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Open Trade Policies: Filthy Fog of the Future?

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Abstract:

This paper focuses on the relationships between open trade, environmental policies, and greenhouse gas exposures between the United States, Canada, and Mexico. Comparative advantage theory posits that opening up to trade will capitalize on a country's efficiency and increase a country's gross national product. Furthermore, because of less government regulations in underdeveloped countries, it is hypothesized that as GDP increases in Mexico, there could also be a subsequent increase in air pollutants. This study focuses on what determinants might have an effect on CO_2, NO_x, N_20, and CHF_3 emissions (the major greenhouse gas emission) in three countries (Canada, Mexico and the United States) between 1980 and 2008. An OLS regression is employed to measure the impact that increases in GDP and political decisions (i.e. NAFTA and the Kyoto Protocol) can have on greenhouse gas emissions. The results indicate that the first implementation of each policy has the largest impact on the environment and economic health of a country.

Keywords: greenhouse gases, NAFTA, competitive advantage, and environmental degradation

I. Introduction

Political leaders consistently debate the beneficial and detrimental outcomes of open trade policies. Proponents of open trade view the benefits of eliminating restrictions on imports or exports. Reducing or eliminating restrictions not only creates stronger ties between countries, but it opens economic opportunities to capitalize on growing markets. Eliminating trade barriers can stimulate economic prosperity in a country's output. However, there has been a growing concern within the last thirty years as to whether these trade policies could cause environmental degradation. Specifically, as production increases, greenhouse gas emissions increase, causing environmental harm. Between 1980 and 2008, two trade policies have been adopted in North America to promote free trade —the Canada-US Free Trade Agreement and NAFTA. During this same time period, two environmental policies have also been enacted, the Montreal Protocol and the Kyoto Protocol, in an effort to reduce global greenhouse gases and ozone depleting gases. The following research will explore whether the overall increase in economic welfare by trade liberalization is actually larger than the negative externality of air pollution it emits.

The Canada-US Free Trade Agreement (FTA) was the first free trade policy signed between Canada and the United States effective January 2, 1988. It did not immediately eliminate trade restrictions. However, both countries agreed to "phase out" restrictions over a period of ten years. With any free trade agreement, lowering trade barriers encourages cross-border trade and foreign direct investment. The United States gained access to Canada's energy industries, while

Canada gained access to America's exports such as manufactured goods (Hufbauer and Schott, 2005).

The North American Free Trade Agreement (NAFTA) was a second free trade agreement, mainly between the United States and Mexico. Canada was also included in the agreement but played a minor role, as they did not seek benefits from Mexico in the same way the United States did. The implementation of NAFTA in 1994 eliminated tariffs on more than one-half of Mexico's exports to the United States and more than one-third of the United States exports to Mexico. Duties were also slowly "phased out" over the next fifteen years (Orme, 1996).

The Montreal Protocol is an international treaty designed to protect the ozone layer. It was also the first policy implemented by several countries (See Appendix A) as a first attempt to reduce harmful ozone depleting gases. Like the free trade agreements, the Montreal Protocol intended to "phase out" the production of several groups of halogenated hydrocarbons. It was officially applied on January 1, 1989. If the protocol is rightfully respected, it should prevent ozone layer depletion from reaching 67% destruction by 2065 (Yutain, et al 2013).

The Kyoto Protocol went into effect in February of 2005. It is an international treaty negotiated by the United Nations (See Appendix A) with the promise that industrialized-heavy countries will reduce greenhouse gas emissions. The goal of this environmental policy is to prevent dangerous human induced interference in the climate system. Under the Kyoto Protocol, there is international emission trading that allows developed countries to trade their permits. With these commitments or permits, the countries may emit a certain amount but they are still limited (Quirion, 2010). Developing countries do not have binding targets under the Kyoto Protocol but are still committed to reducing their emissions.

In this research, I investigate if there is a relationship between these four policies and the four main greenhouse gases: 1) Carbon Dioxide, 2) Nitrous Oxide, 3) Mono-Nitrogen Oxide, and 4) Trifluoromethane. Understanding if any of the four policies can impact emission rates across the three largest economies in the North American Continent (Canada, Mexico, and the United States) can provide policy makers with insight into how greenhouse gas emissions have been changing over the last 30 years.

Carbon dioxide, CO_2, is a naturally occurring chemical compound found in the Earth's atmosphere. The burning of carbon-based fuels since the industrial revolution has increased its concentration in the atmosphere. While it is not classified as toxic by the Organization for Economic Co-operation and Development (OECD), guidelines for the testing of chemicals report that concentrations of carbon dioxide of up to 7% may cause suffocation, even in the presence of sufficient oxygen. Because it is heavier than air, it lingers closer to the ground and makes humans susceptible to higher levels of CO_2.

Nitrous oxide, N_2O, is a chemical compound in the atmosphere. It gives rise to Nitric Oxide (NO) on reaction with oxygen atoms, which reacts negatively to the ozone. Considering over a 100-year period, it has 298 times more potential to impact global warming than carbon dioxide (du Toit, et al., 2013), N_2O is a major greenhouse gas with long-term effects.

Mono-nitrogen oxides, NO_x, are produced from the reaction of nitrogen and oxygen gases in the air during combustion. In areas of high motor vehicle traffic, the amount of nitrogen oxides emitted into the atmosphere as air pollution can be significant. These compounds react to form smog and acid rain and, at greater concentration with the formation of the tropospheric ozone layer. Thermal NO_x formation is recognized as the most relevant source of mono-nitrogen oxides when combusting natural gas in industrial use. Small particles can penetrate deeply into sensitive lung tissue causing respiratory diseases.

Trifluoromethane (CHF_3 or HFC-23) is actually 11,000 times more potent than carbon dioxide and lasts longer in the atmosphere. It has been estimated that its potency *is* 14,800 carbon dioxide equivalents over 100 years (Miller, et al, 2010). Unlike methane, which only lasts about a dozen years in the atmosphere, HFC-23 lasts for 270 years (Miller, et al, 2010). HFC-23 has historically been considered a waste gas that has been vented from refrigerators into the atmosphere. Developed countries like the United States and Canada stopped making these types of refrigerators in 2003. Efforts have been made in the past twenty years in pursuit of reducing HFC-23 emissions, including destruction of facilities in developing countries (Miller, et al, 2010).

The remainder of this paper is as follows: Section II discusses past research on economic development and air pollution consequences in Canada, the United States, and Mexico. Section III discusses the theoretical framework based on trade theory and Section IV sets up four OLS regression models pertaining to the four greenhouse gases. Section V evaluates the results of the research and is expanded upon in Section VI discussing some possible conclusions. Finally, Section VII suggests policy implications from the findings.

II. Literature Review

The environmental impacts of trade liberalization have stimulated considerable discussion in recent decades (e.g. Grossman and Krueger 1993; Yu, et. al., 2011). However, the argument directly connecting increased free trade and environmental degradation have not been articulated (Grossman and Krueger 1993). Because of the lack of research, environmentalists have accumulated several reasons for why free markets could aggravate pollution problems in the future (Grossman and Kruger 1993).

A recent study by Yu et al. (2011) found the initial elimination of trade barriers to Mexico “does not have an immediate impact on the United States greenhouse gas emissions but has a positive effect in the long run” (548). However, they also prove that “greenhouse gas emissions respond negatively to an increase in United States trade openness to other partners in the short run which would apply to Mexico in our North American scenario” (548). They formulate their results by summing all four of the major greenhouse gases into one indicator, finding that there is no clear negative environmental impact of trade liberalization under NAFTA in Mexico.

Open trade could possibly allow developed countries to influence or assist developing countries in improving their already detrimental environmental issues along with boosting economic health (Stern, 2007). With greater access to developed countries, economic activity in developing countries expands and these countries become wealthier. NAFTA has been a large focus for environmentalists and economists alike because it had economically stimulated Mexico (Yu et al, 2011). Since eliminating trade barriers with the United States, Mexican "exports have tripled" and "the growth per capita income since 1995 is among the highest in Latin America" (Morley and Díaz-Bonilla, 2006). As a society becomes richer, countries may "strengthen public desire for better environmental quality in developing countries" and call upon the government to impose more environmental controls (Yu et al. 2011; Grossman and Krueger 1993).

Other studies have found that certain governments encouraged by free trade agreements, have been more compelled to pursue economic success despite high concentrations of air pollution (Sanchez, 2002). This argument stems from the fact that pollution is already a severe problem in Mexico and "the country's weak regulatory infrastructure" is the source of the problem—not open trade (Grossman and Krueger, 1993). It is possible that developing countries resist adopting stringent environmental regulations or lowering standards "to maintain or boost competitiveness of their domestic industries" (Bagwell and Staiger, 2001; Yu et al. 2011). Since environmental problems still exist, it is implied that there is good reason to believe that current levels of pollution exceed optimal levels (Kaufmann et al, 1993).

According to the Environmental Protection Agency, manufacturing industries have become a major contributor to the air pollution problem in Mexico. Industrial processes emit high levels of carbon dioxide (CO_2), methane gases (CHF_3) and fluorinated gases (F-gases). Also, residential and commercial activities contribute to emissions such as the combustion of natural gas and petroleum products for heating. CO_2 and N_20 are most prevalent in these areas (EPA, 2010). Research by the EPA has shown that carbon dioxide (CO_2) accounts for 76% of the greenhouse gases emitted and 57% of the 76% is emitted from fossil fuel use in industrial processes and energy supply production (EPA, 2010).

Logsdon and Husted (2000) found that the impact of NAFTA on environmental quality in Mexico between 1995 and 1999 was mixed and concluded that further analysis with updated data was necessary to truly understand NAFTA's impact. While there is extensive literature on the effects of open trade, comparative advantage, and the effects of greenhouse gases in the atmosphere, there are many studies that have not found evidence of the connection between trade openness and the environment. This paper seeks to fill this gap in the literature by investigating the relationship that trade agreements can have on emission levels between developed countries (the United States and Canada) and agreements that occur between a developed and developing country (the United States and Mexico). Given the data limitations and only incorporating the variables listed, this study should be considered exploratory rather than conclusive.

III. Theory

First, the importance of environmental protection and trade in our economic society must be established to understand the need for them. Trade provides many opportunities for nations to produce greater output and improve their economic welfare. Also, countries will trade to obtain goods, which they produce less efficiently than their neighboring nations (Kaufmann et al. 1993). According to the trade law of comparative advantage, costs are minimized and total output is maximized when countries specialize in the production of goods that they produce more efficiently. To determine the commodities each nation should specialize in, the nation must evaluate which commodities it produces with the lowest opportunity cost. It will benefit the most by producing that good and trading it for other goods from another country. Furthermore, companies seek alternatives to lower their costs and increase their productivity. They feel more compelled and motivated to produce at lower costs regardless of their location (Morley and Díaz-Bonilla 2006). For example, Mexico's minimum wage in 2013 was 0.83 (US$PPP, hourly), the United States' minimum wage was 7.11 (US$PPP, hourly), and Canada's minimum wage was 7.85 (US$PPP, hourly) (OECD 2013). Thus in 2013, Mexico has the potential for having the comparative advantage in labor-intensive activities because it has the lower opportunity cost in producing labor-intensive activities.

Comparative advantage also holds true when considering environmental regulations instead of labor wages. For the same reasons that Mexico has the potential comparative advantage in producing labor-intensive activities in the previous example, Mexico has the comparative advantage in producing pollutant-intensive activities because of its low pollution regulation policies. Between the United States, Mexico, and Canada, firms face significant differences in environmental rules and regulations (Kaufmann et al. 1993). Pollution permits are an example of the environmental regulation developed countries like the United States implement that require firms to pay to pollute. Ultimately, due to lower wages and less environmental regulation costs, more companies can transfer their production plants from developed countries with higher regulation costs to the developing country with lower regulations costs. This allows developing countries to act as somewhat of a "pollution haven" for developed countries. The "pollution haven" hypothesis suggests large industrial nations seek to relocate industries to developing countries to take advantage of lower costs. Essentially, Mexico becomes a place for the United States to "dump" its emissions in order to reduce its own. In this case, Mexico's comparative advantage of pollutant-intensive production and open borders to the United States and Canada entice companies to move some part of their assembling industries to Mexico to generate more output and profit.

Yu et al. (2011) support the idea that when developed and developing countries are members of a free trade agreement, the developed country can adversely affect the environment in a developing country due to the reallocation of higher polluting industries into the undeveloped countries. Liberalizing trade could increase greenhouse emissions in a nation through domestic and foreign use within a host nation. First, liberalizing trade encourages firms to specialize in their pollutant-intensive activities in developing countries causing more activity domestically. Also, it encourages foreign firms to reduce their costs and relocate to the host country and specialize in pollutant intense activities (Kaufmann et al. 1993). In addition, these underdeveloped nations may lack environmental regulations. As trade expansion may stimulate activity and GDP per capita in developing nations it could also result in an increase in greenhouse gas emissions.

IV. Empirical Model

In this study, an Ordinary Least Squares (OLS) regression model is employed to analyze economic indicators and their significance to changes in air pollution. The dependent variables—CO_2, N_2O, NO_x, CHF_3-- will show how the following independent variables affect changes in their emission levels. Four regression models will be run to measure how the independent variables impact each gas separately. These models are depicted in equation 1:

(1) $(\text{GreenhouseEmission})^{i} = \alpha + \beta_1(\text{Canada}) + \beta_2(\text{Mexico}) + \beta_3(\text{POP}/1{,}000) + \beta_4(\text{GDP per capita}) + \beta_5(\text{postNAFTA}) + \beta_6(\text{postCANUS}) + \beta_7(\text{postMONT}) + \beta_8(\text{postKYOTO})$

The independent variables are used to measure each change in emission and summarize the economic activity. From the results we can draw potential policy applications that would influence the change of greenhouse gas concentration in each country. In other words, the coefficients will show how much each variable affects the dependent variable assuming each independent variable is significant. The gross domestic product is calculated on a per capita basis to account for different real population levels in each of the three countries. Table 1 lists the dependent variables employed and the expected sign for each variable. Greenhouse gas emission data is taken from the Emission Database for Global Atmospheric Research (EDGAR), originally collected by the European Union (2013)[1]. Population and GDP per capita data are taken from the World Bank (2012).

[1] The greenhouse gas data are estimates and not measured accurately because concentrations of pollutants in the air depend on the amount that is emitted and the ability of the atmosphere to absorb the gas particles.

Table 1: Description of Variables and Expected Signs

Variables	Descriptions	Expected Sign
CO2ADJ Dependent variable	CO2 gas emitted (kt), adjusted	NA
N20 Dependent variable	N20 gas emitted (kt)	NA
NOxADJ Dependent variable	NOx gas emitted (kt); adjusted	NA
CHF3 Dependent variable	CHF_3 gas emitted (kt)	NA
Canada Independent variable	Canada, country; dummy variable	-
Mexico Independent variable	Mexico, country; dummy variable	+
GDP per capita Independent variable	Real Gross Domestic Product per capita depending on each country	+
POP Independent variable	Population of each country per thousands	+
postNAFTA Independent variable	Data after NAFTA; dummy variable	+
postKYOTO Independent variable	Data after Kyoto Protocol; dummy variable	-
postMONT Independent variable	Data after Montreal Protocol; dummy variable	-
postCANUS Independent variable	Data after Canada-US Free Trade Agreement; dummy variable	+

The expected signs indicate the predicted impact each variable is expected to have on the dependent variable. It is expected that regardless of being a developed or developing country, both Canada and Mexico should be emitting less per capita than the United States, given the fact the United States has more economic activity, which causes higher emissions. It is expected that an increase in a country's population should positively increase emissions because more people cause a greater demand on Earth's natural capital. The four indicator variables that relate the two free trade agreements and the two environmental protocols should have opposing signs. That is, the two free trade agreements should increase emission levels as they increase production, while the two environmental protocols should decrease emission levels.

V. Results

A total of twenty years of data was collected to evaluate the relationship between the economic and greenhouse gas trends between the United States, Canada, and Mexico. For each country, real gross domestic product (GDP), population and estimated greenhouse gases emissions such as CO_2, NO_x, N_2O, and CHF_3 were graphed to visualize any extreme differences between 1980 and 2008. During the researched time period, the Canada-US Free Trade Agreement, NAFTA, Montreal Protocol and Kyoto Protocol were implemented in 1988, 1994, 1989, and 2005, respectively. The Canada- US Free Trade Agreement and NAFTA were agreements set to liberalize trade policies between the countries with the hope of boosting each country's economic output. The Montreal Protocol and Kyoto Protocol, while having no association with the Canada-US Free Trade Agreement and NAFTA, implemented greenhouse gas controls between the United States, Canada, and Mexico (in addition to other countries). With each agreement, each country should expect to experience a distinct difference in GDP and air pollution concentrations.

a. Descriptive Statistics

Figure 1: Greenhouse Gas Emissions

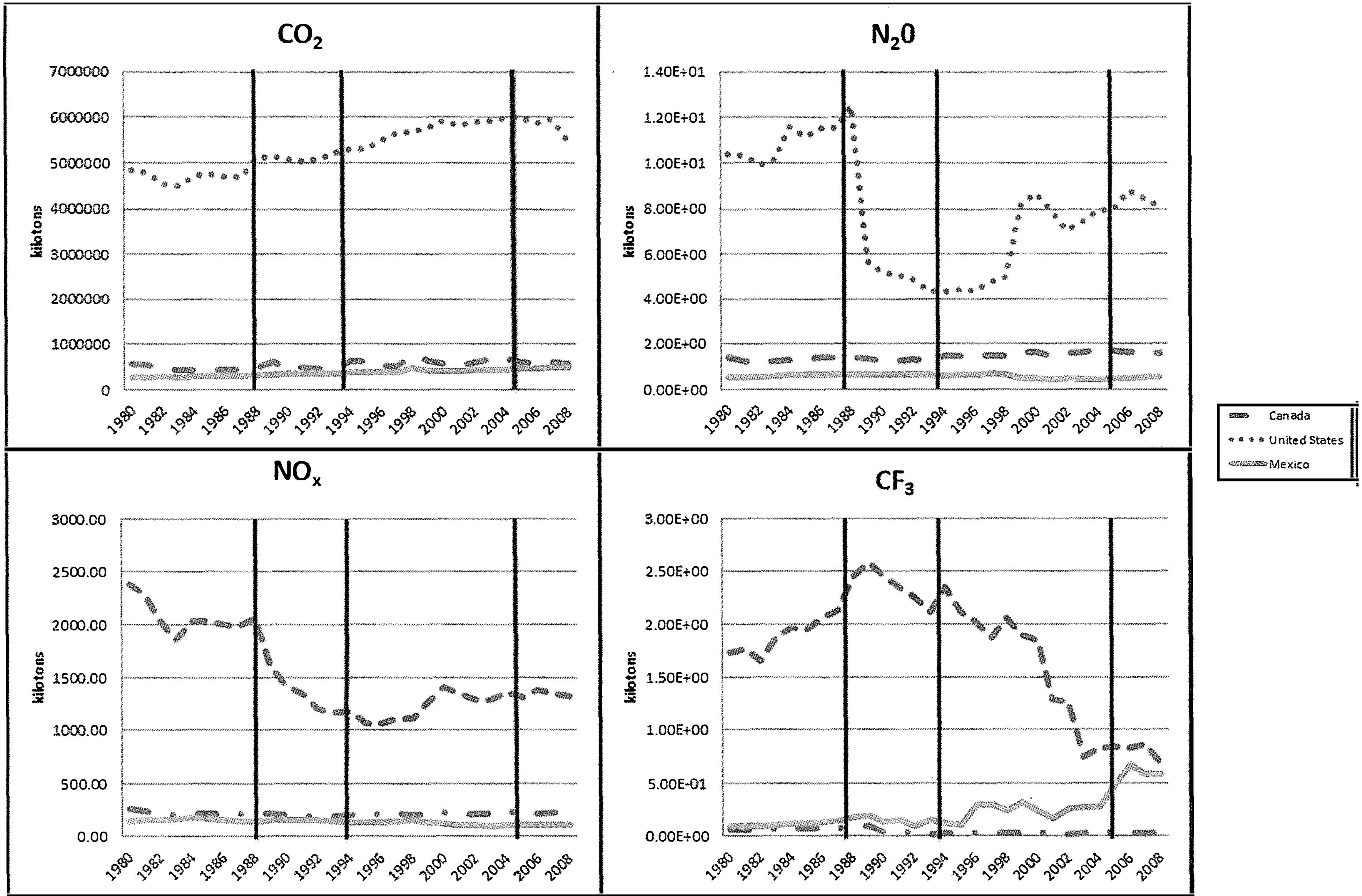

Figure 2: Greenhouse Gas Emissions per Capita

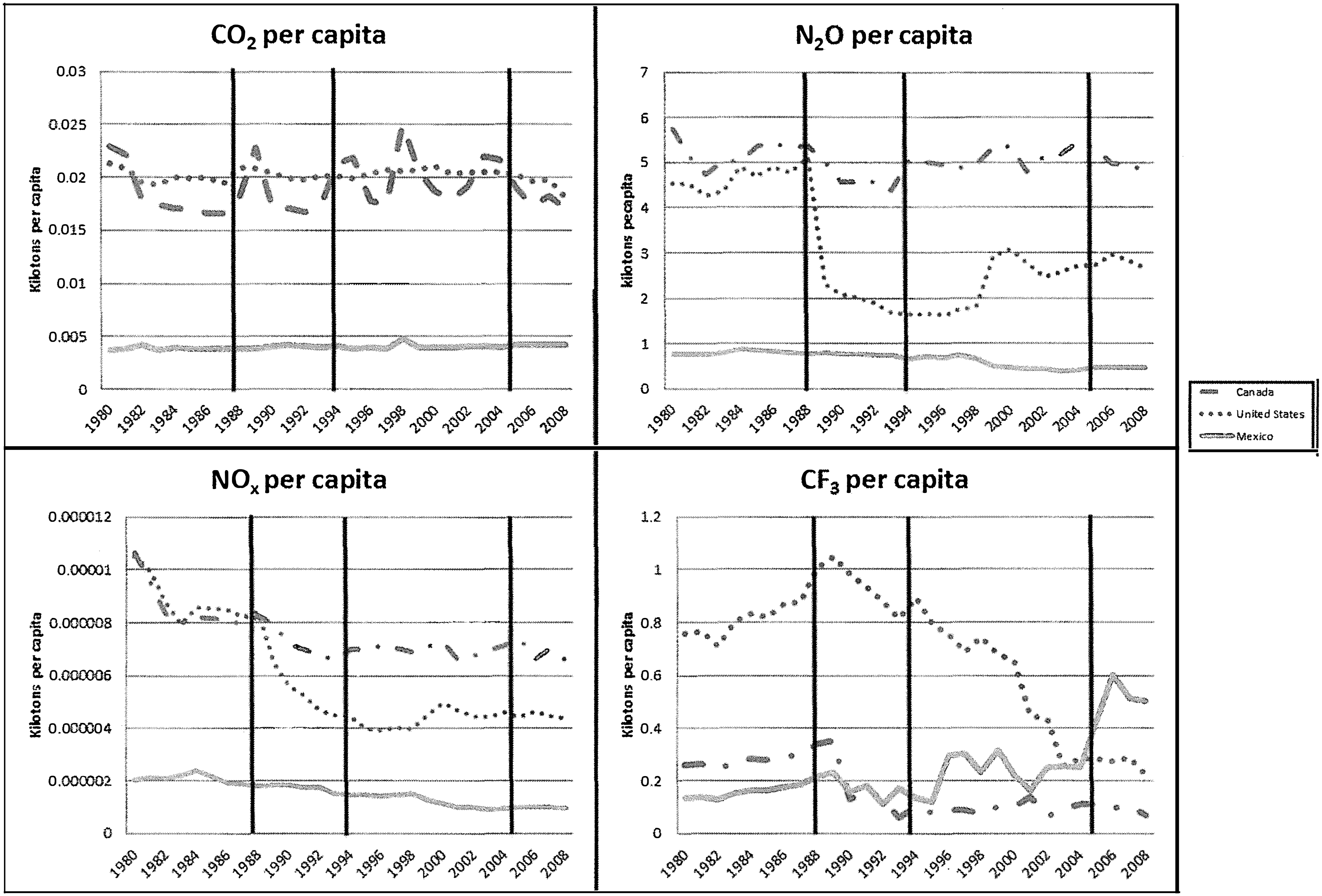

Figure 1 displays the results in terms of total emissions, whereas Figure 2 displays the trends of the four pollutants from 1980 up to 2008 for the three countries in per capita terms to make the results more comparable. The data is estimated from EDGAR. In looking at Figures 1 and 2 there are not any noticeable correlations between GDP and CO_2 levels. Other harmful gases such as triflouromethane, ammonium, and nitrous oxide have consistent changes but are not correlated to NAFTA in any way. While it is important to analyze the empirical model, the descriptive statistics demonstrate visually how the four pollutants have been changing through time.

In the CO_2 graphs in both Figures 1 and 2, the United States has significantly more carbon dioxide emissions than Canada and Mexico. From 1980 to 2008, the levels are steadily increasing, with a slight leveling off in 2000 up to 2006 and a slight decline in emissions from 2006 to 2008. Since the United States has such vast amounts of emissions compared to Canada and Mexico, the changes in CO_2 emissions in Canada and Mexico are not as evident. From Figures 1, it is seen that the United States has consistently higher amounts of CO_2 emissions throughout the twenty-eight years of data. While there are no significant changes in the graph, the recorded data shows that Mexico's emissions doubled from 1980 to 2008. In graph 1 of Figure 2, CO_2 per capita in the United States remains relatively steady. However, from 2003 to 2008, it can be argued that the emissions per capita have since been decreasing. Unlike the United States, Canada's CO_2 per capita oscillates quite frequently starting in 1987 and has been decreasing from 2004 to 2008.

Canada's highest peak occurred in 1998 emitting 0.025 kilotons per person. Mexico, unlike both the United States and Canada, has the lowest CO_2 per capita emissions. This pattern, like the United States, remained relatively consistent and flat.

Like CO_2, in Figure 1, the United States emits more N_2O kilotons than Canada and Mexico. In the United States, N_2O increases until 1988 and then sharply declines. Thereafter, it slowly rises again up to 2003 and remains steady thereafter. In Canada, after 1988, N_2O decreases slightly by 0.18 kilotons compared to the decline of 6.83 kilotons in the United States. From then, it steadily increases by about 0.5 kilotons. Mexico's N_2O graph did not have any decrease after 1988. Instead, N_2O emissions decrease greatly after 1998. It reaches its lowest emission amount in 2004. Since then, it has gradually increased. In Figure 2, the N_2O per capita graph shows more realistic comparisons among the countries. Overall Canada emits larger amounts of N_2O than the United States per capita. Mexico still emits significantly less than both developed countries.

NO_x emissions have decreased somewhat since 1980 in all three countries as seen in Figures 1 and 2. The United States emission changes were the most dramatic. Besides leveling out from1982 to 1988, the U.S. NO_x emissions have decreased sharply from 1980 to 1996 and remained at a lower amount until 2008. Mexico observed increasing NO_x emissions until 1984 with a decrease until 2008. Canada has decreased the least, maintaining consistent level of emissions from 1982 to 2008. In Figure 2, it is evident that Canada and the United States emit roughly the same amount per capita until 1988 when the United States emissions begin decreasing at a faster rate than Canada. This is different than Figure 1 as the graph of NO_x in Figure 1 displays the United States emitting significantly more than Canada without ever emitting the same. Mexico still emits the least amount between the three countries in Figures 1 and 2.

While the United States and Canada have seen vast improvements in reducing their concentration of CHF_3, Mexico has seen an increase over the years and has no indication of slowing down. In Canada, CHF_3 emissions per capita increase until 1989 then sharply decline until 1993 leveling out until 2008 as seen in Figure 2. The United States also emitted less CHF_3 emissions immediately after 1989 but not as much as Canada. Unlike Canada, the United States has the largest change in reduction from 2000 to 2003 leveling out thereafter. In Figure 2, the United States had the most trifloromethane emissions per capita until 2004 when Mexico's emission totals surpass the United States. By 2008, Mexico emitted more CHF_3 per person than the United States and Canada.

Knowing when the policies were implemented, we see that the Montreal Protocol might have affected the changes of N_2O, NO_x, and CHF_3 emissions in the United States because there were drastic differences in emission levels in the graphs in Figures 1 and 2 after 1988. The frequent drastic changes in CO_2 levels in Figure 2 indicate that Canada's emissions may have been directly impacted by all four policies. Each peak in the graph correlates with the years that an agreement was passed (i.e. The Montreal Protocol in 1988, NAFTA in 1994, and the Kyoto Protocol 2005). The empirical results presented next will provide more insight in if and how these four policies can impact pollution levels.

b. Empirical Statistics

From the descriptive statistics in Figures 1 and 2, it is clear each country shows some changes in all emission levels at one point or another. Using the four different pollutants as the dependent variable four different OLS regression estimates, as given in equation 1, are presented in Table 2. The four models were run without GDP per capita, as well (See Appendix B).

Table 2: Variable estimates

	CO_2	N_2O	NO_x	CHF_3
Canada	-1.12***	-19.27***	-4.93***	-4.79***
	(0.393)	(3.244)	(0.381)	(0.764)
Mexico	-2.09***	-17.23***	-3.772***	-4.219***
	(0.274)	(2.254)	(0.261)	(0.532)
GDP	0.009	0.866***	0.054	-0.223***
	(0.037)	(0.304)	(0.035)	(0.071)
POP	1.551***	-5.743***	-1.31***	-1.248***
	(0.172)	(1.416)	(0.164)	(0.334)
postNAFTA	-0.031	0.196	0.029	0.083
	(0.052)	(0.461)	(0.053)	(0.102)
postKYOTO	-0.018	1.05**	0.177***	0.084
	(0.053)	(0.472)	(0.055)	(0.102)
postMONTREAL	-0.147*	0.474	0.129**	0.444***
	(0.056)	(0.46)	(0.053)	(0.109)
postCANUS	0.273***	-3.308***	-0.416***	-0.051
	(0.068)	(0.472)	(0.065)	(0.133)
Constant	1.142	21.922	4.929	5.327
	(0.398)**	(3.28)***	(0.381)***	(0.773)***
Adjusted R2	0.997	0.903	0.964	0.903
F-Stats	3184.864	100.999	285.793	101.186

***Denotes significant at the 1% level **denotes significant at the 5% level and *denotes significant at the 10% level; values in parentheses are clustered standard errors

Estimates for the four gases are highly significant for the Population, Canada, and Mexico variables as seen in rows 1, 2, and 4 of Table 1, with mixed results for each of the four policy variables depending upon which gas is the dependent variable.

First, it is important to note that all four models have at least a 90% adjusted R^2. The first model explains about 99.8% of the variability in CO_2. The second model explains about 90.3% of the variability in N_2O. The third model explains about 96.4% of the variability in NO_X. The fourth model, like the previous three models, explains about 90.3% of the variability in CHF_3. These four statistics demonstrate that the four models are doing a good job predicting how the emission levels are impacted by the different independent variables. [2]

The results of Table 2 provide an analysis of the impact each independent variable has on each of the four different greenhouse gas emissions. The coefficients for the Canada and Mexico dummy variables are significant and negative for all four emissions. This signifies that both Canada and Mexico emit less of each of the four gases than the United States. In addition, Mexico emits less CO_2, but more N_20, NO_X and CHF_3 than Canada in relation to the United States.

The objective with the results is to investigate the proportion of total variability of each greenhouse gas emissions explained by each of the four policy variables. Recognizing that between Canada and the United States (a developed country relationship) and between Mexico and the United States (a developed-developing country relationship) CO_2 emissions will decrease by 1.12 and 2.09, respectively according to the estimates. Also, the model predicts that for an increase of 1,000 people to a countries population, CO_2 will increase by 1.55 kilotons. GDP per capita was not significant but very close, so a change in economic activity is not found to affect changes to CO_2 emissions. The model predicts that as a

[2] See Appendix B. Emissions are estimates, which allude to GDP per capita as the calculations.

result of the Montreal Protocol, it is expected that CO_2 emissions will decline by 0.147 kilotons. Likewise, the effects of the Canada- US free trade agreement (the first FTA) are expected to increase CO_2 emissions by 0.273 kilotons holding all other variables constant. According to the data, NAFTA and the Kyoto Protocol did not have any significance impacts to the changes of CO_2 emissions.

The model predicts that, in Canada, N_20 is 19.27 kilotons lower than the United States while Mexico is 17.23 kilotons lower than the United States. For an additional one thousand-person increase in population, N_20 will decrease by 5.743 kilotons. Also, N_2O, as hypothesized will increase by 0.866 kiloton for every additional ten thousand dollar increase to a country's GDP per capita. Furthermore, given the Canada-US Free Trade agreement, N_20 is decreased by 3.31 kilotons. NAFTA and the Montreal Protocol are not found to have significance impacts for N_20. However, with each year after the Kyoto Protocol was established, N_20 increased by 1.050 kilotons.

The results of mono-nitrogen oxides vary. The model predicts that in Canada, NO_x is 4.34 kilotons lower than the U.S., whereas in Mexico, NO_x is 3.772 kilotons lower than the United States. There were higher NO_x emissions after the Kyoto Protocol with the model predicting NO_x increased by 0.177 kilotons, whereas NO_x emissions increased by 0.129 kilotons after the Montreal Protocol. It is peculiar that emissions were significant and positive after both treaties were established because their sole purpose was to decrease such gas emissions. The Canada-US Free Trade Agreement had the largest impact upon NO_x emissions. The estimates indicate that the free trade agreement is responsible for NO_x decreasing by 0.416 kilotons. This type of result is opposite to expectations.

The Trifloromethane model had just as many significant variables as the previous three models. First, Canada and Mexico are predicted to have lower CHF_3 emissions than the U.S. In Canada, CHF_3 is estimated to be 4.789 kilotons lower and, Mexico is 4.219 lower. The model also predicts that for every thousand people added to a county's population, CHF_3 will decrease by 1.248; and for each ten thousand dollar increase in a country's GDP per capita, CHF_3 will decrease by 0.223. The Montreal Protocol was the only policy that was found to be significant. Post the approval of the protocol, CHF_3 emissions are found to increase by 0.444 kilotons.

VI. Discussion

Looking at the descriptive graphs in Figure 2 and the regression results in Table 2, several insights can be drawn to understand how emission levels have changed over the twenty-eight years this study analyzes. First, there was not a significant change in CO_2 after all three countries signed NAFTA. NAFTA was the most recent agreement to be signed involving the opening of trade between the three countries. Between 1980 and 2008, the Canada-US Free Trade Agreement was the first agreement signed and, from the regression results in Table 2, was most significant in increasing CO_2 emissions.

The indicator variables for the countries display that Canada has fewer amounts of CO_2 emissions than the U.S. and that Mexico has even lower levels as compared to the U.S. This holds true from the graph in Figure 2 as both Canada and Mexico have lower levels of CO_2 with Mexico being the lowest emitter of CO_2.

Although it cannot be seen from the graphs presented, Mexico has the greatest carbon dioxide kiloton emission change according to the data. This follows the theory in the sense that Mexico will change the most. A conclusion that could be drawn is that underdeveloped countries such as Mexico will have the most dramatic change in emissions due to free trade policies as compared to developed countries such as Canada and the United States.

Further results from the CO_2 estimates demonstrate that for an additional thousand people, CO_2 levels will increase by 1.551. Thus, the more people within a nation, the larger CO_2 emissions will be. Likewise, GDP per capita did not have any significance on the change in CO_2 emission. Further research is necessary to understand how human interactions with the economy and the natural environment can cause environmental harm. The CO_2 per capita graph in Figure 2 displays a radical difference in results when considering how much is emitted per person. As the populations of each country have increased, the amount of emissions have also increased in Mexico, remained relatively constant in the United States, and have cyclical patterns in Canada from 1988 to 2004.

Lastly, after the two environmental policies are implemented a spike in Canada's emissions is observed. Specifically reflecting each peak, the Montreal Protocol was applied in 1988, NAFTA in 1994 and the Kyoto Protocol in 1997. There could have been another policy that could be causing the spike in 1998. According to the model, the period after the Montreal Protocol and the Canada-US Free Trade Agreement displays a significant increase in CO_2 emissions. The period following the Montreal Protocol resulted in a decrease in CO_2 emissions while the period following the Canada-US Free Trade Agreement demonstrates higher emission levels. The Kyoto protocol does not result in any significant changes to CO_2 emissions. This insignificant finding could be the result of the Kyoto protocol being the second environmental policy that had a smaller impact upon emission levels. Further research is necessary, using more countries, to understand if this is the case.

Nitrous oxide gas has quite different results. The model indicates that the level of N_2O emissions in Canada is 19.27 kilotons more than the United States. Relative to Figure 2 this change does not appear as drastic. In Mexico, N_2O is also lower by 17.23 kilotons as compared to the United States. According to the N_2O graph in Figure 2, the United States appears to have a drastically and significantly lower level of emissions than both Canada and Mexico. The model does not quite match with the graphs in Figures 1 and 2. When per capita emissions are incorporated into the total emissions in Figure 2, Canada clearly emits the most N_2O of all the countries based on the empirical results and the United States decreases its N_2O emissions the most. It makes sense for Canada to decrease its emissions more than Mexico, since Mexico perhaps does not have the capabilities to decrease its emission amount as much as Canada or the United States. Also, on the other hand, N_2O in Figure 1 shows that Mexico has much lower emissions levels and perhaps does not have the capabilities to decrease emissions as much.

Changes in GDP and Population have significant affects on the changes of N_2O levels. As GDP per capita increases, there is an increase in N_2O emissions. When one thousand people are added to the population, N_2O emissions decrease by 5.743

Since N_2O is mostly associated with agricultural activities, it is plausible that, theoretically speaking, the more people in a given area decreases agricultural activity and, hence, reduces N_2O emissions.

Only two of the four policies were significant to changes in N_2O emission levels. Since the Canada- US Free Trade Agreement was found to have a significant effect, it can be assumed that it was responsible for the large drop in emissions as seen in Figures 1 and 2 after 1988. The Kyoto Protocol was also found to have a significant impact on emissions. A slight spike in N_2O emissions, as observed in Figures 1 and 2 after 2005, could be associated with the Kyoto Protocol. The results from the N_2O model represent the change, as well. According to Table 3, the protocol causes N_20 emissions to increase by 1.05 kilotons. However, based on the Kyoto Protocol's implications, we also know that these greenhouse gases are in the process of being "phased out," which is why the graph in Figure 2 shows continuous decrease after the 2005 spike. Both of these results do not match the expectations from the theoretical model.

Mono-nitrogen oxides in Canada are 4.34 kilotons lower than the United States. Figures 1 and 2 graphs reflect the change in the estimate. In fact, Figure 2 appears to show the United States decreases its emissions at a larger rate than Canada especially after 1988. NO_x is found to be 3.772 kilotons lower in Mexico as compared to the United States. According to Figure 2, the United States is decreasing its NO_X emissions at a faster rate than Mexico

GDP per capita is not found to impact NO_x emissions. However, an additional thousand people added to a country will decrease NO_x emissions by 1.31 kilotons.

Since NO_x has a similar chemical make-up as N_2O, the population increase should affect NO_x emissions the same way it affects N_2O emissions. Based on the descriptive graphs, the decrease over time might be a result of increasing populations in each country.

The drastic decrease of NO_x emissions in the United States after 1988 may also be contributed to the Montreal Protocol or the Canadian- US trade agreement. However, according to the model, the Monteral Protocol has less significance than the Canada- US Free Trade Agreement. The Kyoto Protocol was also equally significant as the FTA, while a change in emissions is not observed in the descriptive graphs in Figures 1 and 2. Considering this, it is likely that the Free-Trade Agreement has more impact on decreasing emissions than the environmental policies.

Lastly, CHF_3 emissions have radically different results than the other greenhouse gases, especially in Mexico. Relative to the United States, Canada emits 4.79 kilotons as compared to the United States while Mexico emits 4.219 kilotons less than the U.S. The model demonstrates that the changes in Canada and Mexico are similar, but the descriptive statistics reveal a different story. While the United States and Canada CHF_3 emissions have decreased, it is apparent from Figures 1 and 2 that CHF_3 have increased in Mexico. Figure 2 displays that Mexico's CHF_3 emissions per capita are larger than the United States.

GDP per capita is highly significant in explaining changes in CHF_3. However, unlike the theoretical model, CHF_3 emissions decease per one million USD increase in GDP. In other words, more economic activity creates more trifloromethane. The increase in population per one thousand people leads to a decrease in CHF_3 emissions by 1.248 kilotons. The characteristics of CHF_3 may be similar to those of N_2O and NO_x. In reflection of the graph in Figure 1 and 2, the increase in CHF_3 emissions in Mexico begins to occur after 1994, which would coincide with the theoretical model that increased economic activity, increases emissions. However, the only policy that could apply would be NAFTA and this variable is insignificant in Table 2.

Figure 1 and 2 display declines in CHF_3 emissions in all three countries after 1988. The Montreal Protocol is the only policy significant to the emission changes. However, the model displays that the Montreal Protocol causes CHF_3 emissions to increase, but the graphs in Figures 1 and 2 show emissions decreasing in Canada and the United States. It is interesting to see that the Montreal Protocol is significant to changes in CHF_3 emissions while the Kyoto Protocol is not. After the United States and Mexico stopped making refrigerators, there are still emissions because their half-life is longer than the other emissions, which may explain why we still see high level of this emission. Mexico might not have stopped making this particular type of refrigerators, which could explain the increase in CHF_3 emissions for Mexico.

While there are other factors that could affect the outcomes of the models, this research did not find evidence of a direct correlation between free trade and environmental degradation. The passing of NAFTA does not seem to influence a change in any of the greenhouse gas. However, the published literature on NAFTA has shown great improvement in GDP per capita for Mexico as a developing country.

Policy leaders should not have to fret about the problem that opening up trade may have detrimental impacts to the environment. However, there is still evidence of changes. With correct environmental regulation, the concentration of pollution could be reduced in the future.

VII. Conclusions

There is no direct correlation between open trade policies and increased greenhouse gas emissions in developing countries. In fact, the results from the models only scratch the surface of the research that can be conducted on greenhouse gas emissions and open trade policies. Each gas model reacted somewhat differently, but there are still evident reactions to the trade and environmental policies that help us take the data further. As a result of the two trade policies, the Canada-US Free Trade Agreement mattered whereas NAFTA was not as important to the changes in emissions. Carbon dioxide increased due to the Canada-US Free Trade Agreement while the other four gases reacted in a negative fashion. The changes in emissions could either be because the Canada-US Free Trade Agreement was the first trade agreement established among the North American countries or because it was an agreement between two developed countries.

The environmental protocols showed some significance to the changes, as well. First, the Montreal Protocol reduced emissions immediately in Figures 1 and 2 for nitrous oxide, mono-nitrogen oxides and trifloromethane. However, the econometric results are mixed in regards to significance due to long term effects of gas. Second, the Kyoto Protocol was only meant to affect carbon dioxide emissions but did not show any impact in the research. Nitrous oxide and mono-nitrogen oxides did show little evidence from the Kyoto Protocol, but reasons are not conclusive. While, in theory, all the policies were meant to change the amount of emissions, the research showed mixed results. Therefore, the results from the research are more exploratory than conclusive. From this study, comparing other developed and developing countries engaged in free trade agreements and in the Montreal and Kyoto Protocols may do more research.

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Appendix A:

Countries include the Cook Islands, Holy See, Niue, and United Nation members. The UN members are Afghanistan, Albania, Algeria, Andorra, Antigua, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bhutan, Bolivia, Bosnia, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cameroon, Canada, Central African Republic, Chad, Chile, China, Colombia, Comoros, Congo, Costa Rica, Cote D'lvoire, Croatia, Cuba, Cyprus, Czech Republic, Democratic People's Republic of Korea, Democratic Republic of the Congo, Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Estonia, Ethiopia, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Grenada, Guatemala, Guinea, Guinea Bissau, Guyana, Haiti, Honduras, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kiribati, Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Latvia, Lebanon, Lesotho, Liberia, Libya, Liechtenstein, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Marshall Islands, Mauritania, Mauritius, Mexico, Micronesia, Monaco, Mongolia, Montenegro, Morocco, Mozambique, Myanmar, Namibia, Nauru, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Palau, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Republic of Korea, Republic of Moldova, Romania, Russian Federation, Rwanda, Saint Kitts and Nevis, Saint Lucia, saint Vincent and the Grenadines, Samoa, San Marino, Sao Tome and Principe, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Singapore, Slovakia, Slovenia, Solomon Islands, Somalia, South Africa, South Sudan, Spain, Sri Lanka, Sudan, Suriname, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Thailand, The former Yugoslav Republic of Macedonia, Timor-Leste, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Tuvalu, Uganda, Ukraine, United Arab Emirates, United Kingdom, Tanzania, United States of America, Uruguay, Uzbekistan, Vanuatu, Venezuela, Vietnam, Yemen, Zambia, and Zimbabwe

Appendix B:
Table 3: OLS Regression Results

	CO_2	N_2O	NO_x	CHF_3
Canada	-818810.9**	-12.994***	-3913.0***	-5.786***
	(332459.7)	(3.476)	(429.42)	(0.767)
Mexico	-2073315.5***	-12.052***	-3277.53***	-4.481***
	(242631.48)	(2.536)	(313.39)	(0.560)
POP	1710863.93***	-2.815*	-1109.69***	-1.739***
	(40907.56)	(1.473)	(182.01)	(0.325)
postNAFTA	10546.66	1.081**	141.30**	0.020
	(43596.81)	(0.456)	(56.312)	(0.101)
postKYOTO	-100233.158**	0.891*	154.14**	0.055
	(49520.3)	(0.518)	(63.963)	(0.114)
postMONTREAL	-107057.1	-0.169	-63.094	-0.039
	(79745.95)	(0.834)	(103.005)	(0.184)
postCANUS	38752.21	-1.552*	-82.527	0.364**
	(77020.3)	(0.805)	(99.484)	(0.178)
Constant	877998.74	15.834	4462.87	6.094
	(35289.38)**	(3.662)***	(452.45)***	(0.808)***
Adjusted R2	0.997	0.866	0.948	0.881
F-Stats	4283.543	80.179	204.346	92.257

***Denotes significant at the 1% level **denotes significant at the 5% level and *denotes significant at the 10% level; values in parentheses are clustered standard errors

The four models were run once more omitting the variable GDP per capita because the gases are estimates from manufacturing which is a large component of GDP. The estimated models essentially have GDP per capita on both sides of the equation, which could invalidate some of the results . This table eliminates GDP per capita from the explanatory variable list.

After running there were some differences (as seen in the Table 2 and Table 3). First, the carbon dioxide coefficients and standard errors are much larger. Second, data after NAFTA is significant for nitrous oxide and mono-nitrogen oxides whereas, before, NAFTA was not significant for any of the greenhouse gas emissions. The significant changes in the results in Table 3 may be correlated to the changes in emissions as described in the graphs in Figure 2. Nitrous oxide and trifloromethane did not have high coefficients or standard deviations and, also, did not deviate much from the original results. The Population variable was highly significant in all of the greenhouse gas emissions, but in Table 3, nitrous oxide shows significance at the 10% level instead. For the most part, the adjusted R squared percentages did not change which means the models explain the variability in each emission.