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Economics Department

Leila Baghdadi
Inmaculada Martínez-Zarzoso
Celestino Suárez-Burguet
Habib Zitouna

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Leila Baghdadi
LIM-MES Polytechnic School of Tunisia
University of Carthage Tunisia

Inmaculada Martínez-Zarzoso
Georg-August University of Göttingen
Universitat Jaume I
martinei@eco.uji.es

Celestino Suárez-Burguet
Universitat Jaume I
Department of Economics
Institute of International Economics

Habib Zitouna
LIM-MES Polytechnic School of Tunisia
University of Carthage Tunisia

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Abstract

This paper evaluates the impact of free trade agreements (FTAs) on carbon dioxide emissions convergence for a cross-section of 182 countries over the period 1980 to 2008, paying particular attention to Mediterranean and European Union countries. In order to overcome the endogeneity problem of the FTA variable, a propensity score matching approach is first used to match country pairs. Next the convergence properties of relative CO_2 emissions are examined for the whole panel and for the matched sample using difference-in-difference techniques. The main results indicate that CO_2 emissions of the pairs of countries that belong to an FTA tend to converge, and do so at a higher rate for more advanced integration agreements. In particular, we find that emissions converge more rapidly for NAFTA and EU-27 countries than for Euro-Med countries.

Keywords: Pollution haven hypothesis, convergence, CO2 emissions, Euro-med Agreements, difference-in-difference
JEL Classification: F18, O13, L60, Q43

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Leila Baghdadi[1],

Inmaculada Martínez-Zarzoso[2]*,

Celestino Suárez-Burguet[3],

Habib Zitouna[4]

[1] LIM, MES cluster, Tunisia Polytechnic School, University of 7th November at Carthage, El Khawerzmi street, B.P. 743, 2078, La Marsa, Tunisia and Tunis Business School, Tunis University, Tunisia.

[2] Corresponding author. Department of Economics and Center for Statistics, Georg-August University of Göttingen and Department of Economics and Institute of International Economics, Universitat Jaume I, Campus del Riu Sec, 12071 Castellón, Spain. Email: martinei@eco.uji.es.

[3] Department of Economics and Institute of International Economics, Universitat Jaume I Campus del Riu Sec, 12071 Castellón, Spain.

[4] FSEGN and LIM-MES Polytechnic School of Tunisia, University of Carthage Tunisia.

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This paper evaluates the impact of free trade agreements (FTAs) on carbon dioxide emissions convergence for a cross-section of 182 countries over the period 1980 to 2008, paying particular attention to Mediterranean and European Union countries. In order to overcome the endogeneity problem of the FTA variable, a propensity score matching approach is first used to match country pairs. Next the convergence properties of relative CO_2 emissions are examined for the whole panel and for the matched sample using difference-in-difference techniques. The main results indicate that CO_2 emissions of the pairs of countries that belong to an FTA tend to converge, and do so at a higher rate for more advanced integration agreements. In particular, we find that emissions converge more rapidly for NAFTA and EU-27 countries than for Euro-Med countries.

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I. Introduction

One of the most controversial debates in trade policy concerns the impact of trade liberalization on the environment. Trade liberalization can be implemented unilaterally, with a single country reducing its trade barriers against all its trading partners, or regionally, with a group of countries forming a Free Trade Agreement to eliminate trade barriers among them. The latter form of trade liberalization has been predominant since the early 1990s and there is increasing interest in assessing the effects stemming from this new regionalism. Not only direct trade and income effects are important, but also the impact on the environment. After two decades of research, it is commonly accepted that the main effects of trade liberalization on the environment can be classified into scale, composition and technique effects and that there may also be interaction between these effects (Copeland and Taylor, 2003).

At the heart of the debate is the question of whether trade liberalization will cause pollution-intensive industries to locate in countries with relatively weak environmental regulations. The Pollution Haven Hypothesis (PHH) predicts that trade liberalization will cause pollution-intensive industries to migrate from countries with stringent environmental regulations to countries with lax environmental regulations (Taylor, 2004; Levinson and Taylor, 2008). In other words, the PHH takes differences in environmental policy as given and asks what happens if a country liberalizes trade (Korves and Martínez-Zarzoso, 2011). One derived consequence, if the PHH holds, is that developing and developed countries should converge in terms of pollution emissions (Jakob, Haller and Marschinski, 2011).

Many studies have focused on the effects of NAFTA on the environment (Grossman and Krueger, 1991; Stern, 2007) and, contrary to early expectations, the early findings point to positive effects. Surprisingly, few studies have been devoted to other regional trade agreements. Most of the recent literature used changes in trade openness as a proxy for trade liberalization. An alternative strategy is to directly include a trade policy variable in an emissions equation. The main shortcoming of this strategy is that countries possibly select into trade agreements, which could generate endogeneity bias.

This research introduces two main novelties in the current literature. Firstly, we apply a fresh methodology to overcome the problem related to the endogeneity of the FTA variable in the emissions equation by using a propensity matching score approach to select similar countries and estimating the model using difference-in-difference techniques. Secondly, we focus specifically on the Euro-Mediterranean Agreements, which are a good example of a North-South FTA, and compare the results to those obtained for NAFTA and EU-27, more advanced integration agreements. The main results indicate that CO_2 emissions of the pairs of countries that belong to an FTA tend to converge and do so at a higher rate for more advanced integration agreements.

The paper is organized as follows. Section 2 states the main theoretical prediction and Section 3 reviews the main empirical literature. Section 4 describes the empirical strategy and the data, variables and main results are presented in Section 5. Finally, Section 6 concludes.

II. Regional Integration and Emission Convergence: Theoretical Predictions

1. Pollution Haven Hypothesis

The negotiations for the North American Free Trade Agreement (NAFTA) were followed by fears about its consequences on the environment. Indeed, the literature between trade and environmental quality has emerged in this period. Grossman and Kruger (1991) was the first paper to decompose the total impact of trade on the environment into three different effects: scale, technique and composition effects.

The scale effect is assumed to have a negative effect on the environment. According to general belief, trade liberalization leads to an expansion in economic activity and, all other things being equal (composition and techniques of production), the total amount of pollution will then increase (for example, economic growth, due to trade, raises the demand for energy and boosts transportation, which is one of the main emitting sectors). It is worth noting that this pass-through between trade and the environment assumes a positive effect of trade liberalization on economic growth[5]. The income effects of trade

[5] A large body of empirical literature provides empirical evidence of this positive effect of openness (see for example Dollar (1992), Ben-David (1993), Sachs and Warner (1995), Edwards (1998), Frankel and Romer (1999) or Rodriguez and Rodrik (2003) for a critical review).

are linked to the literature on the Environmental Kuznets Curve (EKC), which assumes an inverted U-shaped relationship between per capita income and pollution: Pollution increases in the early stages of development until it reaches a turning point and then declines (Copland and Gulati, 2006).[6] However, it is nowadays generally accepted that an EKC for CO_2 does not exist for most economies (Carson, 2010).

The second pass-through between trade and the environment is the so-called technique effect. Holding the scale of the economy and the mix of goods produced constant, a reduction in the intensity of emissions – measured in terms of emissions by unit of output - results in a decline in pollution. Three main arguments are behind this effect. First, increased trade promotes the transfer of modern (cleaner) technologies from developed to developing countries. Second, if trade raises income, individuals may demand higher environmental quality (if the latter is a normal good). Third, according to the Porter-hypothesis (Porter and van der Linde, 1995), increased globalization will increase competition. In order to stay competitive, firms have to invest in the newest and most efficient technologies. Thus, more stringent environmental policy can increase international competitiveness. In summary, the technique effect has a positive impact on the environment (Mathys, 2002).

Third, comparative advantage is also an important factor that could explain the relationship between trade and the environment. The economy will pollute more if it devotes more resources to the production of pollution-intensive goods, holding the scale of the economy and emission intensities constant. The composition effect – also referred to as the trade-composition or trade-induced composition effect - is caused by changes in trade policy. Through trade liberalization, countries specialize in the sectors where they enjoy a comparative advantage. Among the sources of comparative advantage, we

[6] The name of the environmental Kuznets curve relates to the work by Kuznets (1955), who found a similar inverted U-shaped relationship between income inequality and GDP per capita (Kuznets, 1955).

find classical factor endowment differences or unit cost differences and those based on differences in institutions or regulations between countries. On the one hand, t*he factor endowment hypothesis* (FEH) states that environmental policy has no significant effect on trade patterns, factor endowments determining trade instead. This implies that relatively capital-abundant countries will export pollution-intensive goods, since most pollution-intensive goods are capital-intensive. On the other hand, *the Pollution Haven Hypothesis* (PHH) states that differences in environmental regulations are the main motivation for trade and that trade liberalization causes pollution-intensive industries to relocate from high income countries with stringent environmental regulations to low income countries with lax environmental regulations (Taylor, 2004). Hence, with trade liberalization, high income countries will specialize in the production of clean goods and pollution in these countries will decline, while low income countries will specialize in producing dirty goods and their level of pollution will increase.

In general, we expect countries to differ in *both* factor endowments and environmental policy. High-income countries tend to be capital-abundant and also have stricter environmental regulations than low-income countries. On the one hand, the North could become a dirty-good importer (as it has stricter environmental policy) and, on the other hand, it might become a dirty-good exporter (because of its capital abundance). The interaction of these two effects determines the pattern of trade. If pollution haven motives are more important than factor endowment motives, the North will import the dirty good from the South. On the contrary, trade could cause the North to specialize in the production and exportation of the pollution-intensive good when factor endowment differences dominate regulatory differences, despite having the stricter environmental regulations (Copeland and Taylor, 2003).

In summary, we can expect comparative advantage to be determined jointly by differences in regulatory policy and factor endowments. If the PHH dominates, following a liberalization process between a developing and a developed country, per-capita emissions will converge. If FEH motives dominate, per-capita emissions will diverge. In what follows, we describe the theoretical link between regional integration and emissions using the PHH-FEH framework.

2. Regional Integration and Pollution Haven

In the specific case of regional integration agreements (RTA), the pollution haven hypothesis is particularly important. More specifically, when countries sign an RTA, not only tariff dismantling is planned, but also cooperation in other areas, namely the protection of the environment and cross-border investments are sometimes included, among other issues. For example, in the case of NAFTA, in order to address public concerns about its environmental impact, a side agreement on the environment was signed. The North American Agreement on Environmental Cooperation (NAAEC) stipulates that "… 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"[7]. Moreover, in order to avoid a race to the bottom in environmental regulation among the three countries, a Commission for Environmental Cooperation (CEC) was created in 1994.

These two policy mechanisms, created in the case of NAFTA, illustrate the possible policy responses to potential effects of regional integration on the environment. In particular, there could be two opposite effects at work. First, according to the PHH and the race to the bottom arguments, countries, especially southern countries, can adopt lax

[7] North American Agreement on Environmental Cooperation between the government of Canada, the government of the United Mexican States and the government of the United States of America, part 2: Obligations, article 3: levels of protection. http://www.sice.oas.org/trade/nafta/Env-9141.asp#TWO.

environmental legislation in order to attract multinationals and favor a relocation of economic activity from the developed partner. This relocation of "dirty" activities leads to convergence in the level of emissions. Second, regional integration can lead to the harmonization of rules and standards, especially where the environmental is concerned, which could prevent convergence in emissions.

III. Regional integration and emissions: A survey

After describing the theoretical mechanisms, this section briefly surveys the econometric studies dealing with the link between trade and the environment and testing the PHH.

The typical strategy of early studies was to regress trade flows on a measure of environmental stringency (target variable) and other relevant control variables, such as income per capita, by using cross-section country data or pooled cross-section data over time (Tobey, 1990; Grossman and Krueger, 1991; Lucas et al., 1992; Birdsall and Wheeler, 1993; Van Beers and van den Bergh, 1997 and Mani and Wheeler, 1998 are some examples). These studies found rather mixed results, but in general, the estimated coefficient of the target variable is insignificant and small in magnitude. The basic problem is that these specifications were not able to control for unobserved heterogeneity or the endogeneity of right-hand-side variables (Korves and Martinez-Zarzoso, 2011). The recent literature tries to correct this by employing panel data. In reference to the recent studies using trade flows as the dependent variable, it is worth mentioning Levinson and Taylor (2008). The authors examine the effect of environmental regulations on trade flows using data on U.S. regulations and net trade flows between the U.S., Canada and Mexico for 130 manufacturing industries from 1977 to 1986. They conclude that, as predicted by the PHH, industries whose abatement costs increased the most experienced the largest increases in net imports. Jug and Mirza (2005) obtained similar results for a sample of 12 importing countries from the EU15 and 19 exporting countries from the EU 27 over the period 1996-1999.

Antweiler et al. (2001), a widely cited study, extend the work of Grossman and Krueger (1991) and develop a theoretical model based on the decomposition of the effect of trade on the environment into scale, composition and technique effects. They estimate and add up these effects to explore the overall effect of increased trade on the environment, thereby allowing for pollution haven and factor endowment motives. They regress a country's sulfur dioxide concentrations on trade intensity, factor endowments, scale of production activity and determinants of environmental policy (such as per capita income). In order to capture the composition effect of trade, they interact trade intensity with country characteristics determining comparative advantage (per capita income and capital-labor ratio). Their results show that trade intensity per se is not significant. But, when interacted with country characteristics, the estimated effect is positive, statistically significant and small. Moreover, factor endowment motives for trade seem to dominate the pollution haven driven force, thus implying that high income countries tend to have a comparative advantage in pollution-intensive goods. When they add up the estimates of scale, technique and composition effects, they find that increased trade causes a decline in sulfur dioxide concentrations. Hence, Antweiler et al. (2001) conclude that freer trade seems to be good for the environment. Dean (2002) develops an approach using a simple Heckscher-Ohlin model of international trade with endogenous factor supply (i.e. it can be affected by trade policy). It consists of a two-equation system that captures the effect of trade liberalization on the environment through two channels: its direct effect on the composition of output (the composition effect) and its indirect effect via income growth (the technique effect). The author finds that a fall in trade restrictions has multiple effects on emissions growth: A direct negative effect on environmental quality via the composition effect and an indirect positive effect via the technique effect. In the author's estimation, the indirect effect outweighs the direct effect, suggesting trade is good for the environment. Cole and Elliot (2003) rely on Antweiler et al. (2001) to empirically test for the effects of trade on emissions (per capita), emission intensities and concentration levels for different air and water pollutants. They find that results depend on how the dependent variable is measured (concentrations versus emissions) and also vary by pollutant. Frankel and Rose (2005) take into account the endogeneity of income and especially trade, the latter by using instrumental variables derived from the gravity model of bilateral trade. However, the authors use a cross-section approach, instead of using a panel data approach as most recent papers do. This means the study has a possible weakness, since they do not control for unobserved heterogeneity that is time-invariant (Korves and Martínez-Zarzoso, 2011). Frankel and Rose (2005) employ an EKC framework: they regress a measure of air pollutants (measured in concentrations) on per capita income and its square, trade, institutional quality[8] and land area. Their results show that controlling for endogeneity does not affect the earlier findings. They find trade has a positive impact on air quality and they also find support for the EKC. Moreover, they do not find evidence for a 'race to the bottom' driven by trade or support for the PHH. More recently, Managi et al. (2009) combine the specification derived from Antweiler et al. (2001) and the use of instrumental variable estimations to correct the endogeneity of income and trade. They find that trade has a beneficial effect on the environment depending on the pollutant and the country. OECD countries benefit from trade, whereas trade increases emissions in the case of Non OECD countries. The net effect of the increase in international trade flows is likely to be determined by the change in trade patterns (composition effect) in which connectivity may play a crucial role (Bensassi et al, 2011). Finally, Korves and Martínez-Zarzoso (2011) give support to the PHH for CO_2 emissions and energy consumption, but not for SO_2.

Stern (2007) is, to the best of our knowledge, the only study addressing the link between regional integration and emissions convergence. The author investigates whether or not entry into NAFTA has led to a convergence in energy use and emissions of pollutants in

[8] This variable is proxied by an indicator for democracy (polity), which ranges from -10 (strongly autocratic) to +10 (strongly democratic) and is taken from the Polity IV project.

Mexico, the United States and Canada. Results show strong evidence of convergence for all intensity indicators across the three countries toward a lower level. Although intensity initially rises for some variables in Mexico, it eventually begins to fall after NAFTA comes into force. Per capita measures for two pollutants (sulfur and NOx) also show convergence, but this is not the case for energy and carbon. The latter variables drift moderately upwards. The state of technology in energy efficiency and sulfur abatement is improving in all countries, although there is little, if any, sign of convergence and NAFTA has no effect on the trend of technology diffusion. According to these results, Mexico's technology is improving at a slower rate than its two northern neighbors.

IV. Empirical strategy

Along the same lines as Stern (2007), we aim to explore whether emissions converge for countries involved in an FTA. We depart from Stern (2007) by adopting matching and difference-in-difference estimation techniques that allow us to control for the endogeneity of the FTA variable in the emissions equation.

Our starting point is a simplified version of the determinants of emissions. Per capita emissions depend on population, per-capita GDP and an openness ratio. These variables are assumed to control for the scale, technique and composition effects[9].

In order to test for the convergence of emissions, we estimate a log-linear emissions equation in relative terms in which the dependent variable is the log of CO_2 emissions of country *i* relative to country *j* in period t (Em_{it}/Em_{jt}). The estimated model is given by,

$$V_{ijt} = |\ln(Em_{it}/ Em_{jt})| = \alpha + \varphi_1 |\ln(Pop_{it}/ Pop_{jt})| + \varphi_2 |\ln(GDPcap_{it}/ GDPcap$$

[9] Our model considers the main factors affecting emissions in line with the IPAT identity and the STIRPAT model (Martínez-Zarzoso and Maurotti, 2011).

$$+\varphi_3 \left|\ln(Open_{it}/Open_{jt})\right| + \varepsilon_{ijt} \qquad (1)$$

where i and j refer to countries, and t to the year. Y_{ij} represents the pollution emissions gap between a pair of countries i,j . Pop_{it} (Pop_{jt}) is population in number of inhabitants in country i (j) in year t. $GDPcap_{it}$ ($GDPcap_{jt}$) is GDP per capita at constant ppp prices in country *i* (*j*) in year t. $Open_{it}$ ($Open_{jt}$) refers to the openness ratio measured as the sum of exports and imports divided by gross domestic product.

The absolute value of each relative term is considered in order to have only one interpretation of an increase in the value of the variable, since any increase (decrease) implies divergence (convergence) between both countries. For example, an increase in the left-hand-side variable in equation (1), means that there is divergence in the emissions of countries.

We add the variable FTA_{ijt}[10], which is a dummy variable taking the value 1 if countries are involved in a free trade agreement in the considered year and zero otherwise, to the basis specification.

$$Y_{ijt} = \left|\ln(Em_{it}/Em_{jt})\right| = +\varphi_1 \left|\ln(Pop_{it}/Pop_{jt})\right| + \varphi_2 \left|\ln(GDPcap_{it}/GDPcap\right.$$

$$\varphi_3 \left|\ln(Open_{it}/Open_{jt})\right| + \beta\, FTA_{ijt} + \varepsilon_{ijt} \qquad (2)$$

The sign of β allows to test for the PHH. A positive sign means that the emissions gap between a pair of countries that have an FTA increases, whereas a negative sign suggests convergence in the emissions gap of countries linked by an FTA.

The FTA variable will be addressed using matching techniques. These techniques provide a simple way to deal with the selection induced by FTAs. Bergstrand and Baier (2004) give evidence that country pairs involved in FTAs tend to share common

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10 FTA_{ijt} will be denoted as FTA for simplicity.

economic and geographic characteristics. Few studies use matching techniques to deal with FTAs. Egger et al. (2008) used a difference-in-difference panel matching estimator to examine primarily the effect of FTA formations on changes in shares of intra-industry trade. Baier and Bergstrand (2009) provide the first cross section estimates of long-run treatment effects of free trade agreements (FTA) on members' bilateral international trade flows using non parametric matching econometrics. Their findings show that matching estimators provide plausible estimates of the average treatment effects of an FTA on the trade of members that actually form one. We follow a similar methodology to match pairs of countries that have an FTA with similar pairs of countries that are not linked by any FTA. After obtaining the matched samples for each year, we use a difference-in-difference estimator to evaluate the effect of the treated FTA variable on emissions convergence.

The effect of an FTA on the outcome[11] (Y_{ij} which is the pollution emissions gap) of a pair of countries is defined as the difference between the pollution emissions gap of a pair of countries after enforcing a Free Trade Agreement and the outcome that these countries would have without an FTA. Put differently, the impact of an FTA is measured by the change in the pair of countries' outcome, which is attributable to the FTA only.

The difference-in-difference (hereafter DID) approach is well suited to dealing with this question (Meyer, 1994; Heckman et al., 1997). Considering the FTA process as a natural experiment, the DID method evaluates the average effect of the treatment (here the FTA) on treated units (pairs of countries linked by an FTA and denoted by FTA). The idea is that comparing the outcome of a pair of countries before and after an FTA is not satisfactory because we do not have a counterfactual (outcome variable for the pair

[11] We follow Bertrand and Zitouna (2008) in this section and adapt their empirical strategy to FTAs.

of countries if they had not entered the FTA). In order to control for this skew, the DID method compares the difference in outcome before and after the FTA for participating countries to that for a control group. The latter is composed of pairs of countries that have never been part of an FTA. These countries are referred to hereafter as $NFTA$.

Formally, let Y_{ijt}^{1} be the outcome in period t for a pair of countries i,j which has been member of an FTA. We denote Y_{ijt}^{0} the outcome for the same country pair assuming it was not linked by an FTA. The effect of the FTA for this pair i,j is then measured by $Y_{ijt}^{1} - Y_{ijt}^{0}$.

The average impact of the FTA is described by $E\left(Y_{ijt}^{0} \middle| T = 1\right)$. Unfortunately, we cannot observe the outcome for the same pair of countries both as a participant and as a nonparticipant in an FTA. In other words, we cannot ascertain the outcome of the event of nonparticipation for a pair of countries that signed a trade agreement or conversely. In order to overcome this difficulty, we compare the evolution of the groups FTA and NFTA over time, assuming that they would have been identical in the absence of FTA:

$$E\,[\![(Y]\!]_{ijt}^{0} \middle| FTA = 1, t = 1\big) - E\,[\![(Y]\!]_{ijt}^{0} \middle| FTA = 1, t = 0\big)$$
$$= E\,[\![(Y]\!]_{ijt}^{0} \middle| FTA = 0, t = 1\big) - E\,[\![(Y]\!]_{ijt}^{0} \middle| FTA = 0, t = 0\big) \quad \textbf{(3)}$$

The terms $t = 0$ and $t = 1$ refer respectively to the period before and after the FTA. Hence, the missing counterfactual value could be replaced by the state of country pairs before the agreement, adjusted to take into account the growth in aggregate outcome:

$$E\,[\![(Y]\!]_{ijt}^{0} \middle| FTA = 1, t = 1\big) = E\,[\![(Y]\!]_{ijt}^{0} \middle| FTA = 1, t = 0\big) + m_t \quad \textbf{(4)}$$

Where $m_t = E\,[\![(Y]\!]^0_{ijt} \big| FTA = 1, t = 1) - E\,[\![(Y]\!]^0_{ijt} \big| FTA = 0, t = 0)$ denotes the DID estimator that assesses the impact of an FTA on participating countries. We obtain it by regressing data pooled across the treatment (country pairs with FTA) and the control group (country pair without FTA). The estimating equation is given by,

$$Y_{ijt} = \beta_0 + \beta_1 FTA_{ij} + \beta_2 After_t + \beta_3 (FTA_{ij} * After_t) + \varepsilon_{it} \quad (5)$$

FTA is a dummy variable taking a value 1 for treated country pairs and 0 otherwise. It controls for differences in constant outcome Y_{ijt} between treated pairs of countries and the control group. We define the dummy variable $After$ as taking a value 1 in the post-FTA years and 0 otherwise for both FTA and non-FTA countries. This dummy variable controls for time effects on outcome Y_{ijt}. Finally, the term $FTA * After_t$ is an interaction term between FTA and $After_t$. Its coefficient β_3 represents the DID estimator of the effect of an FTA on the treated group. The framework described by equation 3 is extended by including a vector of the characteristic ratio of a country's pair.

These explanatory variables control for differences in observable attributes between the treated and control group. The extended model is given by,

$$Y_{ijt} = \beta_0 + \beta_1 FTA_{ij} + \beta_2 After_t + \beta_3 [\![(FTA]\!]_{ij} * After_t) + \varphi X_{ijt} + \delta_t + \varepsilon_{it} \quad \mathbf{(6)}$$

where the vector X_{ijt} represents the ratio of some observable features of a pair of countries i, j at time t. These observables are population, GDP per capita and Openness ratios as presented in equation (2). δ_t denotes time-specific dummies that control for factors common to all countries. ε_{it} is an idiosyncratic error term that is assumed to be independent and identically distributed.

Next we explain how the choice of the comparison group is made. Intuitively, the DID method does not provide valid estimations when the comparison group differs greatly from the treated pairs of countries over the pre-FTA period. In order to solve this problem, we combine the DID estimation with the matching method (Blundell and Costa Dias, 2000)[12]. Propensity score matching techniques identify a control group without marked differences in characteristics compared to treated pairs of countries. Failure to account for the selection problem would bias the estimated impact of an FTA. It may lead to correlation between the FTA variable and the error term in the outcome equation. This will be the case when the agreement decision is not a random process, but due to observable characteristics associated to a given trading pair of countries, such as distance, which also influences the post-liberalization outcome. The propensity score method therefore controls for selection based on observed characteristics. Furthermore, matching pairs of countries directly could require comparing the groups FTA and NFTA across a large number of observable pre-liberalization characteristics. The propensity score method reduces the dimensionality issue by capturing all the information from these characteristics on a single basis (Rosenbaum and Rubin, 1983). In particular, it measures the probability of signing the agreement according to a vector of pairwise variables. The estimation of this probability value is as follows:

$$P(FTA_{ijt} = 1) = F(Z_{ijt}) \qquad (7)$$

[12] The matching method is a nonparametric method. No particular specification is assumed.

where the vector Z_{ijt} represents pair wise characteristics. Once the propensity scores are calculated, observations from the treated group and the control group are matched. Each treated pair of countries is associated with a pair of control countries endowed with a similar propensity score[13]. We apply this econometric methodology to the pollution emissions gap of a pair of countries linked by an FTA during the period 1980-2008.

We use propensity score matching (PSM) to construct a statistical comparison group that is based on a model of the probability of participating in the treatment, using observed characteristics. Participants are then matched on the basis of this probability, or propensity score, to non participants. We estimate a probit model given by,

$$P(FTA = 1) = F\left(\ln\left(RGDP_{ij}\right), \ln\left(dis_{ij}\right), Contiguity_{ij}, Common\ language_{ij}\right) \quad (8)$$

where $RGDP_{ij}$ denotes the sum of the real GDP of countries *i* and *j* .

Dis_{ij} denotes the great circle distance between countries *i* and *j*.

Contiguity takes a value of one for countries that share a border, zero otherwise.

Common language takes a value of one for countries that have the same official language.

The validity of PSM depends on two conditions:

(a) Conditional independence (namely, that unobserved factors do not affect participation).

(b) Sizeable common support or overlap in propensity scores across the participant and non participant sample.

[13] We use the "calliper" matching method to select the control pairs of countries.

The assumption of common support or overlap condition for matching on the propensity score is that the estimated score is smaller than unity throughout. This condition ensures that treatment observations have comparison observations "nearby" in the propensity score distribution (Heckman, Lalonde, and Smith, 1999). The probability model provides us with an estimate of the propensity score $p(Z)$. In our case, the latter is to be interpreted as the likelihood of entering an FTA, conditional on the observables. Next, we have to ensure that the treated units (new FTA members) and the control units (the comparable subgroup of non-members) are similar with respect to every observable Z . Thus, balancing tests will be conducted to verify whether the average propensity score and mean Z is the same[14].

We base our choice of explanatory variables in the probability model on Baier and Bergstrand (2004). These authors show that gravity variables, namely GDP and distance, are the main determinants of the formation of FTAs:

(i) Distance is used as a proxy for transport costs: two countries that are geographically close will have lower transport costs. The lower the transport costs between countries, the more each country can consume the other country's varieties, enhancing trade creation regionally and the formation of FTAs.

(ii) Incomes are used as a proxy of the economic size of the participating countries.

Other Variables that are associated to a higher probability of forming FTAs are contiguity and common language, as proxies for trade facilitation.

V. Data, stylized Facts and Main Results

1. Data and Stylized Facts

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[14]A balancing score test and a T-test were conducted to check the differences within bands of the propensity score between treated and untreated country pairs.

The FTA data are taken from Jose De Sousa's website[15]. Distance, common language and contiguity come from CEPII. Income, trade and emissions data are from the World Development Indicators (World Bank, 2009) and cover the period dating from 1998 to 2008.

The main variables used in the emissions equation are per capita real gross domestic product (GDPcap); per capita carbon dioxide emissions (Em) as a proxy for the level of pollution and environmental degradation; the openness ratio (Open), which is calculated as exports plus imports over GDP; total population (Pop) and the FTA variable that takes a value of one if a pair of countries is participating in the same FTA and zero otherwise. The date of entry into force of the FTAs is considered in the construction of this variable. All variables are transformed by taking natural logarithms, such that the associated coefficients in the estimated model can be interpreted as elasticities. Table A.2 in the Appendix shows the summary statistics for the described variables.

As shown by Baier and Bergstrand (2009), closer countries with a similar level of wealth are more likely to join a free trade agreement. Table (1) reveals that the means of (ln) distance, sum of (ln) gross domestic products and language and adjacency differ between countries linked by an FTA and pairs of countries without an FTA. Countries linked by FTAs tend to be closer and richer. Moreover, they are more likely to have common borders and share the same language than the rest.

Table 1. Summary of covariate means

Figures (1) and (2) show some differences in the bilateral distances between pairs of countries involved and not involved in FTAs. Figure (1) shows that pairs of countries

[15] http://jdesousa.univ.free.fr/data.htm.

with an FTA are closer than those without an FTA. The kernel densities function of (ln) bilateral distances for non-FTA pairs of countries is more centered to the right in relation to the kernel density function of (ln) bilateral distances for FTA pairs of countries.

Figure 1. Kernel density of the log of bilateral distance for pair wise countries without and with an FTA

Figure (2) shows that country pairs with an FTA tend to be larger economically. The Kernel density function for countries with an FTA is centered to the right in comparison to pairs without one.

Figure 2. Kernel density of the sum of the log of GDPs pair wise countries without and with an FTA

2. Main Results

The matching was implemented for each single year. Country pairs for each year in which there was at least one agreement (year by year) are matched with country pairs without an agreement using propensity matching scores and then a dataset was created with the matched data[16].

Based on the pooled cross-section data, Table A.3 in the Appendix displays the efficiency of the matching procedure. The balancing property is verified[17]. The

[16] The Stata command *pscore* was used to check that the balancing property is satisfied (number of blocks between 5 and 8) and the command *psmatch2* with a calliper (0.01) was used for the matching (years with matching and common support satisfied: 1981, 1983, 1986, 1991, 1992, 1993, 1994, 1995, 1996, 1997-1998 and 1999-2008).

[17] For each independent variable, the difference between target and control countries is checked by employing a T-test on the differences within bands of the propensity score.

reduction in bias[18] is drastic when the bias is initially high. Once reduced, the bias does not exceed the threshold of 16%. Thus, this method provides a valid group of countries to which we will compare changes in target countries' performance.

In order to illustrate the estimations used for the matching, the first column of Table (3) shows the results of a pooled cross-section estimation for the determinant of the decision to enter into an FTA for all country pairs (probit model given by equation 8). It supports the stylized facts and shows that economic characteristics and geographic conditions are the main determinants of the decision to join an FTA for the whole sample. Column 2 (Table 2) shows that the same set of factors are statistically significant for the selected (matched) sample.

Table 2. Determinants of FTAs

Next, Equation (6) is estimated using OLS and also a Least Squares Dummy Variable (LSDV) estimator that includes time effects. The main results are shown in Table 3. Columns (1) and (3) show the results for all pairs of countries, whereas columns (2) and (4) present our findings for the matched sample of countries. We include time-fixed effects in columns (3) and (4) in order to capture time trends that may affect emissions and are common for all countries.

Table 3. Emissions pollution gap and economic integration

The coefficient of the target variable, interaction variable ($FTA_{ij}*After_t$) is negative and statistically significant in both samples. This is the only coefficient that can be

[18] The bias could be defined as the difference of the sample mean in the treated and non treated sub-samples divided by the square root of the average of the sample variances in the treated and non treated groups.

interpreted as causal. Countries involved in FTAs converge in terms of CO_2 emissions after the entry into force of Free Trade Agreements. This negative sign can be interpreted as supporting evidence for the PHH. We have to underline the fact that the effect of FTA participation is smaller for our selected sample than for the enlarged sample. Our preferred specification, with the difference-in-difference and matching techniques, displays a coefficient of *-0.07*. Hence, the gap in emissions per capita between countries involved in an FTA is around 7 percent lower than for countries without an FTA.

With respect to the control variables, our results show that population and gross domestic product per capita ratios are positively related to the emissions gap. These variables are used as control variables and are assumed to capture the scale and technique effect respectively. Convergence in the scale of the economy as well as in technology is positively correlated to convergence in emissions of CO_2 for pairs of countries. Concerning the openness ratio, the corresponding estimated coefficient is negative, indicating that more similarity in trade openness is negatively correlated to the emissions gap. However, we cannot give a causal interpretation of the estimated coefficient, as we do not control for the endogeneity of this variable.

In the second step, similar estimations are made for the Euro-Med agreements (European Union countries and southern Mediterranean countries: Morocco, Algeria, Tunisia, Egypt, Jordan and Turkey). Estimates of equation 6 with time effects are shown in columns (1) and (2) in Table 4. As before, we first estimate Equation (6) for all pairs of countries, namely those involved in Euro-Med agreements (treated sample) and those not involved in any FTA in column (1). Second, equation (6) is estimated for the matched sample, namely the pairs of countries linked by a EUROMED agreement (treated units) and pairs of similar countries (selected control group) in column (2). The results shown in Table 4 indicate that the FTA effect is much more pronounced for EUROMED than for the whole sample (19 versus 7 percent). Indeed, the interaction variable ($EUROMED_{ij}*After_t$) that proxies the Euro-Med membership effect on the emissions gap displays a coefficient of *(-0.21)* in the preferred specification. Hence, the gap in per capita emissions between countries involved in a Euro-Med agreement is 19 percent ((exp(-0.21)-1)*100) lower than for similar countries without an FTA. Therefore, the Euro-Med agreement fosters convergence of CO2 emissions. This result provides some support for the HH hypothesis: Southern Mediterranean countries might act as pollution havens due to their lax environmental regulations.

Table 4. Emissions pollution gap and specific agreements

Similarly, columns (3) and (4) in Table 4 show the results when comparing EU-27 countries to countries not involved in any FTA. In this case the estimated coefficient of ($EU_{ij}*After_t$) is also negative and statistically significant and larger (33 versus 19 percent) than for EUROMED. It is worth noting that both the EUROMED and also the EU-27 agreement entail higher convergence of emissions than the average effect of all FTAs.

Finally, columns (5) and (6) in Table 4 show the effect of being a NAFTA member on emissions convergence. Interestingly, whereas the results for the whole sample (column (5)) show a non-significant effect of NAFTA, the estimations using matching and difference-in-difference techniques display a strong negative effect. Results in column (6), our preferred estimation, show that emissions convergence increases between partner countries with NAFTA membership. The magnitude of the estimated coefficient of the interaction variable ($NAFTA_{ij}*After_t$) is even higher than for the EU-27 agreement

(54 versus 33 percent). This result could again be interpreted as additional support for the PHH.

VI. Conclusions

This paper examines the impact of trade liberalization on CO_2 emissions. We adopted a reduced-form specification linked to the emissions convergence hypothesis in which relative emissions are explained using income, population, openness in relative terms and a dummy for FTA agreements. The model is estimated using a difference-in-difference approach paying special attention to the potential selection induced by FTAs. A propensity matching technique is used to treat FTAs and to extract a sub-sample containing only matched pairs of countries that share similar characteristics.

Our results consistently indicate that FTAs foster convergence of CO_2 emissions. In particular, the gap in emissions per capita is seven percent lower for pairs of countries that have a bilateral trade agreement than for the rest when the matched sample is used.

Our findings also provide a tentative answer to the question raised in this paper. Taken as a whole, our estimations indicate that the emissions pollution gap is 19 percent lower for pairs of countries involved in Euro-Mediterranean Agreements than for similar pairs of countries not involved in FTAs.

An additional finding shows that the pollution gap for EU-27 pairs of countries is 33 percent lower than for similar non-EU-27 countries. It is worth noting that reductions in the emission gap stemming from a deeper integration agreement, like the EU, are larger than those related to a North-South trade agreement such as the Euro-Mediterranean agreement. One final result indicates that stronger convergence between partner countries is found for NAFTA than for the EU-27 and EUROMED countries.

The main economic policy recommendation that can be derived from our results is that regional integration processes seem to reduce the pollution gap between pairs of countries that have joined agreements. This main result provides indirect support for the PHH and for environmentalists fearing that less developed countries may act as pollution havens. Moreover, higher levels of integration, namely a customs union versus a free trade agreement, appear to be linked to greater reductions in the above mentioned pollution gap.

Further research concerning other pollutants is also desirable to ascertain whether the link between regional trade agreements and pollution convergence is in place.

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Tables

Table1: Summary of covariate means

	Country pairs with an FTA	Country pairs without an FTA
Ln of distance	7.34	8.86
Sum of the ln of GDPs	18.64	17.31
Adjacency dummy	0.13	0.009
Language dummy	0.26	0.15

Table 2. Determinants of FTAs

	Model 1	Model 2
	All	Matched
Sum of the ln of GDPs	0.205***	0.127***
	[0.0034]	[0.0059]
Ln distance	-0.955***	-0.212***
	[0.00708]	[0.011]
Contiguity	0.0620**	0.297***
	[0.0262]	[0.0383]
Common language	0.102***	0.110***
	[0.0151]	[0.0239]
Pseudo R^2	0.395	0.032
Observations	201,558	25,629

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3. Emissions pollution gap and economic integration

VARIABLES	Model 1 All	Model 2 Matched	Model 3 All	Model 4 Matched
FTA_{ij}	-0.218***	-0.175***	-0.222***	-0.179***
	[0.0334]	[0.0314]	[0.0334]	[0.0315]
$After_t$	0.432***	0.248***	0.382***	0.194***
	[0.0292]	[0.0326]	[0.0294]	[0.0343]
FTA_{ij}*$After_t$	-0.202***	-0.0734*	-0.210***	-0.0726*
	[0.0346]	[0.0379]	[0.0347]	[0.0379]
Abs Ln population ratio	0.734***	0.822***	0.734***	0.823***
	[0.00264]	[0.00691]	[0.00264]	[0.00692]
Abs Ln GDP per capita ratio	0.389***	0.106***	0.391***	0.110***
	[0.0048]	[0.0148]	[0.00481]	[0.0148]
Abs Ln openness ratio	-0.405***	-0.125***	-0.414***	-0.137***
	[0.00913]	[0.0221]	[0.00917]	[0.0222]
Time fixed effects	No	No	Yes	Yes
Number of observations	176,045	22,423	176,045	22,423
R-squared	0.390	0.523	0.391	0.525

Robust standard errors in parentheses. Abs denotes absolute value and Ln natural logarithms.
*** p<0.01, ** p<0.05, * p<0.1.

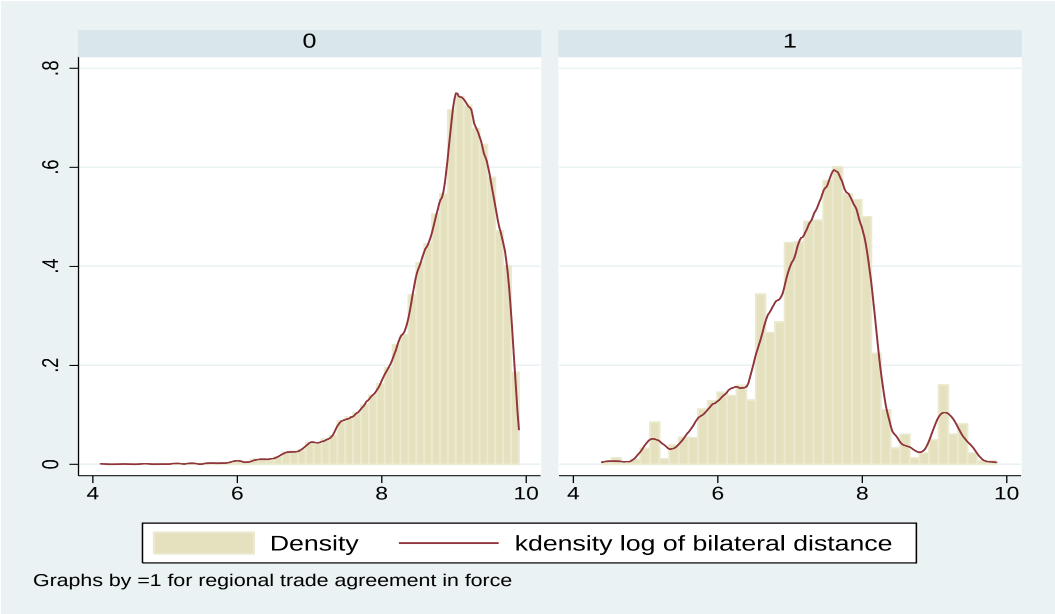
Table 4. Emissions pollution gap and specific agreements

VARIABLES	**EUROMED** All	**EUROMED** Matched	**EU-27** All	**EU-27** Matched	**NAFTA** All	**NAFTA** Matched
EU_{ij}	-0.330***	-0.158***	-0.310***	-0.155***	-0.156	-0.0392
	[0.0521]	[0.0439]	(0.0327)	(0.0406)	[0.272]	[0.147]
$After_t$	0.108**	0.162***	0.379***	0.546***	0.374***	1.284***
	[0.0523]	[0.0489]	(0.0295)	(0.0379)	[0.0296]	[0.367]
EU_{ij}*$After_t$	-0.341***	-0.211***	-0.260***	-0.409***	0.247	-
	[0.0591]	[0.0507]	(0.0340)	(0.0424)	[0.307]	[0.265]
Abs Ln	0.771***	0.817***	0.733***	0.778***	0.728***	0.0995
	[0.0125]	[0.00854]	(0.00270)	(0.00461)	[0.0028]	[0.0853]
Abs Ln GDP per	0.197***	0.118***	0.397***	0.507***	0.407***	0.562***
	[0.0221]	[0.018]	(0.00487)	(0.00705)	[0.00501]	[0.191]
Abs Ln openness	-0.272***	-0.156***	-0.432***	-0.694***	-	1.240***
	[0.0387]	[0.0278]	(0.00939)	(0.0153)	[0.00976]	[0.196]
Time fixed	Yes	Yes	Yes	Yes	Yes	Yes
Observations	159,712	14,867	168,882	63,269	155,611	176
R-squared	0.505	0.549	0.388	0.436	0.365	0.473

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Figures

Figure 1. Kernel density of the log of bilateral distance for pair wise countries without and with an FTA



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