Are Free Trade Agreements Good for the Environment? A Panel Data Analysis

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Abstract

This study attempts to empirically re-examine the relationship between free trade agreements (FTAs) and greenhouse gas (GHG) emissions. For this aim, we chose three different free trade agreements: Southern Common Market (MERCOSUR), North American Free Trade Agreement (NAFTA), and the Australia-United States Free Trade Agreement (AUSFTA). These FTAs are between developing countries, developed and developing countries, and only developed countries, respectively. Panel unit root, panel cointegration, and fully modified OLS (FMOLS) estimators are employed to find the long-run relationship between GHG emission, trade liberalization, and other economic factors. The results indicate that the environmental effect of a free trade agreement depends on the agreement type. When the agreement is among only developed or only developing countries, there is no environmental damage to the world and these types of FTAs can be beneficial for the world environment. However, when developing and developed countries are in the agreement, world GHG emissions increase.

Keywords: Economic Factors, EKC, FTAs, GHG Emissions, Panel Cointegration

JEL Classification: *F18; Q56*

1. INTRODUCTION

Free Trade Agreements (FTAs) have become increasingly prevalent since the early 1990s. A WTO report (2014) shows that 585 notifications of regional trade agreements (counting goods, services and accessions separately) had been received by the GATT/WTO. FTAs can be helpful reducing trade barriers and creating a more stable trade environment. On the other hand, there is an extensive debate about environmental consequences of these FTAs. Their effects get more complicated when there are both developed and developing countries in the same FTA.

Free trade proponents argue that FTAs have a positive impact on the environment because after liberalization countries will have access to environmentally friendly technologies, produce goods in which they have a competitive advantage and have greater income due to trade liberalization. On the other hand, environmentalists argue that trade liberalization is detrimental for the environment because it will encourage more polluting industries to locate in countries with lax environmental regulations. They also believe that scale effects cause more pollution (Grossman and Krueger 1993; Antweiler, Copeland and Taylor 2001; Frankel and Rose 2005; Frankel 2009).

Trade agreements can be established among developing countries, developed countries, or between developed and developing countries. Based on the countries that are in a trade agreement, there are different hypotheses about the effect of FTAs on greenhouse gas (GHG) emissions, which is an important indicator of environmental quality.

The first hypothesis is the “pollution haven hypothesis” (PHH) (Johnson and Beaulieu, 1996). Based on this hypothesis, developing countries will have more pollution after an FTA because of their lax environmental regulations. Polluting industries will relocate from countries with strict environmental regulations to developing countries (Johnson and Beaulieu, 1996). Developing countries will also become producers of more pollution-intensive products (Korves and et.al, 2011). The PHH may hold when there is a trade agreement between developed and developing countries.

The "factor endowment hypothesis" (FEH) is the second hypothesis commonly discussed in the related literature. This hypothesis argues that trade flows are determined by the amount and type of resources owned by trade partners. Usually, developing countries produce more labor intensive products that are clean and developed countries produce capital-intensive products that are dirty goods (Temurshoev, 2006; and Copeland and Taylor, 2013). As a result, FTAs between developed and developing countries may render developed countries with greater pollution.

The "Porter" or "regulatory chill" hypothesis assumes a race-to-the-top. Based on this hypothesis, developed countries may continue to make new and stricter environmental regulations that encourage innovation and in turn increase environmental quality of all countries involved in the agreement (Porter and van der Linde, 1995; Stoessel, 2001; Bagwell and Staiger, 2001).

The last hypothesis is "race-to-the-bottom". Based on this hypothesis developed countries reduce their existing environmental regulations or they do not make new environmental rules. They do this because they want to compete with less environmentally regulated countries where the cost of production can be lower due to lack of effort and resources spent on environmental quality compliance.

The objective of this study is to compare the effects of different FTAs on GHG emissions in different countries and on a global scale. Economic factors such as the impact of a country's income and energy consumption on GHG emission are also considered. The investigation involves both developing and developed countries under FTAs. The findings of this study enable tests of the environmental Kuznets curve (EKC).

We contribute to this growing literature in two important ways. First, we intend to find a long-run relationship between GHG emissions, trade, and other economic factors such as GDP and energy consumption. Second, we hope to find whether the impact of FTAs on the environment differs across agreements. Three different types of agreements are analyzeed in this article. Using different FTAs allows a comparison of FTA effects on the environment when different countries are involved in the agreement.

The three different FTAs considred in this study are: the Southern Common Market (MERCOSUR), the North American Free Trade Agreement (NAFTA), and the Australia-United States Free Trade Agreement (AUSFTA). These agreements involve only developing countries, both developed and developing countries, and only developed countries, respectively. Countries under each of these agreements are treated as panels. Monthly observations for the variables of interest are created and panel cointegration is used to find links between these variables of interest and GHG emissions.

The rest of this article is organized as follows. Section two provides background on the empirical evidence of the effect of different trade agreements on environmental quality. Section three describes data and empirical methodology used. Section four presents empirical results. Conclusion and policy implications are described in the last section.

2. LITERATURE REVIEW

There is a large and growing literature on the impact of trade liberalization on the environment. Literature in this area goes back to the work of Grossman and Krueger (1991). They analyzed the impact of trade on the environment by defining three major effects: scale, technique, and composition. In fact, any change in pollution emissions can be decomposed into these three effects.

"Scale effect" is defined as an increase in emissions related to a higher income, holding everything else constant (e.g., production mix of goods). "Technique effect" is defined as the change in emissions intensity due to access to new technologies (e.g., cleaner technologies). "Composition effect" is defined as a change in emission due to the change in the share of dirty goods production in GDP. Trade liberalization can have all of these effects.

The expectation is that the scale effect will increase emissions and technique effect will decrease emissions. The composition effect will increase or decrease emissions depending on the production mix of goods after trade liberalization. If production of dirty goods increases in the economy, then pollution will increase and if the economy produces cleaner goods after trade liberalization it will lead to decreases in emission level (Antweiler and et. al, 2001).

Part of the previous literature investigated the effects of openness to trade on the environment. Antweiler et.al. (2001) examined how the openness of trade affects pollution level. They developed a theoretical model and tested it with data on 43 countries from 1971-1996. They found little impact on the environment due to trade-induced changes in the location of production (composition effect). For scale effect, they found that each one percent rise in economic activity induces a 0.25 percent rise in pollution concentration. Finally, for technique effect, they found that as free trade expands, each one percent increase in per capita income lowers pollution concentration by 1.25 to 1.5 percent because of the movement to cleaner production techniques. They concluded that by putting together all the effects, freer trade is beneficial for the environment.

Frankel and Rose (2005) attempted to estimate the effect of trade on a country's environment holding GDP constant. They found evidence supporting the environmental Kuznets curve hypothesis; that is growth at low levels of income leads to higher environmental damages and growth at high levels of income helps the environment. Furthermore, they found support for the hypothesis that trade liberalization increases the speed of growth. They did not find evidence supporting the hypothesis that freer trade will increase pollution. The effect of trade on the global environment was not investigated by Antweiler et.al. or Frankel and Rose. One of the contributions of this paper is to find the effect of FTAs on the global environment as well as individual countries` environment.

Most of the previous research focused on the NAFTA. Grossman and Krueger (1991) tried to find these environmental effects for NAFTA and found lower emission of Sulfur Dioxide (SO_2) due to trade liberalization. Gale and Mendez (1998) re-examined one year of SO_2 data drawn from the aforementioned Grossman and Krueger study. They found that factor endowment plays an important role in defining the difference in pollution levels of the various countries, and the effect of trade liberalization on pollution is not significant. Logsdon and Husted (2000) found that the impact of NAFTA on environmental quality in Mexico is mixed, and they could not determine either a positive or negative impact of this agreement. Reinert and Roland-Holst (2001) used a general equilibrium model for the three countries under the NAFTA agreement.

The result showed that most types of pollution increased in the three countries due to the NAFTA. Yu et al. (2010) focused on the NAFTA effects on pollution in the United States and Mexico. They found that the U.S. and Mexico greenhouse gas emissions increased due to the NAFTA passage, but the amount of this increment is larger in Mexico. Furthermore, they concluded that the pollution haven hypothesis may hold for Mexico.

The commonality between all of the above studies is that they focused only on NAFTA, which is an FTA between developing and developed countries on the environment quality. Based on our knowledge this is the first article that considers different types of FTAs. In this article, we investigate the effect of FTAs between only developed, only developing, and developing and developed countries on the global environment and the countries in the agreements individually. In other words, what is the impact of FTAs on country environments when there is a group of developed countries in the FTA? What happens to the environmental situation of the region and countries when a group of exclusively developing countries decides to have an FTA? These FTAs effects on GHG emission are estimated by individual country and the world as a whole.

3. MODEL AND DATA

Similar to past research (Cole, 2004; Frankel and Rose 2005; Halicioglu, 2009) GHG emission can be described as a function of income, energy consumption, and trade openness. We add an FTA dummy to the model, so the empirical model is specified as follows:

$$lnGHG_{it}^{k} = \alpha_{it} + \beta_{1i}\ln GDP_{it} + \beta_{2i}(\ln GDP_{it})^2 + \beta_{3i}\ln EC_{it} + \beta_{4i}ROWO_{it} + \beta_{5i}FTA_{it} + \varepsilon_{it} \qquad (1)$$

Where, ln indicates variables in log form, i identifies the country, and t identifies time, k=1, 2, … , K for each FTA. $\ln GHG_{it}$ is the log of greenhouse gas emission per capita in country i at time t. $\ln GDP_{it}$ is the log of per capita real gross domestic product, $\ln EC_{it}$ is per capita energy consumption, $ROWO_{it}$ is the trade openness of the country to rest of the world, and FTA_{it} is a dummy variable for each FTA agreement by assigning a one for the time period after implementation of the FTA. For the MERCOSUR agreement, the FTA dummy will be zero before the MERCOSUR passage in 1990, and one after 1990. Similarly, the beginning year for the NAFTA and AUSFTA is 1993 and 2005, respectively. All variables are in logarithms except the FTA dummy variable.

Under the environmental Kuznets curve (EKC) hypothesis, the sign of β_1 is expected to be positive and the sign of β_2 is expected to be negative. The EKC hypothesis assumes that the pollution level rises as income per capita in the countries increases until a threshold level and after that increases in income per capita have a negative effect on pollution levels. The sign of β_3 is expected to be positive. This means that higher levels of energy consumption should increase economic activity and as a result GHG emission increases. The sign of β_4 and β_5 is undetermined and depends on the country of study, agreement type and other factors.

The following countries are investigated in this study: Argentina, Brazil, Paraguay, and Uruguay under the MERCOSUR agreement; the United States, Canada, and Mexico under the NAFTA agreement; and United States and Australia under the AUSFTA agreement.

This study utilizes an annual panel data set for each FTA separately over the period of 1970-2012 for the MERCOSUR, and 1980-2012 for the NAFTA and AUSFTA. These periods were determined by data availability. Per capita GHG emissions (that includes the sum of Carbone Dioxide (CO), Methane (CH_4), Nitrous Oxide (N_2O), and F-gase) is measured in metric tons of carbon dioxide equivalent (mt CO_2 eq), and obtained from the Emission Database for Global Atmospheric Research (EDGAR). Yu et al. (2010) used similar data. Real GDP per capita is measured in 2005 US$. Per capita energy consumption is measured in kilograms of oil equivalent, and the population is obtained from World Developments Indicators (WDI, 2014). Yu et al. (2010); Lee and Chang (2008); Ozcan (2013) also used these dataset in their research.

Other economic factors such as trade openness to the rest of the world are calculated using the UN Cometrade Bilateral Trade dataset. In this study, we calculate trade openness of each country to the rest of the world (non-members) by dividing total trade to non-members (sum of exports and imports) to GDP of each country. Frankel and Rose (2005) and Stern (2007) used the same method to find a country's openness to trade for non-members.

Table 1 shows summary statistics for the MERCOSUR members from 1970-2012. Mean GHG emissions per capita range from 14.21 for Paraguay to 8.76 for Argentina. The GDP per capita ranges from Argentina, with a mean GDP per capita of $5,321, to Paraguay with a mean GDP per capita of $1,367. Mean per capita energy consumption ranges from 1,566 for Argentina to 680 for Paraguay. Paraguay has the highest mean of trade openness to non-members (25%), and Brazil has the lowest trade openness to non-member countries (12%).

Table 2 shows summary statistics for members of the NAFTA from 1980-2012. GHG emissions per capita range from 25.64 in Canada to 5.61 in Mexico. The United States has the highest per capita GDP mean ($36,899) and Mexico has the lowest mean ($7,216). The United States has the highest mean energy consumption per capita (7,612), and Mexico has the lowest (1,438). Canada is the most open country with mean trade openness of 12%, and Mexico has the lowest trade openness to non-members (8%).

Table 3 presents the summary statistics for the USAFTA members. Australia has a higher level of per capita GHG emission than the United States. Per capita GDP and per capita energy consumption in the United States is higher than Australia, while trade openness to rest of the world in Australia is higher than the United States.

4. METHODS AND FINDINGS

In this study, we applied a panel vector error correction model (PVECM) in order to find the relationship between GHG emission, income, energy consumption and trade liberalization in the long run. For finding these relationships, we need to follow three steps. First, we need to find whether the panels are stationary. If all of the variables are integrated of order one, we test for cointegration in our panels as a second step. Finally casual relationships among variables are examined based on an estimated vector error correction model.

4.1. PANEL UNIT ROOT TEST

Different unit root tests have been developed for panel data. Before testing for unit roots in the panel, we need to test for cross-sectional independence to decide upon the appropriate unit root test for the data. The null hypothesis is that the ε_{it} from equation (1) are independent and identically distributed over periods and across cross-sectional units. An alternative is that ε_{it} is correlated across cross sections, but the assumption of no serial correlation remains (Hoyos and Sarafidis, 2006).

Table 4 shows the result of cross-sectional dependence tests for the different agreements. Based on the result of the LM test and the Pesaran's CD test we cannot reject the null that residuals are not correlated for the MERCOSUR and NAFTA panels. In other words, there is no cross-sectional dependence in those panels, and unit root tests should be used that do not have cross-sectional dependence. However, for the AUSFTA panel we reject the null of independence between residuals at the 10% significance level using the LM test and at the 1% significance level using Pesaran's CD test.

The Levin-Lin-Chu (LLC) (2002) unit root test does not allow for cross-sectional dependence. Based on the Table 4 results we implemented this test for the MERCOSUR and NAFTA panels. The Im–Pesaran–Shin (2003) unit root test (IPS) allows for cross-sectional dependence. Based on the LM and Pesaran's CD test result in Table 4 we used the IPS test only for the AUSFTA panels.

The result for the panel unit root test for the MERCOSUR is reported in Table 5. Table 5 shows that we cannot reject null the existence of unit roots in the panels for all the variables in levels, but the null hypothesis of an existing unit root can be rejected for all variables in the panel after first differencing. From this result, we can conclude that all MERCOSUR variables are integrated of order one, I(1). Because all the variables are I(1), we can test for cointegration in the MERCOSUR panel.

Table 6 shows the panel unit root test result for the NAFTA panel. The results are the same as for the MERCOSUR panel: the null hypothesis of existing unit root in the panel cannot be rejected in levels. However, the null of a unit root is rejected when first differences are used. These results show that all the variables are integrated of the first order and we can test for cointegration.

Finally, for the AUSFTA panel we used the IPS test to check the existence of a unit root in the panel. The IPS is used because the results of the cross-sectional independence test (Table 4). Table 7 shows the result of this test. Based on the result we can conclude that all the variables are integrated of order one I(1), and we can test for cointegration in the AUSFTA panel.

4.2. PANEL COINTEGRATION ANALYSIS

The next step is testing for cointegration in the panels. The methodology developed by Pedroni (1999) is used to determine whether cointegration exists among the variables. This cointegration test is implemented after initial estimation of equation (1). This test has seven test statistics -- four are panel statistics and three are group panel statistics. The null hypothesis for the Pedroni (1999) test is no cointegration in the panel, and it will be tested against existing one cointegration in the panel.

Table 8 shows the cointegration test results for the MERCOSUR panel. We implement this test by using an intercept as well as an intercept and trend in our model. Five out of seven statistics reject the null of no cointegration in the model at l% significance level. By considering this result, we conclude that there is a long-run relationship between the variables in the MERCOSUR panel.

Table 9 shows the cointegration test results for the NAFTA panel. Tests involving an intercept and an intercept and trend are considered. The null hypothesis of no cointegration in the panel is rejected using five out of seven test statistics with only the intercept. By considering an intercept and trend, we reject the null of cointegration in four cases. Thus the conclusion is that there is a cointegration in the NAFTA panel. This means that there is a long-run relationship among variables in the NAFTA panel too.

Table 10 shows the cointegration test results for the AUSFTA panel. Test statistics show that there is cointegration between variables with and without considering the trend in the model. Based on these result the conclusion is that cointegration exists among the AUSFTA variables and there is a long run relationship among variables in the model.

4.3. LONG-RUN RELATIONSHIPS

The next step is the estimation of long-run parameters in the panels. Several estimators can be used to estimate the long-run relationship in the panel framework. Kao and Chiang (1999) showed that the OLS estimator has a non-negligible bias in finite samples, so the long-run relationships are estimated using fully modified OLS (FMOLS) that is introduced by Phillips and Moon (1999); Pedroni (2000) and (2001); Mark and Sul (2003). This model produces asymptotically unbiased, normally distributed coefficient estimates for each country. The panel estimate for the agreement from the FMOLS estimator is:

$$\hat{\beta}_{panel} = N^{-1} \sum_{i=1}^{N} \hat{\beta}_{individual\ countries}$$

Where $\hat{\beta}_{individual\ countries}$ is obtained from estimation of the equation (1) using the FMOLS method for individual countries (members of each agreement). In the same way we can obtain t-statistics for the panel using the following.

$$t_{\hat{\beta}_{panel}} = N^{-\frac{1}{2}} \sum_{i=1}^{N} t_{\hat{\beta}_{individual\ countries}}$$

4.3.1. THE MERCOSUR RESULT

FMOLS estimation results for the MERCOSUR panel are given in the Table 11. The long-run elasticity of GHG emission with respect to GDP is positive, and the long-run coefficient of the quadratic term of income is negative. This shows that the EKC hypothesis holds for this region as a unit. Considering the region as a unit, growth increases GHG emissions in the region until a certain point of income and after that increases in income (growth) decreases GHG emission in the region.

The openness of region countries to non-members (rest of the world) coefficient (OROW) is positive (0.26), indicating that trade liberalization of the region to the rest of the world causes more GHG emissions. This means that the negative effects of trade liberalization outweigh the positive effects and openness generates more GHG in the region.

Our central interest is the coefficient on the FTA dummy, which is negative. This shows that after the MERCOSUR was implemented in 1990, per capita GHG emission decreased in the region. Indeed, the panel FTA dummy coefficient is representative of the FTA`s net effect (sum of composition, technical, and scale effects) on the region`s environment. We found that the FTA among developing countries in this study is beneficial for world environmental quality.

Considering individual members, the long-run elasticity of GHG emission in Argentina with respect to energy consumption per capita is positive, similar to the sign that we expected, and equal to 1.30. This indicates that in the long-run a 1% increase in energy consumption per capita in Argentina increases GHG emission per capita by 1.30%. Because the FTA coefficient is not significant for Argentina, this supports that FTA has no statistically significant effect on Argentina environment quality.

The EKC hypothesis holds for Brazil. Trade openness to non-members has a positive effect (1.77) on GHG emission and shows that Brazil`s environment is harmed by opening its borders (trade liberalization) to non-members of the MERCOSUR agreement. However, the FTA coefficient (-0.068) shows that the MERCOSUR agreement had a negative effect on Brazil`s environmental quality.

For Paraguay, the results indicate that openness to non-members has a negative effect (-0.33) on GHG emission in this country. Recall that Paraguay has the lowest per capita income among the members of the MERCOSUR. Through trade liberalization, this country has access to cheaper and higher tech tools for production that are likely to be more environmentally friendly. Furthermore, the FTA coefficient for Paraguay is positive and indicates that GHG emission in Paraguay increased after MERCOSUR was implemented in 1990. Because Paraguay has the lowest income among members, one can conclude that this is evidence for supporting the pollution haven hypothesis (PHH), where higher income countries relocate their dirty industries in lower income countries.

Lastly, for Uruguay, the EKC hypothesis holds. The long-run elasticity of GHG emission with respect to energy consumption is 0.47 which indicates that a 1% increase in energy consumption per capita in Uruguay will increase GHG emission per capita by 0.47%. Trade openness to non-members and the FTA coefficient is insignificant.

4.3.2. THE NAFTA RESULT

Table 12 presents the FMOLS estimation results for the NAFTA panel. The last row of this table presents the panel results. Result shows that the EKC hypothesis does not holds for this region as a unit because coefficient on GDP is positive but not significant.

The estimated effect of energy consumption per capita on GHG emission is positive (as expected) and specifies that the long-run elasticity of GHG emissions with respect to energy consumption is 1.33 for the panel. Considering the NAFTA members separately indicates that higher energy consumption increases pollution in all three members.

The openness of region countries to non-members (rest of the world) coefficient (OROW) is negative (-0.293), indicating that trade liberalization of the region to the rest of the world causes less GHG emissions. This means that the positive effects of trade liberalization outweigh the negative effects and openness lowers GHG in the region.

Lastly, we want to focus on the NAFTA effect on GHG emission in the region. The FTA coefficient is positive (0.020), indicating that the region`s GHG emission increased after NAFTA. Comparing with pervious section, we can conclude that FTA between only developing countries (MERCOSUR) is beneficial for the world environment, while FTA between developed and developing countries (NAFTA) is harmful for the world environment.

Considering individual members, the EKC hypothesis holds for the U.S. and Canada, but does not hold for Mexico. The long-run elasticity of GHG emission in all of three countries with respect to energy consumption per capita is positive, similar to the sign that we expected.

Openness to nonmembers is beneficial for the U.S. environment but has no significant effect on the Canadian or Mexican environment. The NAFTA implementation has no effect on GHG emission in the U.S. or Canada. The NAFTA effect on GHG emission in Mexico is positive. In other words, Mexico is the only environmental loser in the NAFTA.

4.3.3. THE AUSFTA RESULT

Table 13 presents the FMOLS estimation result for the AUSFTA panel. Coefficients on LGDP and LGDP square are, respectively, positive and negative as expected. The results indicate that the EKC holds for the U.S. and Australia in the AUSFTA panel. As we expected the estimated effect of energy consumption per capita on GHG emission is positive and equal to 1.47 meaning that a 1% increases in energy consumption in the region increases GHG emissions by 1.47% in the region.

Trade openness to non-members has a negative effect on GHG emission in the long-run for the region as a unit. The FTA coefficient indicates that the AUSFTA effect on the world environment is not statistically significant. Comparing with MERCOSUR and NAFTA result, we can conclude that an FTA between developed countries is not harmful or beneficial for the world environment, an FTA between developing countries is beneficial for the world environment, and an FTA between developed and developing countries is harmful for the world environment.

Considering individual members, the EKC hypothesis holds for the U.S. (similar to the result we had from the NAFTA panel) and Australia. The long-run elasticity of GHG emission in both countries with respect to energy consumption per capita is positive, similar to the sign that we expected.

Openness to nonmembers is beneficial for the U.S. (similar to the result form the NAFTA panel for the U.S.) and Australian environment. The AUSFTA implementation has no significant effect on GHG emission in Australia. The AUSFTA effect on GHG emission in the U.S. is negative. In other words, the AUSFTA makes the U.S. better off environmentally which is consistent with the “factor endowment hypothesis” that trade makes countries specialize in producing goods where they have a competitive advantage. Comparing the NAFTA implementation with the AUSFTA implementation on the U.S. environment, the U.S. FTA with only developed countries (AUSFTA) makes the U.S. better off environmentally but the FTA with developing and developed countries (NAFTA) has no significant effect on the U.S. environment.

5. CONCLUSIONS AND IMPLICATIONS

Different hypotheses about trade liberalization and pollution levels were examined in this study. Three different FTA were examined: MERCOSUR, NAFTA, and AUSFTA. The period of the study for the MERCOSUR was from 1970-2012 and for the AUSFTA and NAFTA was from 1980-2012. After testing for unit roots and cointegration, among variables, long-run coefficients were estimated for members of each FTA using Pedroni`s (2000) estimation.

The FTA among developing countries (in this case the MERCOSUR countries) is associated with lower GHG emissions for the world. However, when the FTA is among developed and developing countries (in this case the U.S, Canada, and Mexico) the effect is positive and GHG emissions increase for the world after implementation of the FTA. The FTA among developed countries (in this case the U.S. and Australia) has no significant effects on GHG emission in the world.

The conclusion of this study is that FTA's effect on world environment depends on the type of the agreement. FTAs between only developing countries or only developed countries can be beneficial or harmless for the environment in the long-run. However, FTAs between developed and developing countries may be harmful for the world environment.

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Table 1: Summary statistics for members of the MERCOSUR

Countries	Mean	S.D.	Minimum	Maximum
Panel A: GHG emission per capita (metric ton carbon dioxide equivalent per capita)				
Argentina	8.76	0.58	7.84	10.37
Brazil	10.65	2.00	6.26	15.04
Paraguay	14.21	3.90	7.37	26.06
Uruguay	9.57	0.58	8.39	10.80
Panel	10.80	3.04	6.26	26.06
Panel B: Real per capita GDP (constant 2005 U.S. dollar)				
Argentina	5321	904	3969	7833
Brazil	4224	694.42	2577	5730
Paraguay	1367	272	740	176
Uruguay	4553	1103	3200	7505
Panel	3866	1699	740	7833
Panel C: Per capita energy consumption (Kilograms of oil equivalent)				
Argentina	1566	189	1363	1967
Brazil	1013	164	709	1371
Paraguay	680	85	525	870
Uruguay	880	164	663	1309
Panel	1035	364	525	1967
Panel D: Trade openness to rest of the world (non-members) (%)				
Argentina	14	8	2	35
Brazil	12	9	2	38
Paraguay	25	23	5	100
Uruguay	18	12	3	55
Panel	17	15	2	100

Table 2: Summary statistics for members of the NAFTA

Countries	Mean	S.D.	Minimum	Maximum
Panel A: GHG emission per capita (metric ton carbon dioxide equivalent per capita)				
United States	23.81	1.22	20.21	25.4
Canada	25.64	3.85	21.51	37.32
Mexico	5.61	0.29	5.19	6.87
Panel	18.35	9.38	5.19	37.32
Panel B: Real per capita GDP (constant 2005 U.S. dollar				
United States	36899	6393	25748	45431
Canada	30794	4527	23752	37208
Mexico	7217	692	6209	8532
Panel	24970	13627	6209	45431
Panel C: Per capita energy consumption (Kilograms of oil equivalent)				
United States	7612	303	6794	8057
Canada	7749	371	7052	8424
Mexico	1438	73	1331	1588
Panel	5599	2972	1331	8424
Panel D: Trade openness to rest of the world (non-members) (%)				
United States	11	4	6	19
Canada	12	6	6	25
Mexico	8	7	2	24
Panel	10	6	2	25

Table 3: Summary statistics for members of the AUSFTA

Countries	Mean	S.D.	Minimum	Maximum
Panel A: GHG emission per capita (metric ton carbon dioxide equivalent per capita)				
United States	23.81	1.22	20.21	25.4
Australia	38.46	13.12	25.16	63.95
Panel	31.13	11.83	20.21	63.95
Panel B: Real per capita GDP (constant 2005 U.S. dollar)				
United States	36899	6393	25748	45431
Australia	28524	5448	20709	37175
Panel	32712	7247	20709	45431
Panel C: Per capita energy consumption (Kilograms of oil equivalent)				
United States	7612	303	6794	8057
Australia	5246	406	4561	5883
Panel	6429	1244	4561	8057
Panel D: Trade openness to rest of the world (non-members) (%)				
United States	15	6	7	27
Australia	31	18	13	77
Panel	23	15	7	77

Table 4: Results of cross-sectional dependence tests

Panel	LM test	p-value	CD test	p-value
MERCOSUR	9.93	0.287	4.52	0.236
NAFTA	5.705	0.126	0.920	0.357
AUSFTA	3.30*	0.069	1.81*	0.069

Notes: * indicates significance at 10% level

Table 5: Results of panel LLC unit root test for the MERCOSUR

Variable	No intercept & Trend	Intercept	Intercept & Trend
lnGHG	0.30 [0.61]	-0.83[0.20]	2.21 [0.98]
lnGDP	4.74 [1.00]	-0.52 [0.29]	-0.21 [0.41]
lnEC	3.73 [0.99]	3.35 [0.99]	2.39 [0.99]
OROW	4.35 [1.00]	4.27 [1.00]	5.82 [1.00]
ΔlnGHG	-11.20 [0.00]	-16.88 [0.00]	-16.11 [0.00]
ΔlnGDP	-7.12 [0.00]	-7.73 [0.00]	-3.88 [0.00]
ΔlnEC	-9.24 [0.00]	-8.71 [0.00]	-8.08 [0.00]
ΔOROW	-8.50 [0.00]	-10.1 [0.00]	-10.9 [0.00]

Notes: numbers in brackets are p-values. Δ is the first difference, operator.

Table 6: Results of panel LLC unit root test for the NAFTA

Variable	No intercept & trend	Intercept	Intercept & trend
lnGHG	-1.17 [0.11]	0.27 [0.60]	-0.68 [0.24]
lnGDP	3.53 [0.99]	-0.98 [0.16]	0.03 [0.51]
lnEC	-0.21 [0.41]	1.72 [0.95]	1.92 [0.97]
OROW	4.08 [1.00]	3.28 [0.99]	1.40 [0.91]
ΔlnGHG	-8.99 [0.00]	-6.31[0.00]	-6.70 [0.00]
ΔlnGDP	-2.78 [0.002]	-6.38 [0.00]	-6.39 [0.00]
ΔlnEC	-4.20 [0.00]	-4.39 [0.00]	-7.84 [0.00]
ΔOROW	0.33 [0.63]	-4.72 [0.00]	-10.44[0.00]

Notes: numbers in brackets are p-values. Δ is the first difference, operator.

Table 7: Results of panel IPS unit root test for the AUSFTA

Variable	IPS	
	Intercept	**Intercept & trend**
lnGHG	0.97 [0.83]	1.53[0.93]
lnGDP	0.70[0.75]	1.00[0.84]
lnEC	1.41[0.92]	1.10[0.86]
OROW	4.74[1.00]	0.06[0.52]
ΔlnGHG	-8.17[0.00]	-8.06[0.00]
ΔlnGDP	-5.20[0.00]	-5.10[0.00]
ΔlnEC	-7.13[0.00]	-7.11[0.00]
ΔOROW	-7.92[0.00]	-7.21[0.00]

Table 8: Panel cointegration tests for the MERCOSUR

Test statistic	Intercept	Intercept & trend
Panel v-Statistic	-1.13(0.87)	-2.01(0.97)
Panel rho-Statistic	-3.02(0.001)***	-2.41(0.007) ***
Panel PP-Statistic	-8.82(0.00)***	-9.71(0.00)***
Panel ADF-Statistic	-8.51(0.00)***	-9.18(0.00)***
Group rho-Statistic	-0.90(0.18)	-0.14(0.44)
Group PP-Statistic	-6.38(0.00)***	-6.07(0.00)***
Group ADF Statistic	-5.64(0.00)***	-5.30(0.00)***

Notes: The cointegration test is based on the relationship among GHG emissions and other variables (the dependent variable is log of GHG emission). The modified Schwarz criteria is used for lag selection in the cointegration test. Numbers in parentheses are p-values; ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels, respectively

Table 9: Panel cointegration tests for the NAFTA

Test statistic	**Intercept**	**Intercept & trend**
Panel v-Statistic	-1.81(0.965)	-2.55(0.994)
Panel rho-Statistic	-1.88(0.02) **	-0.40(0.343)
Panel PP-Statistic	-6.06(0.00)***	-15.38(0.00)***
Panel ADF-Statistic	-2.08(0.018)**	-7.67(0.00)**
Group rho-Statistic	0.12(0.550)	1.13(0.87)
Group PP-Statistic	-10.19(0.000)***	-13.68(0.00)***
Group ADF-Statistic	-3.54(0.000)***	-5.97(0.00)***

Notes: The cointegration test is based on the relationship among GHG emissions and other variables (the dependent variable is log of GHG emission). The modified Schwarz criteria is used for lag selection in the cointegration test. Numbers in parentheses are p-values; ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels, respectively

Table 10: Panel cointegration tests for the AUSFTA

Test statistic	Intercept	Intercept & trend
Panel v-Statistic	0.70(0.24)	0.11(0.45)
Panel rho-Statistic	-0.00(0.46)	0.31(0.62)
Panel PP-Statistic	-4.70(0.00)***	-4.64(0.00)***
Panel ADF-Statistic	-3.62(0.00) ***	-3.64(0.00)***
Group rho-Statistic	-0.021(0.49)	0.38(0.65)
Group PP-Statistic	8.93(0.00) ***	-7.12(0.00)***
Group ADF-Statistic	-4.24(0.00) ***	-3.95(0.00)***

Notes: The cointegration test is based on the relationship among GHG emissions and other variables (the dependent variable is log of GHG emission). The modified Schwarz criteria is used for lag selection in the cointegration test. Numbers in parentheses are p-values; ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels, respectively

Table 11: FMOLS estimation results for MERCOSUR members

Country	LGDP	$LGDP^2$	LEC	OROW	FTA
Argentina	13.66(1.22)	-1.80(-1.19)	1.30(2.41) **	-0.48(-1.29)	-0.031(-0.63)
Brazil	50.00(1.86) *	-6.90(-1.80) *	-1.59(-1.48)	1.77(3.03) **	-0.068(-1.85) *
Paraguay	6.33(0.42)	-1.05(-0.40)	-0.50(-0.88)	-0.33(-3.25) ***	0.008(01.75)**
Uruguay	12.03(3.98) ***	-1.67(-3.96) ***	0.47(6.10) ***	0.10(1.25)	-0.017(.50)
Panel	20.50(2.70) ***	-2.84(-2.55) **	-0.08(-0.26)	0.26(1.65) *	-0.027(-2.02) **

Notes: *, **, and *** indicate significance at 10%, 5%, and 1% levels respectively. Numbers in parentheses are t-statistics.

Table 12: FMOLS estimation results for NAFTA members

Country	LGDP	$LGDP^2$	LEC	OROW	FTA
United States	1.29(1.62)*	-0.13 (-0.57) ***	1.05(9.39) ***	-0.229(-5.37) ***	0.0005(0.93)
Canada	53.51(1.95)*	-6.06(-1.97)*	1.82(3.11) **	-0.14(-0.50)	0.027(1.45)
Mexico	24.78(0.99)	-3.23(0.99)	1.13(3.43) ***	-0.51(-1.34)	0.033(3.58)***
Panel	26.52 (1.18)	-3.14(-0.51) **	1.33 (5.31) ***	-0.293 (-2.40) **	0.020 (1.98) *

Notes: *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively. Numbers in parentheses are t-statistics.

Table 13: FMOLS estimation results for AUSFTA members

Country	LGDP	$LGDP^2$	LEC	OROW	FTA
United States	7.15(3.02) ***	-0.78(-3.01) ***	0.83(8.81) ***	-0.134(-1.61) *	-0.015(-2.76) **
Australia	86.84(4.58) ***	-10.03(-4.70) ***	2.12(2.83) ***	-1.081(-9.14) ***	0.007(0.16)
Panel	46.99(5.48) ***	-5.41(-5.60) ***	1.47(4.34) ***	-0.60(-9.39) ***	-0.003(-0.20)

Notes: *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively. Numbers in parentheses are t-statistics.