,5), de dioxyde de soufre (SO₂) et d'oxydes d'azote (NO_x).

L'analyse identifie une relation statistiquement significative et positive entre la participation aux ACR, avec ou sans dispositions environnementales, et une amélioration de la qualité environnementale pour deux des trois polluants étudiés. Cependant, l'impact spécifique sur les émissions des ACR assortis de dispositions environnementales (par rapport aux ACR qui ne comportent pas de dispositions environnementales) ne peut être conclue avec suffisamment de certitude statistique dans le cadre empirique actuel. L'analyse fait face à un certain nombre de défis tels que: (i) mesurer correctement les indicateurs environnementaux; (ii) séparer l'impact des ACR des autres facteurs; (iii) les problèmes d'endogénéité et de causalité inverse. Les futures analyses pourraient donc bénéficier d'une meilleure information sur les mécanismes en jeu ainsi que le développement d'indicateurs plus précis sur les politiques environnementales mises en place et les performances environnementales.

Classification JEL: F13, F18, R11, Q56, Q58

Mots clés: Les accords commerciaux régionaux, les accords de libre-échange, les dispositions environnementales, le commerce et l'environnement, la politique de l'environnement, la politique commerciale.

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Executive Summary

Environmental objectives are increasingly being incorporated into Regional Trade Agreements (RTAs) to promote environmental quality, to prevent market failures and externalities related to increasing levels of pollution and ultimately to ensure the mutual supportiveness of trade and environmental policies. The rationale for including environmental provisions (EPs) in RTAs is four-fold: (i) to contribute to the overarching goal of sustainable development; (ii) to ensure a level playing field among parties to the agreement; (iii) to enhance environmental cooperation of shared interest, and (iv) to pursue international environmental objectives. The number of RTAs that include environmental provisions has been increasing since the mid-1990s and reached 121 RTAs in force in 2016 with an explicit reference to environmental objectives in the preamble of the agreement. These provisions vary in content and degree of enforcement and have been mainly proposed by developed countries to strengthen stringency of domestic environmental policies of potential RTA Partners. In particular, upholding environmental law between trading partners is one of the main principles of these provisions to avoid the relocation of pollution intensive industries to potential destinations with lax environmental standards, so called the “pollution haven hypothesis”.

However, despite their increasing importance, the evidence on the impact of including environmental provisions in RTAs on environmental outcomes has been scarce. There is however, some anecdotal evidence on how RTAs with environmental provisions might improve environmental quality. For example, environmental provisions in RTAs can contribute to strengthening of domestic environmental regulations (such as on air quality), introducing new institutional arrangements (such as the creation of a Ministry of Environment), establishing co-operation mechanisms on improving environmental law and enforcement, and improving environmental awareness and public participation.

Empirical evidence on the effects of environmental provisions in RTAs on environmental outcomes is still very limited. To date, only two studies of Ghosh and Yamarik (2006) and Baghdadi et al. (2013) are known to address the relationship between RTAs and environmental quality. Building on these two studies, this Working Paper aims to test whether the inclusion of environmental provisions in RTAs has contributed to improve environmental quality among RTA members through empirical modelling and analysis. The following three indicators are considered in this analysis as a proxy of environmental quality: concentrations of suspended particulate matter less than 2.5 microns (PM_{2.5}), sulphur dioxide (SO₂) and nitrogen oxide (NO_x). Clearly, there is a broader range of possible environmental outcomes than the air quality measures used in this analysis. The selection of the proposed indicators has been based mainly on data availability, representativeness and relevant literature.

Empirical models are estimated for each of these three pollutants to investigate whether the level of the given indicators over the period 1999–2011 for PM_{2.5} and 1970–2008 for SO₂ and NO_x for a global cross section of countries indicate an improvement in environmental quality after the entry into force of the agreements. The actual number of countries was dependent upon data availability. For SO₂ and NO_x the coverage is almost global with 157 countries, while for PM_{2.5}, 48 countries could be included in the empirical analysis.

The empirical analysis in this Working Paper indicates that there appears to be a statistically significant relationship between membership in RTAs, either with or without environmental provisions, and improved environmental quality for two out of three of the pollutants investigated (SO₂ and NO_x), while the results for PM_{2.5} do not always hold. For SO₂ and NO_x, the magnitude of the effect is slightly larger for the number of RTAs with EPs than without EPs. However the effect of the number of RTAs with EPs on emissions is not

statistically different from those without EPs. To be clear, environmental provisions may still have an additional positive effect on the environment beyond the RTA itself. However, these effects could not be demonstrated in a statistical sense.

These results should, be further considered as tentative for a number of reasons. First, measuring the environmental end points in a given country is a difficult exercise. Air emissions of PM_{2.5}, SO₂ and NO_x are known to be local pollutants and may not be a perfect proxy to represent environmental quality at the national level. Similarly, air emissions do not respect country borders, hence measuring emission concentrations and linking it to domestic policy conditions may be problematic (especially for small countries).

Second, separating the impact of RTAs from other factors influencing country-level emissions is also a challenging task. Clearly, RTAs are not assigned randomly to a country, which leads to a potential selection bias. Trade agreements can also have economy-wide effects, which even spill over to other countries via price and income effects, and subsequently may have an indirect impact on environmental quality. On the contrary, there are many other factors that could influence country-level emissions in the broader economy in parallel to RTAs. There are some signs of anecdotal evidence that environmental provisions in RTAs may have positive environmental effects through channels such as strengthening national environmental regulations, introducing new institutional arrangements, promoting environmental co-operation and improving environmental awareness. However, these potential channels also lack comprehensive data in order to test over the vast range of RTAs agreed across developed and developing countries.

Finally, there are potential endogeneity issues. While RTAs, trade openness and income levels may all impact air emissions, air emissions may also have an impact on the level of income, trade or the signing of an RTA, leading to reverse causality, which is a source of endogeneity, or may be influenced by other factors for which data are not available (omitted variable bias). As an example of omitted variables bias, a country that seeks to improve environmental quality may also be more likely to enter into negotiations of RTAs with substantive environmental provisions. The empirical challenge is to separate out the effect of the RTA and its environmental provisions from other drivers of environmental policy at the state level. In this study, a generic econometric method (i.e. Generalised Method of Moments (GMM)) is applied to address potential endogeneity of the RTA variables. Nevertheless, this estimation technique may also have some drawbacks arising from limited sample distributions.

Further extension of this kind of work could include better proxies and broader coverage of environmental indicators based on countries and time periods. Further analysis is also needed to shed light on the channels through which environmental provisions in RTAs may influence domestic policy processes, and ultimately environmental outcomes. Environmental policy indicators that cover both developed and developing countries would be required to further develop such analysis.

1. Introduction

The interactions between international trade and environmental quality have been widely recognised by scholars and policy actors since the early 1990s. Trade and the environment was already identified as a relevant area in the 1992 Rio Earth Summit and referred to as well in the Rio+20 agreement. The agreement recognised that more action was required to ensure that countries could pursue development policies with the necessary environmental protection to ensure a sustainable path of economic growth and social progress.

This report is a continuation of the efforts undertaken by the OECD Joint Working Party on Trade and the Environment (JWPTE), which has been analysing the links between trade and the environment for over 20 years. Specifically, it provides new insights on the link between Regional Trade Agreements (RTAs) and environmental outcomes. The JWPTE has been exploring this area since 2005.

The increasing importance of regional and bilateral trade negotiations, with more than 250 RTAs in force in 2014 (see Figure 1), has been reinforced by the slow progress in the multilateral negotiation arena, on both trade and environmental issues. In some instances, it seems reasonable to tackle environmental issues within the framework of the numerous ongoing RTA negotiations. For instance, by taking the opportunity of the negotiations to sign a side agreement covering environmental issues or by directly including a chapter dedicated to the environment in the main text of the agreement.

Since the late 1990s, an increasing number of RTAs have introduced environmental provisions in the main text of the agreement or in companion side agreements. These provisions aim at protecting the environment and at establishing ways of collaboration in environmental issues. For instance, Art. 3 in the agreement on environmental cooperation between Canada and Chile states: “each Party shall ensure that its laws and regulations provide for high levels of environmental protection and shall strive to continue to improve those laws and regulations”, whereas Art. 6 refers to the enforcement of environmental regulations and Art. 8 contemplates the creation of the Canada-Chile Commission for Environmental Cooperation in charge of implementing the agreement. On the other hand, EU agreements with partners tend to include a chapter dedicated to sustainable development, as for example the EU-CARICOM agreement, which in Art. 6 recognize that the Parties to an agreement have the autonomy to determine their own levels of domestic environmental protection. Gallager and Serret (2011) provide extensive examples of the most frequently included environmental provisions.

The rationale for including environmental provisions (EPs) in RTAs is four-fold: (i) to contribute to the overarching goal of sustainable development; (ii) to ensure a level playing field among parties to the agreement; (iii) to enhance environmental cooperation of shared interest, and (iv) to pursue international environmental objectives (OECD, 2007). In particular, upholding environmental law between trading partners is one of the main principles of these provisions to avoid the relocation of pollution intensive industries, so called the “pollution haven hypothesis” (George, 2014a).

Environmental provisions widely vary by agreement. While different environmental issues are included in the legal text, some environmental provisions refer to aspects related to the enforcement mechanisms included in the provisions. At a minimum, newer RTAs tend to incorporate environmental issues in the preamble or in some articles dealing with investment issues or exceptions. Other RTAs include a chapter dedicated exclusively to

environmental matters. The bars in Figure 1 show the evolution over time of the number of RTAs dealing with environmental issues. An increase is observed, particularly, in the 2000s. In cumulative terms, around 50% of the agreements signed until 2014 incorporate environmental issues (versus only 20% in 2000).

Since 2007, the OECD has undertaken regular reviews of how environmental issues are treated in RTAs (OECD, 2007) and provided an updated inventory of RTAs with environmental provisions (Tébar Less and Gigli, 2008; Gigli, 2009; Gallagher and Serret, 2010 and 2011; George, 2013, 2014a and 2014b). The OECD reports refer to some ex-post assessments of environmental impacts (e.g. EU-Chile in George, 2013) and mention the difficulty of isolating the impact of the RTAs on environmental outcomes from other factors.

Figure 1. Cumulative number of RTAs by date of entry into force

Source: WTO, RTA gateway and author's elaboration. Cum N RTAs with EPs denotes the cumulative number of RTA with environmental provisions or with side environmental agreements.

The scarce literature on the impact of including environmental provisions in RTAs motivates this report. This paper investigates whether participation in RTAs with environmental provisions affects environmental quality, and whether the inclusion of more comprehensive environmental provisions has a stronger effect on environmental quality. The analysis is done considering the RTAs that entered into force or were enlarged over the period 1970 to 2011, out of which 94 include environmental provisions. The data on environmental indicators is available for the period 1999 to 2011 for PM_{2.5}, and 1970 to 2008 for SO₂ and NO_x, which is also the timeframe for the econometric analysis.

The rest of this paper is structured as follows. Section 2 reviews the literature on the impact of trade liberalisation and RTAs on the environment. Section 3 presents the empirical framework and the main modelling strategy. Section 4 presents and discusses the main empirical results. Finally, Section 5 draws conclusions.

2. Literature Review

2.1. The impact of trade liberalisation on the environment

There is no consensus on the impact of trade liberalisation on the environment. Increasing openness and trade generates a mixture of potential positive and negative effects on the environmental and natural resources of countries (Grossman and Krueger, 1991; Copeland and Taylor, 2003; Yamarik and Ghosh, 2011; Baghdadi, Martínez-Zarzoso and Zitouna, 2013). For this reason, the interactions between trade and the environment have been widely investigated by economists in the last two decades. Grossman and Krueger (1991), using a computable general equilibrium model,¹ focused on predicting the environmental effects of the entry into force of the North American Free Trade Agreement (NAFTA) and broke down the environmental impact of trade liberalisation into scale, technique and composition effects. This decomposition has been frequently used in subsequent related literature,² with some authors stating that when trade is liberalised, all these effects interact with each other (Copeland and Taylor, 2003; Managi et al., 2009). In what follows a brief description of the scale, technique and composition effects is presented.

The *scale effect* indicates that an increase in global economic activity due to increased trade raises the total amount of pollution and, as a consequence, creates environmental damages. Thus, the scale effect is generally expected to have a negative impact on the environment. However, the evidence from the literature also reports that higher incomes could affect environmental quality positively (Grossman and Krueger, 1991; Copeland and Taylor, 2003). This suggests that when assessing the effects of growth and trade on the environment, trade cannot be held responsible for environmental damage (Copeland and Taylor, 2003). A way to reconcile these two opposing effects of increasing income on environmental quality is to acknowledge that the relationship changes with the level of income. That is, for low income levels, increasing economic activity increases pollution, whereas for higher income levels further increases in economic activity could be linked to better environmental quality, since increasing incomes per capita are usually associated to a greater demand for environmental quality and in turn to beneficial changes in environmental policy. This argument is linked to the so-called Environmental Kuznets Curve (EKC), which hypothesises the existence of an inverted U-shaped relationship between environmental quality and per capita income. The EKC, which posits that environmental quality first decreases and then rises with increasing income per capita (Stern, 2004) is discussed in Box 1.

¹ The study was a theoretical ex-ante assessment based on estimates of NAFTA impacts on the production structure of Canada, US and Mexico available from Brown, Deardorff and Stern (1991) and it was not a study on the actual effects of NAFTA.

² Antweiler et al. (2001), Stoessel (2001), Cole and Elliot (2003), Lopez and Islam (2008).

Box 1. Environmental Kuznets Curve

The concept of the Environmental Kuznets Curve (EKC) – the hypothesis of an inverted U-shaped relationship between environmental degradation and the level of economic development – was introduced by Grossman and Krueger (1991) to support their argument that economic growth in Mexico improved, rather than reduced, environmental quality. One year later, the World Bank Development Report popularised the EKC by arguing that greater levels of income per capita do not necessarily harm the environment. They can instead be associated with an increase in demand for more environmental quality and lead to decreases in pollution.

Over the last few decades, numerous empirical studies have tested for the existence of an EKC (See Dinda, 2004; Carson, 2010 and Stern (2004 and 2014) for a summary of the empirical literature). The results obtained mainly depend on the indicator and the sample of countries examined. The basic model uses emissions of CO₂ (or other pollutants) per capita as dependent variable and the main independent variables are the level and the square term of income per capita. Evidence supporting the EKC is found when the estimated coefficient of the level term is positive and the coefficient of the squared term is negative. Income per capita is usually measured in natural logarithms; in this case the turning point³ can easily be calculated. Generally, the EKC hypothesis is more likely to be confirmed for local-impact pollutants rather than for global (Dinda, 2004). Whereas a number of authors empirically verified the inverted-U relationship between income and sulphur emissions (Seldon and Song, 1994; Panayotou, 1997; Stern and Common, 2001); others found that for CO₂ the relationship is monotone or even N-shaped, where degradation initially follows the inverted-U pattern, but then begins to increase again with higher incomes (Martínez-Zarzoso and Bengochea-Morancho, 2004; Dijkgraaf and Vollebergh, 2005; Cole, 2003; Galeotti et al., 2006).

In general, the results obtained are sensitive to the functional form considered (quadratic or cubic specifications are usually adopted) and, mainly, to the model assumptions adopted (Harbaugh et al. 2002). As regards the different environmental indicators used, the literature concludes that for pollutants with local and more short-term impacts a significant EKC is more likely to hold than for global and long-term pollutants (Dinda, 2004; Carson 2010).

According to Carson (2010), the focus should be shifted from exclusively studying the shape of the relationship between pollution and income per capita to investigating the mechanisms and transmission channels that affect the income-environmental quality relationship. Therefore, more comprehensive models that include the influence of policy explicitly should be used in empirical evaluations.

The second effect of trade liberalization on environmental quality is the *technique effect*, which is expected to have a positive impact on the environment. According to this effect, the state of the technology improves with trade liberalization in the countries that participate in the process and the widespread use of cleaner technologies helps to reduce pollution. Researchers widely agree that trade is a main channel for technology transfers and new technology should benefit the environment if pollution per output is reduced. In particular, a reduction in the emission intensity results in a decline in pollution, holding constant the scale of the economy and the mix of goods produced. Recent studies suggest that this effect can in some cases prevail over the scale effect (Levinson, 2015).

Finally, the third effect resulting from reduction in trade barriers and increasing trade that influences environmental quality is the *composition effect*. Trade liberalisation results in changes in the comparative advantage and the composition of production in the economies. On the one hand, when the induced change fosters production mainly in clean sectors, then environmental quality increases. On the other hand, when the new protection structure benefits sectors that are pollution-intensive, environmental quality decreases. Therefore, the net impact of the composition effect of trade on the environment is

³ The turning point gives the level of income per capita after which the relationship turns out to be negative, that is higher levels of income per capita are associated with lower levels of pollution.

ambiguous according to economic theory. Trade based on comparative advantage results in countries specialising in the production and the trade of those goods that the country is relatively efficient at producing. This comparative advantage could not only result from differences between countries in factor endowments, but also from environmental regulations. In this sense, countries will benefit economically from having looser regulations, and environmental damage might result. The Pollution Haven Hypothesis (PHH) predicts that trade liberalisation in goods will lead to the relocation of pollution-intensive production from countries with high income and more stringent environmental regulations to countries with low income and less stringent environmental regulations. Therefore, developing countries could become pollution havens. However, if factor endowments are the main source of comparative advantage, the Factor Endowment Hypothesis (FEH) claims that countries where capital is relatively abundant will export capital-intensive (dirty) goods. This stimulates production while increasing pollution in the capital-rich country. Countries where capital is scarce will see a fall in pollution given the contraction of the pollution generating industries.

Thus, the effects of liberalised trade on the environment deriving from the composition effect mainly depend on the distribution of comparative advantages across countries and the relative importance of the main factors that determine comparative advantages. Earlier studies using aggregate trade did not find strong evidence of a pollution haven effect. Nevertheless, new studies using more disaggregate data and accounting for endogeneity issues and spillovers tend to find some support for it (Broner, Bustos and Carvalho, 2012; Millimet and Roy, 2016; Martínez-Zarzoso, Vidovic and Voicu, 2017).

In summary, the earlier literature identifies the existence of both positive and negative effects of the liberalisation of trade on the environment. The positive effects include increased growth and technology transfers accompanied by the distribution of environmentally safe, high quality goods, services and technology. The negative effects stem from the relocation of pollution-intensive economic activities in countries with lax environmental regulations that could potentially threaten the regenerative capabilities of ecosystems while increasing the danger of depletion of natural resources. Most of the empirical literature has used changes in trade openness as a proxy for trade liberalisation (Antweiler et al., 2001; Cole and Elliot, 2003; Frankel and Rose, 2005; Managi et al., 2009). In contrast to the theoretical predictions, early findings pointed to net positive effects of trade on the environment (Frankel and Rose, 2005). The explanation for this positive effect is that trade encourages innovation, speeds the absorption of new technologies and could also bring clean production techniques from more technologically advanced countries to the less advanced.

Surprisingly, few studies have been devoted so far to regional trade agreements (RTAs), except in the case of NAFTA (Grossman and Krueger, 1991; Stern, 2007; Cherniwchan, 2017). To the best of our knowledge, only two studies have used the existence of RTAs instead of trade openness as a trade policy variable that could influence pollution levels or more generally environmental outcomes (Ghosh and Yamarik, 2006; and Baghdadi et al., 2013). These two studies are described in detail in the next section.

2.2. The impacts of RTAs on the environment

The first published study evaluating the possible quantitative impact of RTAs on the environment was Ghosh and Yamarik (2006). The authors propose and estimate an empirical model where trade, growth and RTAs are linked and in which RTAs can have a direct and an indirect effect on the environment (through increasing trade and growth). Their empirical approach combines three well-known modelling strategies in the economics literature. First, the gravity model of trade, which has been considered the

workhorse of empirical trade modelling since the early 1990s (Feenstra, 2004), is used to estimate the determinants of bilateral trade flows.⁴ Second, growth in GDP per capita is modelled following the growth empirics literature that considers trade openness as one of the deep factors explaining economic growth (Frankel and Romer, 1990; Doyle and Martínez-Zarzoso, 2011).⁵ Finally, the above-mentioned literature linking trade with growth and environmental quality, based on the seminal work of Grossman and Krueger (1991) and Antweiler et al. (2001), is used to estimate the determinants of environmental degradation. As a proxy for degradation, three indicators of air quality (suspended particulate matter, sulphur dioxide and nitrogen dioxide) and four of resource utilisation (carbon dioxide per capita, percentage change in deforestation, energy depletion per capita and water pollution per capita) are considered. They apply ordinary least squares (OLS) in combination with instrumental variable estimation techniques (IV), the latter being used to control for the endogeneity of trade and income, to a sample of 35 92 countries, depending on the indicator, in 1995 (using bilateral trade data for 1990).

The main findings show that membership in RTAs (without distinguishing between those with and without environmental provisions) reduces pollution by raising trade and income per capita, indicating that there is an indirect positive effect on environmental quality. In contrast, no evidence is found for the existence of a direct effect, for instance, they do not find any evidence that membership of RTAs itself affects environmental outcomes. There are three main limitations to this study. First, it is based on data for a cross-section of countries in a single year and therefore is unable to include dynamics and to control for unobserved factors that are time-invariant. Second, and perhaps this is the main shortcoming, the authors do not explain the mechanism through which the membership to RTAs could affect the environment. Finally, a third limitation is that there are important differences among RTAs in the way they take into account environmental issues. Whereas some RTAs include an extensive range of environmental provisions (e.g. Canada-Panama), others are limited to confirming the general exceptions of GATT (art XIV and XIV) or exceptions for specific chapters (e.g. Australia-Malaysia).

The two first issues are addressed in a subsequent paper by Baghdadi et al. (2013), which is the only other study that evaluates the impact of RTAs on the environment to explain changes in environmental outcomes. Baghdadi et al. refine and extend the modelling strategy applied in Ghosh and Yamarik (2006) by considering not only trade and GDP growth as endogenous variables, but also membership in RTAs. Moreover, the models are estimated for a panel-data set of 182 countries over the period from 1980 to 2008 and the endogeneity of the RTA variable is addressed by using matching and difference in differences (DID) techniques. The most remarkable departure from Ghosh and Yamarik (2006) is that Baghdadi et al. (2013) introduce the idea that if a direct positive effect of RTAs on the environment exists, it should only be found for those agreements that specifically include environmental provisions in the main text of the trade agreement, or for those that are accompanied by side environmental agreements, as in the case of NAFTA.⁶

⁴ The gravity model of trade estimates that trade between countries is positively determined by their size (GDP, population and land area) and negatively determined by geographical and cultural distance. See Annex 2, A.2.2 for more details.

⁵ The growth-empirics literature, as in Frankel and Rose (2005), estimates that income levels can be predicted by lagged income per capita, population size, rates of investment, and human capital formation. See Annex 2, A.2.1 for more details.

⁶ Ghosh and Yamarik (2006) just mention that regional trade agreements address environmental issues and give the examples of NAFTA and the EU (page 20, second paragraph: “*Whatever the route through which trading blocs impact the environment, regional trading arrangements are addressing environmental issues...*”).

The direct effect is explained by the fact that environmental provisions in RTAs will encourage members to apply and enforce more stringent environmental regulations and these should in turn enhance environmental quality. Hence, the link with regulations should induce an improvement in environmental outcomes independent of the trade-induced and income induced effects and even for similar levels of national environmental regulations. In their paper, a distinction is made between RTA's membership in agreements with and without environmental provisions. The first limitation of this study is that environmental degradation is proxied with a single variable, namely carbon dioxide emissions. While an important driver of climate change, CO₂ emissions are not necessarily linked to other indicators of environmental quality. A second limitation is that environmental provisions are very heterogeneous, with some RTAs including very detailed provisions and others only mentioning the environment in the investment chapter (e.g. OECD, 2007). Hence, modelling this using a dummy variable is over-simplistic. Finally, a measure of national environmental regulations is missing in the analysis. National environmental regulations can affect environmental quality, but also trade (Tsurumi et al., 2015).

The methodology in Baghdadi et al. (2013) consists of modelling per-capita emissions as a function of population, land area per capita, GDP per-capita, trade and RTAs. Since there could be reverse causality between the independent and the dependent variables, they assume that GDP per-capita and the trade variables are endogenously determined. The authors use instrumental variables (IV) techniques to estimate GDP per-capita (with a model borrowed from the growth-empirics literature) and trade (using a gravity model) and address RTA endogeneity due to self-selection into agreements using matching econometrics in combination with DID. To test whether countries' CO₂ emissions trajectories converge, a model for per-capita emissions is first estimated in relative terms using the log of carbon dioxide emissions per capita ($\log(\text{CO}_2 \text{ emissions of country } i \text{ relative to country } j \text{ in period } t)$, E_{mit}/E_{mjt}) as dependent variable and expressing GDP per-capita, land area per-capita and population also in relative terms. Next, the model is also estimated in absolute terms to examine the direct effect of RTAs on absolute pollution levels. In this case, the RTA variable is generated as a weighted average, using emissions in the partner countries as weights.

The main results obtained from estimating the emissions model in relative terms provide evidence that RTAs with environmental provisions foster the convergence of pollution levels across pairs of countries. Moreover, the agreements that specifically include provisions to ensure enforcement (NAFTA) are converging at a higher rate than others (EU), which leave compliance measures to the legal system. Conversely, RTAs without environmental provisions do not affect relative pollution levels, indicating that controlling for bilateral trade levels and overall openness, the trade policy variable (membership of RTAs) does not have a direct effect on emissions convergence for this type of agreements. When the model is estimated in absolute terms, the findings indicate that emissions are around 0.3% lower for countries that have RTAs with environmental provisions, whereas the effect is not statistically significant for countries with RTAs without environmental provisions. Hence emissions converge to a lower level when both countries belong to the same RTA and the RTA includes environmental provisions. With respect to the trade-environment link, the results do not show a significant effect of openness on absolute levels of carbon dioxide emissions.

3. Empirical Framework and Analysis

In this section we present the analytical framework proposed to investigate the effect of environmental provisions in RTAs on a number of environmental indicators.

3.1. Possible channels of environmental effects

Environmental quality at the local and regional level may have a number of drivers including demography, economic variables, and international trade as given below in Figure 2.

Figure 2. Potential drivers of environmental quality

Understanding the possible channels of environmental provisions in RTAs that may deliver environmental benefits is an important step in setting up the empirical framework. There is some anecdotal evidence on how RTAs with environmental provisions might promote environmental outcomes. According to George and Yamaguchi (2018) environmental provisions in RTAs can seemingly contribute to improve environmental quality through four different channels that are outlined in what follows with the corresponding real-life examples:

- Strengthening of environmental regulations, such as adopting new environmental laws, as seen in the case of US-Chile (GAO, 2014); adopting new environmental impact assessment frameworks or regulations, as in the case of the Dominican Republic–Central America Free Trade Agreement (CAFTA-DR) (OAS, 2009); and adopting laws on air pollution, as in the case of US-Morocco (GAO, 2009).⁷

⁷ For example, the United States – Chile FTA (2003) Article 19.1 states that “[...] each Party shall ensure that its laws provide for high levels of environmental protection and shall strive to continue to improve those laws” while Article 19.2(2) affirms that “it is inappropriate to encourage trade or investment by weakening or reducing the protections afforded in domestic environmental laws” and Article 19.8 asserts that “[e]ach Party shall ensure that judicial, quasi-judicial, or administrative proceedings are available under its law to sanction or remedy violations of its environmental laws”. According to the evaluation report made available by GAO (2014), Chile has taken steps to

- Introducing new institutional arrangements, such as creating a Ministry of Environment, as in US-Chile, US-Peru, and US-Jordan (GAO, 2009; 2014); creating an Environmental Auditing Unit in Guatemala in the framework of CAFTA-DR (GAO, 2014).⁸
- Providing co-operation on improving environmental law and enforcement, such as co-operation in creating a Technical Council for Enforcement of Environmental Law in Guatemala as a follow up to CAFTA-DR (OAS, 2009); co-operation in creating a National Environmental Law Enforcement Strategy, in Honduras as a follow up to CAFTA-DR (OAS, 2009), co-operation to encourage the exporting private sector to comply with EU standards, as in the case of EU-Chile (ITAQA, 2012); and co-operation to adopt a Pollutant Release and Transfer Registry (PRTR) work plan, as in CAFTA-DR (OAS, 2009).
- Improving environmental awareness; such as the public participation process introduced by the Commission for Environmental Cooperation (CEC), having impact on Mexico's civil society under the framework provided by NAFTA and the North American Agreement on Environmental Cooperation (NAECC) (CEC, 2004).

More specifically, the adoption of stricter standards, better enforcement, and cooperation under the EU-Chile FTA seemingly helped to reduce air pollution in Chile (ITAQA, 2012). Also, progress on pollution prevention in Mexico has been facilitated under the framework of NAFTA and NAECC (CEC, 2004).

It is worthwhile to note that, Mexico and Morocco have passed new environmental laws, prior to the enforcement of their respective agreements, NAFTA/ NAECC and US-Morocco, which were possibly influenced through the negotiation process (CEC, 2004; GAO, 2009). As the negotiation process itself can have implications to environmental policies and the environment, we could possibly argue that it is difficult to identify a suitable lag of time that enables these effects to appear.

At the same time, it is also important to point out that the possible effects on environmental outcomes described above are largely anecdotal and have not been subject to rigorous analysis. They, for example, could be influenced by many other factors. Environmental provisions in RTAs may not be the main driver of these effects but could rather arguably be an additional factor in proposing certain changes.

strengthen its environmental standards in-line with its commitments in RTAs and established a new environmental law approved in 2010. Furthermore, the United States – Chile FTA (2004) contains an enforceable provision that is subject to dispute settlement in Article 19.2 (1.(a)) which commits the Parties not to “[...] fail to effectively enforce its own environmental laws, through a sustained or recurring course of action, in a manner affecting trade between the parties.” With the legislation in place and its enforcement subject to dispute settlement, this RTA makes strong commitments towards establishing and implementing its environmental law.

⁸ In the case of United States – Peru FTA (2006), Article 18.1 affirms that “[...] each Party shall strive to ensure that those laws and policies provide for and encourage high levels of environmental protection and shall strive to continue to improve its respective levels of environmental protection” while Article 18.6 commits the Parties to “establish an Environmental Affairs Council [...] and [...] designate a senior level official with environmental responsibilities to represent it on the Council and an office in its appropriate ministry or government entity to serve as its contact point” to oversee the implementation of environmental commitments. With these commitments in place, the GAO (2014) study indicated that the RTA has helped Peru to take steps to improve environmental protection and establish its Environment Ministry in 2008.

3.2. Overview of the analytical framework

Drawing on the anecdotal evidence on the possible channels of the effects as illustrated in the previous subsection, the analysis aims to test whether there is empirical evidence between the membership to an RTA with environmental provisions and environmental quality. The main modelling strategy is based on Ghosh and Yamarik (2006) and Baghdadi et al. (2013) and consists of extending their approaches to estimate the effects of trade and RTAs on several environmental indicators using data for more years. The environmental indicators considered are concentrations of suspended particulate matter of less than 2.5 microns (PM_{2.5}), sulphur dioxide (SO₂) and nitrogen oxide (NO_x) as indicators of air quality. Environmental indicators used as dependent variables in the empirical models and the corresponding explanatory variables and data sources are described in the data section below.

3.3. Data sources and variables

Annual data for a cross-section of countries over time are used in the empirical estimations. The number of countries and years included depends on the environmental indicator considered and on data availability. For SO₂, NO_x the coverage is almost global with 157 countries, while for PM_{2.5}, 48 countries could be included in the empirical analysis.

The selection of the proposed metrics of environmental quality has been based mainly on data availability, representativeness of environmental quality and previous related literature (see Table 1).⁹ Typically environmental provisions could strengthen environmental policy stringency through enforced environmental legislation, institutional mechanisms, and environmental co-operation, as well as public awareness which may have influence on environmental endpoints where air quality based on emissions would provide as a proxy indicator. More specifically, PM_{2.5} is a more suitable indicator than PM₁₀,¹⁰ ambient levels of ozone are not directly related to economic activity and most of the existent environmental performance indices are only available for a single year.

⁹ Other indicators, such as CO₂, GHG, N₂O, CH₄, energy depletion, deforestation, water quality indicators, PM₁₀, ambient levels of ozone and existent environmental performance indices were also initially considered but disregarded for different reasons. In particular, time series available for CO₂ are largely estimated through national inventories and are not physically measured as the air pollution indicators of PM_{2.5}, SO₂ and NO_x. Since this adds further complexity to the country-level data analysis, CO₂ data was not used in this model.

¹⁰ We use PM_{2.5} instead of PM₁₀ or SPM in this study. SPM refers to particles in the air of all sizes, whereas PM_{2.5}, usually called fine particles, are not visible to the eye and are more harmful for health.

Table 1. Description of environmental indicators, data and sources

Environmental Indicator, (variable name) ¹¹	Definition	Source	Period
PM 2.5 Population Weighted mean Concentration (pm25pw)	PM less than 2.5 microns in diameter from motor vehicles, fossil-fuel power plants, wood burning (micrograms per cubic meter)	Boys et al., 2014 OECD elaboration	1999-2011
Sulphur Dioxide per Capita (so2pc)	Emissions of SO ₂ (Kt)	EDGAR ^b , UNFCCC ^c	1970-2008
Nitrogen Oxide per Capita (noxpc)	NO, NO ₂ , Produced when fossil fuels are burnt, main constituent of acid rain (Kt)	EDGAR ^b , UNFCCC ^c	1970-2008

Notes:

a. Kt denotes Kilotonnes.

b. Emission Database for Global Atmospheric Research: <http://edgar.jrc.ec.europa.eu/>. Land-Use Change and Forestry is from FAO 2014, FAOSTAT Emissions Database.

c. UNFCCC data derives directly from United Nations Framework Convention on Climate Change (UNFCCC) Secretariat (http://unfccc.int/ghg_data).

Data for PM_{2.5} are from the OECD.¹² The variable used is the population weighted mean concentration of PM_{2.5} computed and kindly provided by the OECD. The data are available for 51 countries for the period from 1999 to 2011, which enables the analysis of PM_{2.5} concentration and RTAs for a cross-section of 48 countries. Data for Sulphur Dioxide (SO₂) and Nitrogen oxides (NO_x) are from EDGAR and available for the period 1970-2008.

Other variables used in the estimations of the empirical models are described in what follows. Bilateral exports are from UN-COMTRADE and data for factors influencing bilateral trade, namely country and country pair characteristics are from CEPII. The variables used include distance between capital cities of the trading countries, dummy variables for common language, common colony, exit to the sea, area of the countries, common border.

Data for factors explaining income per capita in the growth regressions (population growth, human development index) are from the WDI and the Penn World Table 8.1 (PWT 8.1: www.rug.nl/research/ggdc/data/pwt/pwt-8.1).¹³

Information concerning RTAs has been collected from De Sousa (2012), whereas information concerning the environmental provisions included in each agreement comes from the World Trade Organization (WTO) and from the legal text of the agreements obtained from the corresponding government agencies of the signatory countries. A description of environmental indicators, number of RTAs and countries analysed is summarised in Table 2.

¹¹ The environmental indicator for PM_{2.5} refers to population weighted mean concentration which is suggested as one of OECD's green growth headline indicators (see Mackie, Hašič and Cárdenas Rodríguez (2016)). Other indicators denote per capita emissions which are not population weighted due to data availability for local pollutants of SO₂ and NO_x.

¹² Data kindly provided by Walid Oueslati, elaborated using data from the Atmospheric Composition Analysis Group (Boys et al., 2014). Available at: http://fizz.phys.dal.ca/~atmos/martin/?page_id=140.

¹³ The human development index is only available for 150 countries. The same applies to PWT 9.1.

Table 2. Description of environmental indicators, RTAs and countries analysed

Environmental Indicator, (variable name)	Period ^a	Number of RTAs ^b			Number of Countries
		Total	with environmental provisions	without environmental provisions	
PM2.5	1999-2011 (1999-30/06/11)	151	83	68	48 ^c
SO ₂	1970-2008 (1970-30/06/08)	159	51	108	157 ^d
NO _x	1970-2008 (1970-30/06/08)	159	51	108	157 ^d

Notes:

a. The period indicates the years for which the environmental indicators are available. The period in brackets indicates the period for which RTAs are included in the regressions.

b. See Table A.1.1 for the list of RTAs included in the regressions.

c. See Table A.1.3 for the list of countries with PM2.5 data included in the regressions.

d. See Table A.1.2 for the list of countries with SO₂ and NO_x data included in the regressions.

3.4. Modelling framework: environmental-impact model

The main methodology builds on Ghosh and Yamarik (2006) and Baghdadi et al. (2013) and it is applied to a number of environmental indicators selected from the available data described in the previous subsection.

Similar to Ghosh and Yamarik (2006), three main theoretically-based models serve as a basis for the empirical application. First, the gravity model of trade is used to predict bilateral trade. Second, GDP per capita is predicted estimating a model based on the growth-empirics literature. Finally, the core model is based on the theory in-line with Frankel and Rose (2005) and Baghdadi et al. (2013) that identifies the links between trade, growth and environmental impact. The description of the core equations for environmental impact is provided in the following paragraphs.

According to the underlying theories that relate trade with the environment, environmental damage depends on population, land area per capita,¹⁴ per-capita GDP, openness to trade and RTAs. These variables are assumed to control for scale, technique and composition effects.^{15,16} In addition, we hypothesise that there is a cumulative effect coming from signing additional RTAs with environmental provisions, implying that when a given country is linked to more and more countries through RTAs with environmental provisions, this country could face a greater pressure to comply with environmental regulations, which could come from any trading partner as a member of the RTAs.

¹⁴ Since land area is time-invariant and our empirical strategy implies differencing the data with respect to the within-mean or with respect to the value in the previous period, the coefficient for landcap cannot be estimated and this variable is excluded from the estimated model.

¹⁵ Our model considers the main factors affecting emissions in line with Frankel and Rose (2005) and Baghdadi et al. (2013). As in Frankel and Rose (2005) and Ghosh and Yamarik (2006), a Kuznets-curve term, namely the square term of the log of income per capita, is added in the model given in equations (1) and (2).

¹⁶ A similar model is developed by Antweiler et al. (2001) which decomposes and separately estimates the environmental impact by scale, composition and technique effects.

Taking account of the possible channels of environmental effects that may be fostered by the inclusion of environmental provisions in RTAs as shown in section 3.1, a proxy for policy intervention in the environmental area was originally considered to be included in the model. However, comprehensive datasets were not available at the time of this study and such variables were not included in this analysis.¹⁷

To examine the direct effect of RTAs on absolute environmental quality we specify the estimated equation as,

$$\ln(E_{it}) = \delta_i + \gamma_1 \ln(Pop_{it}) + \gamma_2 \ln(GDPcap_{it}) + \gamma_3 \ln(GDPcap_{it})^2 + \gamma_4 \ln(Open_{it}) + \gamma_5 \sum_j w_{jt} * rtaenv_{ijt} + \gamma_6 \sum_j w_{jt} * rtanenv_{ijt} + \theta_t + \mu_{it} \quad (1)$$

where:

- $\ln(E_{it})$, the natural logarithms of per capita emissions (SO₂ and NO_x) or population weighted mean concentration (PM2.5) in country i at time t , is the dependent variable. All the independent variables are also in natural logarithms apart from the two RTA variables.
- δ_i is a country-specific constant term.
- Population (Pop_{it}) is measured in number of inhabitants in country i in year t and it is used as a proxy for the scale effect.
- $GDPcap$ denotes GDP per capita ($GDPcap_{it}$) and its squared term serves to test the EKC hypothesis that predicts that environmental quality eventually increases with income. $GDPcap_{it}$ is GDP per capita at constant US dollars in country i in year t .
- $Open_{it}$ refers to the openness ratio measured as the sum of exports and imports divided by gross domestic product in country i . It could be positively or negatively affecting environmental quality, as discussed in the previous section.

¹⁷

An environmental policy index, which measures the environmental policy stringency in OECD countries and has been constructed by the OECD (Botta and Koźluk, 2014), was initially considered in the analysis as a proxy for policy intervention in the environmental area. The inclusion of this indicator would highlight the possible channels of environmental provisions in RTAs that may strengthen environmental policies and lead to better environmental quality. However, since the current version of the indicator only covers 24 OECD countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Slovak Republic, Spain, Sweden, Switzerland, the United Kingdom and the United States) plus the six BRIICS (Brazil, Russia, India, Indonesia, China and South Africa) for the period 1990-2012, it is not able to capture a majority of OECD countries that emerged during this period such as Chile, Mexico, Turkey and Eastern European countries. In addition, it would not be suitable in covering many of the developing countries that are anticipated to have improved their environmental quality due to environmental provisions in RTAs. For this reason of limited data availability, environmental policy stringency (EPS) indicators or other proxy indicators of environmental policy and regulation have been excluded from this analysis. However, in a companion analysis done for a restricted sample of countries we included an environmental performance index as a proxy for national environmental regulations and the main result for our target variable remained unchanged.

- $rtaenv_{ijt}$ denotes the value of one when countries i and j have a RTA with environmental provisions in force in year t , zero otherwise and $rtanenv_{ijt}$ denotes the value of one when countries i and j have a RTA without environmental provisions in force in year t , zero otherwise. Both variables are generated as a weighted average of the variables $rtaenv_{ijt}$ and $rtanenv_{ijt}$. w_{jt} denotes the weights given to the different RTAs, equal weights ($1/J$, where J denotes the total number of partners, $j=1, \dots, J$) for all agreements are used as default (alternatively population weights are also considered). As a robustness check we also use the level of pollution in country j as weights (as in Baghdadi et al., 2013) in unreported regressions and the results remain very similar.
- θ_t denotes year dummies that are a proxy for business cycles that equally affect all countries in the sample.

The endogeneity of income and trade variables is addressed by estimating first step regressions with instrumental variables and using the predicted GDP per capita and the predicted openness as explanatory variables in the environmental models. Since $GDPcap$ is endogenously determined, we use a set of instrumental variables for income taken from the growth literature to predict $GDPcap$ in a first step equation. Hence, instead of $\ln GDPcap$, $\widehat{\ln GDPcap}_{it}$ the generated regressor, is used as explanatory variable in equation (1). Openness is endogenous, too. Consequently, we use a second set of instrumental variables for this variable based on the estimation of a gravity model of trade using a large dataset on pair wise trade (see Annex 1) to predict bilateral trade. In particular, we use Badinger's specification of the model (Badinger, 2008). Next, the exponent of the fitted values across bilateral trading partners is aggregated to obtain a prediction of total trade for a given country ($\widehat{Open}_{it}$), which will be used (in natural logs) as regressor in equation (1). The details of the first step procedures for the instrumental variables estimation are explained in Annex 2.

Estimation techniques for panel data are used to control for the endogeneity of the RTA variable in the environmental-impact model. A dynamic Generalised Method of Moments (GMM) estimator, in particular difference GMM estimator is used (see section 3.5 for details).

The empirical model is estimated distinguishing between RTAs with environmental provisions ($rtaenv$) and RTAs without environmental provisions ($rtanenv$). In this way, we are able to test the prediction that only RTAs with environmental provisions as a policy variable should affect a given environmental indicator directly, whereas RTAs without environmental provisions should only affect the environment through trade or income. There is some evidence of the effects on the environment from a number of ex-post evaluation reports on the implementation of environmental provisions in RTAs. Although these are mainly limited to agreements concerning the US and the EU, this could provide some insights on the possible channels of the effects of environmental provisions on the environment.

3.5. Addressing endogeneity and reverse causality or RTAs

One of the main challenges of this empirical framework is the potential issue of endogeneity and reverse causality of the RTA variable. For instance, as anticipated in our model, the accumulation of RTAs with environmental provisions may lead to better environmental outcomes that could be attributed to possible channels of strengthening environmental regulations, introducing new institutional arrangements, promoting environmental co-operation and improving environmental awareness, as identified in section 3.1. However, conversely, emission levels in a given country may also determine the likelihood that a country will sign up to a trade agreement with substantive environmental provisions. In other words, a country that seeks to improve environmental quality may also

be keen to enter into negotiations of RTAs with environmental provisions. In this respect, it is difficult to isolate the effects of reverse causality. For this reason, the Generalised Method of Moments (GMM) estimation is applied in this empirical analysis framework as a way to address the issue of reverse causality of the RTA variable.

GMM is a method for estimating parameters in econometric models. It requires a number of the so-called “moment conditions” that are functions of the model parameters and the data available. The main assumption is that the expected value of the moment conditions is zero at the true value of the parameters. The estimation method consists therefore on minimising a function of the sample average of the moment conditions. It has become extremely popular in a panel data context to estimate static and dynamic panel data models (Arellano and Bond, 1991; Blundell and Bond, 1998).

A considerable strength of the GMM method is the potential for obtaining consistent parameter estimates in the presence of measurement error and endogenous right-hand-side variables. In practical terms, when using panel data, in a dynamic model framework, the unobserved country-specific component is eliminated by taking first differences of the left- and right-hand-side variables and the endogeneity issue is solved by using the lagged values of the levels of the endogenous variables to define the moment conditions. The dynamic versions of equation (1) is specified as,

$$\begin{aligned} \Delta \ln(E_{it}) = & \delta_0 + \lambda \Delta \ln(E_{i,t-1}) + \gamma_1 \Delta \ln(Pop_{it}) + \gamma_2 \Delta \ln(\widehat{GDPcap}_{it}) \\ & + \gamma_3 \Delta \ln(\widehat{GDPcap}_{it})^2 + \gamma_4 \Delta \ln(\widehat{Open}_{it}) \\ & + \gamma_5 \Delta \sum_j w_{jt} * rtaenv_{ijt} + \gamma_6 \Delta \sum_j w_{jt} * rtanenv_{ijt} + \Delta \theta_t \\ & + \mu_{it} \end{aligned} \quad (2)$$

where the variables in equation (2) are described above, Δ denotes the first difference of the corresponding variable.¹⁸

¹⁸ The validity of specific moment conditions can be tested in the GMM framework by using the Hansen test of over-identifying restrictions. The lagged dependent variable ($[\ln(E)]_{(i,t-1)}$) is treated as endogenous in the model.

In the context of this research, we estimated dynamic panel data models using the difference GMM estimator that consider the variables related to RTA with environmental provisions (rtaenv) as an endogenous variable and the moment conditions are based on the orthogonal conditions of the lagged values in levels of the respective variables with respect to the error term. We are using dynamic GMM because this estimator allows controlling for endogenous regressors.

The difference GMM estimator used generates efficient estimates of the coefficients as well as consistent estimates of the standard errors. The efficiency gains of this estimator relative to the traditional IV/2SLS estimator derive from the use of the optimal weighting matrix, the over identifying restrictions of the model, and the relaxation of the i.i.d. assumption.

The model is specified adding dynamics (lagged dependent variable) because emission levels are highly path dependent. In particular, we address the endogeneity of the lagged dependent variables with this method.

4. Empirical Results

This section presents the main results for the three selected pollutants. The three indicators of local air pollution –PM2.5, SO₂ and NO_x– are important since they are likely to be addressed by regulations at the national level.

It has been explained in the previous section that, for a given level of environmental regulations, participating in RTAs with environmental provisions could also help reducing air pollution mainly if the environmental provisions provide enforcement mechanisms and encourage the member countries to effectively apply their national regulations. However, for RTAs without such provisions, countries may be less committed to effectively enforce their regulations and there will likely be no additional effect on the environmental indicators coming from participation in RTAs without environmental provisions. In any case, this is an empirical question that will be answered by estimating the corresponding model.

In the next subsections, we first present the results for each indicator, PM2.5, SO₂, and NO_x, and then combine them into a summary of findings concerning the estimated coefficients of the target explanatory variables and their significance for each environmental indicator. In addition, some brief guidance on how to interpret the coefficients and measures (R-squared, standard errors, tests) is presented in Annex 5.

4.1. Results for each pollutant

First, the model given in equation (2) is estimated for PM2.5 (population weighted mean concentrations) and the full results are presented in Annex 3, Table A.3.1. It presents and includes the variables *rtaenv* and *rtanenv*, the number of country members in the RTA agreements signed by each country and year with and without environmental provisions, respectively.

The variable *rtaenv*, in column (1), shows a negative and non-significant coefficient (at conventional levels). Hence, we do not interpret these results.

The result for income variables show evidence of a Kuznets-curve model with the squared coefficient of GDP per capita being statistically significant and showing the expected negative sign. It indicates that concentrations are negatively correlated with GDP per capita for income levels that surpass the turning point, which is shown at the bottom of the Table and it is USD 37.2 thousand. The predicted openness variable shows a negative coefficient that is not statistically significant at conventional levels, indicating that higher levels of trade do not seem to increase concentrations of PM2.5.

The right half of the Table (columns (4) - (6)) uses actual values of income and openness to crosscheck the results. Column (4) for PM2.5 presents similar results for the coefficients of the target variables (first row), which are also not statistically significant. Concerning the turning point for GDP per capita, it increases to USD 71.1 thousand out of sample in comparison with column (1). Nominal openness is now statistically significant at the 5% significance level but with very low impact, indicating that an increase in openness of 1% decreases PM2.5 emissions concentrations by 0.02%. The Hansen test indicates that the instruments are valid instruments.

Next, the respective results for SO₂ emissions are also presented in Annex 3, Table A.3.1. According to the estimates in the second column of Table A.3.1, RTAs with environmental provisions are associated with lower levels of Sulphur dioxide emissions.

Figure 3 below presents details of short-run and long-run effects for SO₂.¹⁹ On average, each additional RTA²⁰ with environmental provisions signed by a country is associated with reduced pollution levels of SO₂ by 0.26% in short-run and 2.19% in long run. Significant results are also found for RTAs without environmental provisions: i.e. an additional RTA signed without environmental provisions are related to 0.16% reduction of SO₂ emissions in short run and 1.36% reduction in long-run. In particular, membership in RTAs without environmental provisions is also associated to lower SO₂ emissions. These effects are beyond any impacts related the effect of the RTA on trade openness or GDP per capita. An explanation for this effect could be related to the hypothesis that countries more integrated in the global economy potentially enjoy positive environmental benefits such as innovation and access to cleaner technologies and this is independent from the environmental-regulation channel.

The results for the income variables indicate evidence of a Kuznets-curve model in column (2) with the corresponding turning point being USD 8.7 thousand. Openness is not statistically significant in the specification and the coefficient is negatively signed. The model in the second part of the table (column (5)) in which trade and income are considered as exogenous reveal that the estimated coefficients for the target variables are slightly higher in magnitude than those in the first part of the table, indicating an upward bias probably due to the fact that openness and GDP are considered as exogenous in this specification. With respect to the coefficients of the control variables, namely population, income and openness are poorly estimated with high standard errors and none of them is statistically significant.

The results for NO_x for the model in equation (2) are shown in Table A.3.1 in Annex 3. Also in this case the coefficient of the RTAs with environmental provisions (*rtaenv*) is statistically significant at the 1% level indicating that environmental provisions are negatively correlated with emission of NO_x. Figure 3 below also presents details of short-run and long-run effects for NO_x. An additional RTA with environmental provisions is co-related with reduced NO_x emissions by 0.17% in short-run and 1.41% in long-run. Moreover, an additional RTA without environmental provisions is also associated with lower NO_x emissions by 0.11% in short-run and 0.91% in long-run however only statistically significant at the 5% level. As mentioned in the previous paragraph, it could be that countries more integrated in the global economy potentially enjoy environmental benefits that are beyond trade openness or GDP per capita.

Concerning GDP per capita, the coefficient of the squared term is statistically significant at the 5% level in the first part of the table, when the predicted value is considered. In case of NO_x the turning point is around USD 5.6 thousand. Similar to results of PM_{2.5} and SO₂, the second part of Table A.3.1 shows that the coefficients of the target variables are slightly higher than in the first part of the table, in which openness and income variables were considered as endogenous, indicating one slight upward bias in the estimates due to the lack of consideration of these econometric problems. Concerning the control variables, only population is statistically significant in the second part of the table, indicating that emissions per capita are lower in most populated countries.

¹⁹ As the estimation uses a lagged dependent variable, the short-run change is given by the coefficient itself (γ_5 or γ_6) and the long-run change is given by: Coefficient / (1- λ) in equation (2).

²⁰ For RTAs with more than one partner, the interpretation should refer to the number of partners in the agreement.

Figure 3. Short-run and long-run effects for SO₂ and NO_x

Source: Estimates are taken from columns (2) and (3) in Table A.3.1 in the Annex.

4.2. Summary of findings

Table 3 summarises the results given in Table A.3.1 in Annex 3, and presents the estimates of the determinants of emissions for equation (2) including the variables *rtaenv*, *rtanenv* and the number of participants in RTAs signed by each country and year for each pollutant (PM_{2.5}, SO₂, and NO_x in columns). The variable *rtaenv* shows a negative and statistically significant coefficient (at the 1% level for two pollutants) indicating that for each additional RTA with environmental provisions signed by country *i*, SO₂ emission per capita decrease by around 0.26% in short-run and 2.19% in long-run, for NO_x the corresponding decrease is 0.17% in short-run and 1.41% in long-run. The negative and statistically significant coefficient of *rtaenv* indicates that RTAs with environmental provisions seem to reduce emissions.

There are also some negative and statistically significant results found for the *rtanenv* variable, in particular for NO_x and SO₂ emissions, where a membership in RTAs without environmental provisions is also associated with lower emissions. More specifically, the *rtanenv* variable shows a negative and statistically significant effect (at the 1% level for SO₂ and 5% level for NO_x) where an additional RTA without environmental provisions is associated with a decrease in emissions by 0.16% in short-run and 1.36% in long-run for SO₂, and 0.11% in short run and 0.91% in long-run for NO_x respectively. GDP per capita and trade openness are considered in this model, and hence such environmental effects are

beyond the scale effect. A possible explanation could be that RTAs provide better access to environmental goods and services irrespective of the environmental-regulation channel.

Indeed, for these two pollutants we can observe that decreases in emissions are slightly more strongly related to the number of RTAs with EPs than to number of RTAs without EPs. However, further tests were conducted which concluded that the difference between the two coefficients were not statistically significant.²¹ These results imply that a membership into RTAs contributes to decreasing emissions on SO₂ and NO_x among the Parties to an agreement. However, the extent to which environmental provisions make an additional difference cannot be concluded with enough certainty by this analysis.

Table 3. Summary table for main indicators

VARIABLES	(1) PM2.5	(2) SO ₂	(3) NO _x
<i>rtaenv</i>	-0.00609 [0.00521]	-0.00259*** [0.000775]	-0.00173*** [0.000632]
<i>rtanenv</i>	0.000538 [0.000594]	-0.00161*** [0.000568]	-0.00112** [0.000560]
Observations	478	3,114	3,114
R ² Adjusted	0.619	0.693	0.435
Number of id	48	127	127
Hansen test (p)	0.462	0.539	0.204

Note: Full results are presented in Tables A.3.1 for each environmental indicator and including all explanatory variables. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.10. The reported R² refers to the one obtained in the first regression in each column (with the *rtaenv* variable).

4.3. Robustness check

For robustness check, the model in equation (2) has been also estimated for two different groups of countries using dynamic difference GMM. The first group contains 22 highly developed countries²² and the second group contain the rest. The summary results are presented in Table A.4.1 in Annex 4. The main results indicate that for PM2.5 concentrations negative and significant coefficients of the target variables (*rtaenv* and *rtanenv*) are shown for other countries, whereas for highly developed countries, the coefficients on the core variables are not statistically significant. The same is the case for SO₂, for which none of the coefficients for highly developed countries is statistically significant, whereas for “others” most coefficients are significant at the 10% significant level. The magnitude of the coefficients is slightly higher for other countries in general. Similarly, concerning NO_x the coefficients are only significant and have the expected negative sign for the group of “non-rich” countries, but not for the group of 22 most advanced countries. This evidence could be indicating that the gains in terms of environmental quality will possibly be higher in agreements involving North-South countries and for the “South” countries, which have in general less stringent environmental regulations than North countries.

²¹ T-test of equality of the coefficients of the variables *rtaenv* and *rtanenv* run for each model in Table 3 indicate that whereas we cannot reject the null that they are equal for NO_x and SO₂, the difference is statistically significant for PM_{2.5}.

²² The countries are: Australia, Austria, Belgium, Canada, Denmark, Estonia, Finland, Germany, France, Greece, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United States and United Kingdom.

We have also considered real openness instead of nominal openness in the regressions presented in the second part of Table A.3.1 (i.e. in columns (4)-(6)) and the results remain unchanged. Also variations of the first step growth model and gravity model have been estimated in unreported regressions and the corresponding predictions were used as regressors in the second step models and the results remain unchanged.

Finally, to provide information about the economic importance of the estimated effects alongside with the statistical relevance we report in Table A.4.2 in Annex 4 standardized (beta) coefficients for all explanatory variables when using SO₂ and NO_x as dependent variables. The beta coefficients have been obtained by estimating the corresponding model using standardized variables (dependent and independent variables have been transformed by subtracting the mean and dividing by the standard deviation).

5. Discussion and Conclusions

This Working Paper aims to test whether the inclusion of environmental provisions in RTAs has contributed to improve environmental quality among RTA members through empirical modelling and analysis. The main policy implications of the empirical results are twofold. First, RTAs both with and without environmental provisions appear to have a statistically significant effect on reducing environmental degradation. These results hold for SO₂ and NO_x, and do not always hold for PM_{2.5}. An explanation for this effect could be related to the hypothesis that countries more integrated in the global economy potentially enjoy positive environmental benefits such as innovation and access to cleaner technologies and this is independent from the environmental regulation channel. Second, although decreases in emissions are slightly more strongly related to the number of RTAs with EPs than to the number of RTAs without EPs, the effect of membership in RTAs with EPs on emissions is not statistically different from the effect of membership in RTAs without EPs for these two pollutants. These results imply that the extent to which environmental provisions make an additional difference could not be concluded under the current analysis. To be clear, environmental provisions may still have a positive effect on the environment, however, these effects could not be demonstrated with sufficient statistical certainty under the available data and approach. The anticipated direct effects that including environmental provisions in RTAs will encourage members to apply more stringent environmental regulations and reduce environmental damage needs to be further examined.

We have to bear in mind that the analysis is not free of challenges and limitations for the following reasons. First, measuring the environmental end points in a given country is a difficult exercise. Air emissions of PM_{2.5}, SO₂ and NO_x are known to be domestic pollutants and may not be a perfect proxy to represent environmental quality at the national level. Similarly, air emissions do not respect country borders, so measuring air emission concentration such as PM_{2.5} through geospatial data within a small country like Panama for example, and relating it to Panama's number of trade agreements may also be a challenge. Even with a focus on air emissions, PM_{2.5} data is only available for around 10 years and enables analysis for only 48 countries whereas RTAs with environmental provisions cover a broader cross section of a number of countries for a period of more than two decades. The empirical framework requires data with a broad cross-country coverage as well as extensive time-series and therefore the current data availability on environmental quality at the national level poses some restrictions to the analysis.

Second, separating the impact of RTAs from other factors influencing country-level emissions is also a very difficult task. Clearly, RTAs are not assigned randomly to a country, which leads to a potential selection bias. Trade agreements can also have economy-wide effects, which even spill over to other countries via price and income effects, and subsequently may have an indirect impact on environmental quality. On the contrary, there are many other factors that could influence country-level emissions in the broader economy in parallel to RTAs. There are some signs that environmental provisions in RTAs have positive environmental effects through channels such as strengthened environmental regulations, introducing new institutional arrangements, promoting environmental co-operation and improving environmental awareness. However, these potential channels also lack comprehensive data in order to test over the vast range of RTAs agreed among developed and developing countries, such as the OECD's environmental policy stringency (EPS) indicator.

Finally, there are potential endogeneity and reverse causality issues. While RTAs, trade openness and income levels may all impact air emissions, air emissions may also have an impact on the level of income, trade or the signing of an RTA, leading to reverse causality, or may be influenced by other factors for which data are not available. Notably, RTAs with environmental provisions may lead to better environmental outcomes such as channels through increased environmental policy stringency. Conversely, a country that seeks to improve environmental quality may also be more likely to enter into negotiations of RTAs with substantive environmental provisions. In this respect, there is a major challenge in isolating these potential effects. In this study, the GMM method is used to address potential endogeneity—due to reverse causality—of the RTA variables. However, this estimation technique may have some drawbacks arising from limited sample distributions. Despite the fact that the empirical estimation uses techniques to identify causality at the macro level, it may well be difficult to identify causal effects of RTAs on emissions using cross-country aggregate regressions due to these caveats. In this respect, the estimates should be interpreted as conditional correlations rather than strictly causal effects.

Further extension of this kind of work requires better proxies and broader coverage of environmental indicators based on countries and time periods. Further analysis is also needed to shed light on the channels through which environmental provisions in RTAs may influence domestic policy processes, and ultimately environmental outcomes. The currently available EPS indicators are only available for 30 countries, which do not capture the stringency of environmental policy in many of the OECD countries that have emerged in the past two decades or most of the developing countries that are sought to have improved their environmental policies in accordance with progressive environmental provisions in RTAs. Environmental policy indicators that cover both developed and developing countries would be required to further develop such analysis. In this sense, the current investigation could be extended using proxies for environmental regulation (treaties and laws) in a broad sample of countries.

This investigation could be complemented with a detailed survey of case studies for specific agreements that include a wide range of environmental provisions and for which ex-post impact evaluation reports are available. As we mentioned in the main text, although such studies are available mainly for agreements involving the US and the EU, they provide some insights on the channels explaining the positive effects of environmental provisions on the environment. Among them, the adoption of new environmental laws and new environmental impact assessment frameworks, the creation of environmental institutions and the cooperation to improve environmental law enforcement are some of the channels that could be linked to the entry into force of the RTAs and that surely help to improve environmental outcomes.

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Annex 1. List of RTAs and Countries Included in the Analysis

Table A.1.1 List of RTAs with and without environmental provisions included in the analysis

n	RTA_full_name	DATE (entry into force)	FTA_EP
1	EU-EFTA	01/01/73	0
2	Caribbean Community	01/08/73	0
3	Australia-Papua New Guinea	01/02/77	0
4	Syria-EU	01/07/77	0
5	Syria-Turkey	01/07/77	0
6	United States-Israel	19/08/85	0
7	Andean Community	25/05/88	0
8	United States- Canada	01/01/89	0
9	MERCOSUR	17/02/91	1
10	ASEAN	28/01/92	0
11	EFTA-Turkey	01/04/92	0
12	Russian Federation- Azerbaijan	17/03/93	1
13	Russian Federation-Tajikistan	30/03/93	1
14	CEFTA -Eastern Europe	21/12/92	0
15	EFTA-Czech Republic	01/04/93	0
16	EFTA-Hungary	01/04/93	0
17	EFTA-Israel	01/04/93	0
18	EFTA-Poland	01/04/93	0
19	EFTA-Romania	01/05/93	0
20	EFTA-Slovak Republic	01/04/93	0
21	EFTA-Ukraine	01/04/93	0
22	Russian Federation-Armenia	25/03/93	0
23	Russian Federation-Belarus	20/03/93	0
24	Russian Federation-Kyrgyz Republic	24/03/93	0
25	Russian Federation-Moldova	30/03/93	0
26	Russian Federation-Turkmenistan	06/04/93	0
27	Russian Federation-Uzbekistan	25/03/93	0
28	Colombia-Mexico	13/06/94	1
29	ECOWAS	24/07/93	1
30	NAFTA	01/04/94	1
31	EU-Eastern European countries agreements	01/01/94	0
32	EFTA-Bulgaria	01/07/93	0
33	Russian Federation-Georgia	10/04/94	0
34	Russian Federation -Kazakhstan	07/07/93	0
35	Russian Federation-Ukraine	21/02/94	0
36	COMESA	01/12/94	1
37	Commonwealth of Independent States	30/12/94	0
38	Mexico- Costa Rica	01/01/95	0
39	Romania-Moldova	01/01/95	0
40	MERCOSUR-Bolivia	01/01/96	0
41	MERCOSUR-Chile	01/01/96	0
42	Ukraine-Turkmenistan	04/11/95	0
43	Turkey-EU	01/01/96	0

44	Canada-Israel	01/01/97	1
45	EU27	01/01/97	1
46	EU-Faroe Island	01/01/97	0
47	Armenia-Turkmenistan	07/07/96	0
48	Turkey-Israel	01/03/97	0
49	Canada -Chile	05/07/97	1
50	Tunisia-EU	01/03/98	1
51	CARICOM-DOMINICAN REP	01/01/98	0
52	Croatia-Macedonia	30/10/97	0
53	Hungary-Israel	01/01/97	0
54	Hungary-Turkey	01/01/98	0
55	Pan-Arab Free Trade Area	01/01/98	0
56	Poland-Israel	01/01/98	0
57	Romania-Turkey	01/02/98	0
58	CEMAC	24/06/99	1
59	Bulgaria-Turkey	01/01/99	0
60	Mexico- Nicaragua	01/07/98	0
61	EU-South Africa	01/01/00	1
62	EU-Morocco	01/03/00	1
63	Mexico-Chile	01/08/99	1
64	Bulgaria-Macedonia	01/01/00	0
65	EFTA-Morocco	01/12/99	0
66	EU-Israel	01/06/00	0
67	Macedonia-Turkey	01/09/00	0
68	Poland-Turkey	01/01/00	0
69	Georgia-Turkmenistan	01/01/00	0
70	East African Community	07/07/00	1
71	EU-Mexico	01/10/00	1
72	United States-Jordan	17/12/01	1
73	Bosnia and Herzegovina-Croatia	01/01/01	0
74	EFTA-Macedonia	01/01/01	0
75	India-Bhutan	15/12/01	0
76	Mexico-Guatemala	15/03/01	0
77	Mexico-Honduras	01/06/01	0
78	Mexico-Israel	01/07/00	0
79	Mexico-Slovak Republic	01/06/01	0
80	EU-Macedonia	01/06/01	0
81	Romania-Israel	07/01/01	0
82	Southern African Development Community	01/09/00	0
83	New Zealand-Singapore	01/01/01	0
84	Dominican Republic-Central America	04/10/01	1
85	EFTA-Jordan	01/01/02	1
86	Jordan-EU	01/05/02	1
87	Bulgaria-Israel	01/01/02	0
88	Chile-Costa Rica	15/02/02	0
89	Chile-El Salvador	01/06/02	0
90	EFTA-Mexico	01/07/01	0
91	India-Sri Lanka	15/12/01	0
92	Canada-Costa Rica	01/11/02	1

93	Chile-EU	01/02/03	1
94	Albania-Croatia	01/06/03	0
95	Albania-Macedonia	01/06/03	0
96	Bosnia and Herzegovina-Macedonia	15/07/02	0
97	EFTA-Singapore	01/01/03	0
98	EU-Lebanon	01/03/03	0
99	Panama-El Salvador	11/04/03	0
100	Pacific Island Countries Trade Agreement	13/04/03	0
101	Romania-Bosnia and Herzegovina	24/10/03	0
102	Japan-Singapore	30/11/02	0
103	Chile-Korea	01/04/04	1
104	EFTA-Chile	01/01/04	1
105	EU-Egypt	01/06/04	1
106	Chinese Taipei-Panama	01/01/04	1
107	United States-Chile	01/01/04	1
108	United States-Singapore	01/01/04	1
109	Albania-Moldova	01/01/04	0
110	Bosnia and Herzegovina-Moldova	01/05/04	0
111	Bosnia and Herzegovina-Turkey	01/07/03	0
112	Bulgaria-Albania	01/09/03	0
113	EFTA-Croatia	01/01/04	0
114	Macedonia-Moldova	01/12/04	0
115	Romania-Albania	01/01/04	0
116	Romania-Macedonia	01/01/04	0
117	Singapore-Australia	28/07/03	0
118	Mexico-Japan	01/04/05	1
119	United States-Australia	01/01/05	1
120	Albania-Bosnia and Herzegovina	01/12/04	0
121	ASEAN-China	01/01/05	0
122	Bulgaria-Bosnia and Herzegovina	01/12/04	0
123	Bulgaria-Moldova	01/12/04	0
124	Croatia-Moldova	01/10/04	0
125	EFTA-Tunisia	01/01/05	0
126	Pakistan-Sri Lanka	12/06/05	0
127	Southern African Customs Union	01/07/04	0
128	Thailand-Australia	01/01/05	0
129	Tunisia-Turkey	01/07/05	0
130	EU-Algeria	01/09/05	1
131	Korea-Singapore	02/03/06	1
132	TPSEP	28/05/06	1
133	United States-Bahrain	01/08/06	1
134	United States-Morocco	01/01/06	1
135	United States-CAFTA- Dominican Republic	01/03/06	1
136	India-Singapore	01/08/05	0
137	Morocco-Turkey	01/01/06	0
138	Jordan-Singapore	22/08/05	0
139	Thailand-New Zealand	01/07/05	0
140	EU-Albania	01/12/06	1

141	Chile-China	01/10/06	1
142	Japan- Malaysia	13/07/06	1
143	Guatemala-Chinese Taipei	01/07/06	1
144	EFTA -Korea	01/09/06	0
145	Egypt-Turkey	01/03/07	0
146	Panama-Singapore	24/07/06	0
147	Albania-Turkey	01/05/08	1
148	EU-Bosnia Herzegovina	01/07/08	1
149	Chile-Japan	03/09/07	1
150	Chile-Panama	07/03/08	1
151	EFTA-Egypt	01/08/07	1
152	Pakistan-China	01/07/07	1
153	Thailand-Japan	01/11/07	1
154	Chinese Taipei-Honduras	01/03/08	1
155	Chinese Taipei-Salvador	02/03/08	1
156	Chinese Taipei-Nicaragua	01/01/08	1
157	EFTA-Lebanon	01/01/07	0
158	Pakistan-Malaysia	01/01/08	0
159	EFTA-SACU	01/05/08	0
160	ASEAN-Japan	01/12/08	1
161	Canada-Peru	01/08/09	1
162	CARIFORUM-EU	01/11/08	1
163	Chile-Australia	06/03/09	1
164	Chile-Colombia	08/05/09	1
165	Chile-Honduras	19/07/08	1
166	Chile-Peru	01/03/09	1
167	China-New Zealand	01/10/08	1
168	EU-Côte d'Ivoire	01/01/09	1
169	Japan-Brunei	31/07/08	1
170	Japan- Indonesia	01/07/08	1
171	Japan-Philippines	11/12/08	1
172	Panama-Guatemala	20/06/09	1
173	Singapore-China	01/01/09	1
174	Turkey-Georgia	01/11/08	1
175	United States-Oman	01/01/09	1
176	United States-Peru	01/02/09	1
177	Panama-Costa Rica	23/11/08	0
178	Panama-Honduras	09/01/09	0
179	ASEAN-Australia-New Zealand	01/01/10	1
180	ASEAN-Korea	01/01/10	1
181	ASEAN-New Zealand	01/01/10	1
182	Chile-Guatemala	23/03/10	1
183	EU-Cameroon	01/10/09	1
184	Colombia-Guatemala	12/11/09	1
185	Colombia-Honduras	12/11/09	1
186	Colombia-El Salvador	12/11/09	1
187	EFTA-Canada	01/07/09	1
188	EU-Papua New Guinea / Fiji	20/12/09	1
189	India-Korea	01/01/10	1

190	Japan-Switzerland	01/09/09	1
191	Japan- Vietnam	01/10/09	1
192	EU-Montenegro	20/12/09	1
193	Panama-Nicaragua	21/11/09	1
194	Peru-China	01/03/10	1
195	Peru-Singapore	01/08/09	1
196	EU-Papua New Guinea	01/02/10	1
197	Turkey-Montenegro	01/03/10	1
198	ASEAN-India	03/01/10	0
199	Australia-New Zealand	02/01/10	0
200	India-Nepal	27/10/09	0
201	Mexico-Bolivia	07/06/10	0
202	Chile-Turkey	01/03/11	1
203	EFTA-Albania	01/11/10	1
204	Malaysia-New Zealand	01/01/10	1
205	Turkey-Jordan	01/03/11	0
209	Turkey-Serbia	01/09/10	1
206	EFTA-Serbia	01/10/10	1
207	Hong Kong-New Zealand	01/01/11	1
208	EU-Serbia	01/01/11	1
213	EFTA-Colombia	01/07/11	1
214	EFTA-Peru	01/07/11	1
216	India-Malaysia	01/07/11	1
218	Korea-EU	01/07/11	1
215	India-Japan	01/08/11	1
221	Peru-Korea	01/08/11	1
210	Canada-Colombia	15/08/11	1
212	Costa Rica-China	01/12/11	1
219	Mexico-Peru	01/02/12	1
217	Japan-Peru	01/03/12	1
211	Chile-Malaysia	18/04/12	1
220	Panama-Peru	01/05/12	1
222	United States-Colombia	15/05/12	1
223	United States-Korea	15/03/12	1
224	United States-Panama	31/10/12	1
225	EU-Eastern and Southern Africa States Interim EPA	14/05/12	0
226	Chile-Nicaragua	19/10/12	1
227	EU-Peru	01/03/13	1
228	Turkey-Korea	01/03/13	1
229	Malaysia-Australia	01/01/13	0
230	Peru-Costa Rica	01/06/13	0
231	Turkey -Mauritius	01/06/13	0
232	EU-Colombia	01/08/13	1
233	Croatia-Turkey	01/07/13	0

Note: The list includes RTAs in force since 1970 to 2013 with and without environmental provisions. The RTAs considered in the regressions presented in Tables A.3.1, A4.1 and A.4.2 vary according to data availability for the variables in the corresponding models. FTA_EP takes the value of one for RTAs with environmental provisions.

Source: Author's elaboration using information in WTO website.

Table A.1.2 List of countries included in the analysis for SO₂ and NO_x

Country Name			
Albania	Cyprus ²³	Kuwait	Sao Tome and Principe
Angola	Czech Republic	Kyrgyzstan	Saudi Arabia
Antigua and Barbuda	Denmark	Lao PDR	Senegal
Argentina	Djibouti	Latvia	Sierra Leone
Armenia	Dominica	Lebanon	Singapore
Australia	Dominican Republic	Lesotho	Slovak Republic
Austria	Ecuador	Liberia	Slovenia
Azerbaijan	Egypt	Lithuania	South Africa
Bahamas	El Salvador	Macedonia, FYR	Spain
Bahrain	Estonia	Madagascar	Sri Lanka
Bangladesh	Ethiopia	Malawi	Saint Kitts and Nevis
Barbados	Fiji	Malaysia	Saint Lucia
Belarus	Finland	Maldives	Sudan
Belgium	France	Mali	Suriname
Belize	Gabon	Malta	Swaziland
Benin	Gambia, The	Mauritania	Sweden
Bermuda	Georgia	Mauritius	Switzerland
Bhutan	Germany	Mexico	Syrian Arab Republic
Bolivia	Ghana	Moldova	Tajikistan
Bosnia and Herzegovina	Greece	Mongolia	Tanzania
Botswana	Grenada	Morocco	Thailand
Brazil	Guatemala	Mozambique	Togo
Brunei Darussalam	Guinea	Namibia	Trinidad and Tobago
Bulgaria	Guinea-Bissau	Nepal	Tunisia
Burkina Faso	Honduras	Netherlands	Turkey
Burundi	Hungary	New Zealand	Turkmenistan
Cabo Verde	Iceland	Niger	Uganda
Cambodia	India	Nigeria	Ukraine
Cameroon	Indonesia	Norway	United Kingdom
Canada	Iran	Oman	United States
Central African Republic	Iraq	Pakistan	Uruguay
Chad	Ireland	Panama	Venezuela
Chile	Israel	Paraguay	Viet Nam
China (People's Republic of)	Italy	Peru	Vincent and the Grenadines
Colombia	Jamaica	Philippines	Yemen
Comoros	Japan	Poland	Zambia
Congo	Jordan	Portugal	Zimbabwe
Costa Rica	Kazakhstan	Qatar	
Cote d'Ivoire	Kenya	Russian Federation	
Croatia	Korea	Rwanda	

Note: List of countries included in the results presented in Tables A.3.1. and A.4.1 Bold letter indicates countries not included in the regressions with predicted openness and predicted GDP due to lack of data.

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1. Note by Turkey: The information in this document with reference to “Cyprus” relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the “Cyprus issue”.

2. Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Table A.1.3 List of countries included in the analysis for PM2.5

Country Name	
Argentina	Ireland
Australia	Israel
Austria	Italy
Belgium	Japan
Brazil	Latvia
Bulgaria	Lithuania
Canada	Malta
Chile	Mexico
China (People's Republic of)	Netherlands
Colombia	New Zealand
Costa Rica	Norway
Croatia	Poland
Cyprus ²⁴	Portugal
Czech Republic	Russian Federation
Denmark	Saudi Arabia
Estonia	Slovakia
Finland	Slovenia
France	South Africa
Germany	Spain
Greece	Sweden
Hungary	Switzerland
Iceland	Turkey
India	United States
Indonesia	United Kingdom

Note: List of countries included in the results presented in Tables A.3.1. and A.4.1.

²⁴

1. Note by Turkey: The information in this document with reference to “Cyprus” relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the “Cyprus issue”.

2. Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Annex 2. Growth Empirics and Gravity Model

A.2.1 Growth empirics

As emphasised by Frankel and Rose (2005), trade flows, regional agreements, pollutants' emissions and environmental regulations may affect income. Therefore, we predict real income with a number of variables, namely lagged income per capita (GDP/Pop , conditional convergence hypothesis), population (pop), investment per income (I/GDP) and human capital formation. The latter is approximated by a human capital index (HCI), available in the new version of the PWT (version 8.1). The predicted values (linear projection= $\ln \widehat{GDPcap}_{it}$) of this equation are used in the models in equation (2) instead of the actual values.

$$\begin{aligned} \ln(GDPcap)_{it} = & \alpha_i + \delta_1 \ln(Pop)_{it} \\ & + \delta_2 \ln(GDPcap)_{i,t-1} + \delta_3 \ln\left(\frac{I}{GDP}\right)_{i,t} + \delta_4 n_{it} + \delta_5 \ln(HCI)_{it} + u_{it} \end{aligned} \quad (A.3.1)$$

where n_{it} is the growth rate of population and u_{it} is a random term that is assumed to be independently and identically distributed and with a constant variance. Equation (A.3.1) is estimated using panel-data estimation techniques, mainly assuming that the country-unobserved heterogeneity (time invariant factors that determine GDP per capita and differ by country) is modelled using fixed effects (a different intercept for each country).²⁵

The income equation is taken from Baghdadi et al. (2013). The main difference between the model specified in equation (A.3.1) and the income equation in Frankel and Rose (2005) and Ghosh and Yamakita (2008) is that the Frankel and Rose (2005) also include openness as an explanatory variable and Ghosh and Yamakita (2008) include in addition to openness, an RTA variable. We relegate openness and trade policy factors to the error term (unexplained part of the income model), since we are interested in predicting changes in GDP per capita that are explained by factors different from trade and trade policy. In this way, we obtain a “pure” scale effect that does not include the indirect effect of trade in emissions through income.²⁶

A.2.2 Gravity model with geographical determinants

The predicted openness used in equation (2) above is obtained from a gravity model of trade, which is estimated using a large panel-dataset on pair-wise trade flows. The standard gravity model states that trade between countries is positively determined by their size (GDP, population and land area) and negatively determined by geographical and cultural distance. The geographical variables are exogenously determined and hence are suitable instruments for trade (Frankel and Romer, 1999; Cavallo and Frankel, 2008).²⁷ We follow Badinger (2008)'s specification of the gravity model, in

²⁵ The model with country fixed effect is preferred to a random effects model because the error term is correlated with the unobserved heterogeneity and hence a random effects model does not provide consistent estimates. Estimation results are available upon request. The regression F-statistic=1146, with associated probability=0.00.

²⁶ The indirect effect of trade and RTAs on emissions through income per capita could also be obtained in a separate exercise by including the prediction of the gravity model and the RTA variable in equation (A.3.1).

²⁷ A comparable approach, using gravity estimates for several years, has been used by Cavallo and Frankel (2008). The method consists of aggregating the prediction of a gravity equation across a country's partners. The gravity estimates are based mainly on geographical variables that are plausible exogenous and when aggregated across all bilateral trading partners are highly correlated with a country's openness (export+imports).

which bilateral openness is regressed on countries' populations (Pop_{it} , Pop_{jt}), land area ($Area_{ij}=Area_i*Area_j$), distance (D_{ij}), a common border dummy (Adj_{ij}), a common language dummy ($Lang_{ij}$) and a landlocked variable ($Landlok$ = sum of a landlocked dummy of countries i and j). Two other variables are included in order to be consistent with the theoretical model: a measure of similarity of country size ($Landcap_i/Landcap_j$) and remoteness from the rest of the world ($Remote$).²⁸

$$\begin{aligned} \ln(Trade_{ijt} / GDP_{it}) = & \gamma_i + \chi_j + \varphi_t + \beta_1 \ln Pop_{it} + \beta_2 \ln Pop_{jt} + \\ & + \beta_3 \ln Dist_{ij} + \beta_4 Area_{ij} + \beta_5 Lang_{ij} + \beta_6 Adj_{ij} + \beta_7 Landlok_{ij} \\ & + \beta_8 \ln(Landcap_i / Landcap_j) + \beta_9 Remote_{ij} + \mu_{ijt} \end{aligned} \quad (A.3.2)$$

Finally, from equation (A.3.2) the exponent of the fitted values across bilateral trading partners ($\widehat{Open}_{it}$) is aggregated to obtain a prediction of total trade for each country and year.

$$\widehat{Open}_{it} = \sum_j \exp[\ln(\widehat{trade}_{ijt}/GDP_{it})] \quad (A.3.3)$$

The aggregated bilateral prediction in natural logs ($\ln \widehat{Open}_{it}$) is used as regressors in the environment-damage models (equation (2)). By using these predicted values we are able to isolate the part of trade that is explained exclusively by geographical, cultural and country-specific factors. Other policy changes that could also explain trade variations are relegated to the unexplained part of the model (error term).²⁹

²⁸ $Remote_{ij} = 0.5 D_{ij}^{CC} \{ [\ln(\sum_{k=1, k \neq j}^N Dist_{ik}/(N-1))] + [\ln(\sum_{k=1, k \neq i}^N Dist_{kj}/(N-1))] \}$. Origin and destination dummy variables are also included in the gravity model to proxy for multilateral resistance factors.

where D_{ij}^{CC} is a common continent dummy. This variable will then be equal to zero if countries are on the same continent. Remote is then the log of the average value of the mean distances of countries i and j from all other countries.

²⁹ Estimation results from the first step estimations are available upon request. The F-statistic from the regression is: $F(409, 25750)=164.36$ and the associated probability is $\text{Prob} > F = 0.0000$.

Annex 3. Results by Indicator

Table A.3.1 Dynamic GMM estimations for PM2.5, SO₂, and NO_x

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variables:	Ln PM2.5 pw	Ln SO ₂ pc	Ln NO _x pc	Ln PM2.5 pw	Ln SO ₂ pc	Ln NO _x pc
Independent variables:						
rtaenv	-0.00609 [0.00521]	-0.00259*** [0.000775]	-0.00173*** [0.000632]	-0.00759 [0.00512]	-0.00311*** [0.000810]	-0.00279*** [0.000694]
Lag. dep.var.	0.417*** [0.0685]	0.882*** [0.0190]	0.877*** [0.0268]	0.418*** [0.0687]	0.875*** [0.0171]	0.882*** [0.0226]
rtanenv	0.000538 [0.000594]	-0.00161*** [0.000568]	-0.00112** [0.000560]	0.000554 [0.000586]	-0.00205*** [0.000521]	-0.00180*** [0.000529]
Ln population	0.627*** [0.147]	0.0245 [0.0391]	-0.0506 [0.0355]	0.559*** [0.138]	0.0285 [0.0368]	-0.0784** [0.0337]
Ln GDPcap predicted	1.666*** [0.338]	0.258** [0.104]	0.261** [0.122]			
Ln GDPcap predicted^2	-0.0822*** [0.0184]	-0.0157*** [0.00584]	-0.0151** [0.00669]			
Ln openness predicted	-9.85e-05 [0.00460]	-0.0136 [0.0101]	-0.0186 [0.0124]			
Ln GDPcap				1.878*** [0.361]	0.0496 [0.0460]	0.0537 [0.0507]
Ln GDPcap^2				-0.0920*** [0.0189]	-0.00265 [0.00230]	-0.00297 [0.00244]
Ln openness				-0.0191** [0.00803]	0.00467 [0.00564]	0.00543 [0.00534]
Turning point	37234.834	8746.7119	5666.8240	71105.607		
Observations	478	3,114	3,114	478	3,924	3,924
R-squared	0.671	0.709	0.464	0.674	0.691	0.520
Number of countries	48	127	127	48	157	157
R ² Adjusted	0.619	0.693	0.435	0.624	0.675	0.495
Hansen test (Prob)	0.462	0.539	0.827	0.461	0.633	0.955
RMSE	0.0521	0.196	0.204	0.0518	0.210	0.221

Note: Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.10. Ln denotes natural logarithms. The list of countries can be found in Annex A1.2 and A.1.3. Time dummy variables are included in all models, but are not reported to save space.

Annex 4. Results of the Robustness Check

Table A.4.1 Dynamic GMM estimations for highly advanced and other countries

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variables:	Ln PM2.5 pw	Ln PM2.5 pw	Ln SO ₂ pc	Ln SO ₂ pc	Ln NO _x pc	Ln NO _x pc
Independent variables:	Advanced	Others	Advanced	Others	Advanced	Others
rtaenv	-0.00235 [0.00227]	-0.00199* [0.00112]	-0.000996 [0.00123]	-0.00150* [0.000922]	-0.000930 [0.00152]	-0.00123* [0.000736]
rtanenv	0.00184 [0.00129]	-0.000876 [0.000730]	0.000969 [0.00123]	-0.00237*** [0.000651]	-0.000647 [0.00168]	-0.00174*** [0.000637]
ln_pop	0.255 [0.228]	0.825*** [0.168]	0.0666 [0.158]	-0.0256 [0.0495]	-0.0868 [0.133]	-0.114** [0.0466]
lgdppc_pred	3.437* [2.016]	1.274*** [0.375]	1.184* [0.619]	0.0757 [0.125]	0.880* [0.473]	0.146 [0.140]
lngdpcap_pre2	-0.168* [0.0961]	-0.0628*** [0.0205]	-0.0601** [0.0306]	-0.00403 [0.00717]	-0.0413* [0.0226]	-0.00822 [0.00796]
ln_open_predict	0.00535 [0.00567]	-0.0280* [0.0146]	-0.0130* [0.00780]	-0.0391** [0.0186]	-0.00740 [0.00632]	-0.0352 [0.0225]
L.lpwm_pm25olde	0.567*** [0.0846]	0.266*** [0.0981]				
L.lnso2pce			0.947*** [0.0194]	0.848*** [0.0215]		
L.lnnoxpc					0.898*** [0.0288]	0.858*** [0.0301]
Observations	220	258	555	2,346	597	2,517
R-squared	0.781	0.583	0.933	0.598	0.744	0.456
Number of countries	22	26	22	105	22	105

Note: Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.10. See also section 4.3 for the list of advanced and other countries.

Table A.4.2 Results with standardised variables. Dynamic GMM estimations with standardised variables

	(1)	(2)
Dependent variables:	ln SO ₂ pc	ln NO _x pc
Independent variables:		
Std_rtaenv	-0.0101*** [0.00301]	-0.00864*** [0.00316]
std_rtanenv	-0.00955*** [0.00337]	-0.00856** [0.00427]
Std_ln_population	0.0333 [0.0531]	-0.0884 [0.0619]
Std_lgdppc_pred	0.192** [0.0775]	0.250** [0.116]
Std_ln_gdpcap_pre^2	-0.201*** [0.0746]	-0.248** [0.110]
Std_ln_open_predict	-0.0343 [0.0254]	-0.0605 [0.0403]
Lag.std_Inso2pc	0.882*** [0.0190]	
Lag.std_Innoxpc		0.877*** [0.0268]
Observations	3,114	3,114
R-squared	0.709	0.464
Number of countries	127	127
Hansen (Prob.)	0.539	0.827

Note: std_ denotes standardised variable. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.10. The list of countries can be found in Annex A1.2. Time dummy variables are included in all models, but are not reported to save space.

Annex 5. Brief Guidance on Interpretation of Results in the Main Tables

R_squared measures the goodness of fit of the regressions. That is, what is the percent of variability of the explained (dependent) variable that is explained by the model (by the explanatory variables). In most cases, for the panel-data regressions the within R-squared (R2_w) is reported. Meaning that the variability explained is the within variation (variation over time for each unit of the panel, the unit is country).

Estimated coefficients: the coefficients can be interpreted as elasticities, since the model is in logarithmic for both dependent and some independent variables. Some explanatory variables are however in levels: dummy variables and count variables. In those cases, the interpretation is slightly different. An increase in one unit of the explanatory variable increases (decreases in case of negative coefficient) the dependent variable by $\beta \times 100$.

Standard errors: the standard errors indicate the accuracy of the estimated coefficients. They are used to calculate t-statistics (dividing the coefficient by the standard error). When the t-statistics are higher than the reported level in the tabulated values for the corresponding levels of significance, then the coefficient is statistically significant at the 10, 0.5 or 1% level. These are the standard levels used in regression analysis.

Significance level of the estimated coefficient is denoted by stars: *, **, *** denote that the coefficient is significant at the 10, 5% and 1% level, meaning that with a 90%, 95%, 99% confident level we can reject the null hypothesis that the coefficient equals zero.

Test for autocorrelation in panel data: A test discussed in Wooldridge (2002) for serial correlation in the errors of a linear panel-data model indicates that the null of no serial correlation of the first-differenced variables cannot be rejected in some cases (e.g. PM2.5). The current estimation results report standard errors that are robust to autocorrelation in the residuals.

Test for heteroskedasticity in panel data: A likelihood ratio (LR) test was implemented estimating restricted (equal residual variance) and an unrestricted (different residual variance for each panel unit) models by iterated feasible generalised least squares (FGLS) that produces maximum-likelihood parameter estimates. The results indicate that heteroskedasticity was present in most models and hence, all the reported standard errors are robust to heteroskedasticity.

Hansen test: Under the null hypothesis, the instruments used to address the endogeneity of some regressors are valid instruments. An associated probability value lower than 0.05 indicates rejection of the null hypothesis.