Trade and the environment: A dichotomy?:

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TRADE AND THE ENVIRONMENT: A DICHOTOMY?

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Abstract: Over the past decades, anti-globalization groups have denounced trade as a major source of environmental degradation in both the developed and developing worlds. From heated debates on trade in endangered species to the more recent public concern about the global climate, the international community has been struggling over maintaining a balance between economic growth and environmental protection in the context of globalization. Drawing on panel data of more than 170 countries, my research investigates whether trade openness results in more environmental and climate degradation. More specifically, I look at how different levels of development interact with trade openness and domestic value added ratio. These interactions have important implications for environmental and climate outcomes.

1. Introduction

In April 1994, negotiators from around the world gathered in Marrakesh to compose the Marrakesh Agreement that established the World Trade Organization (WTO). The preamble of the agreement recognizes trade as the means towards higher standard of living, increasing income, optimal use of resources and more importantly, environmental protection. Ever since, international organizations have praised the benefits of trade in preserving the environment through raising level of development, facilitating technology transfer and converging regulations among countries. Despite these publicized benefits, environmental concerns have been one of the principal arguments against free trade. From the shrimp-turtle case in 1994 to the most recent debates on the Trans-Pacific Partner agreement, trade was considered a significant source of environmental degradation. The resentment toward trade from environmentalists poses a fundamental question of whether or not free trade is anti-environment.

2016 has been a victory for the anti-globalization movement. With Brexit, the Trump administration and worldwide increase in protectionism, the world is observing a downward trend in global trade that will continue throughout 2017 (Mendez-Parra, 2017). While some environmentalists may rejoice at this trend, it is important to refrain from labeling trade as either good or bad for the environment and truly understand the complicated interaction between these two forces. Trade influences the environment through four channels: the income, composition, scale and technique effects (Pugel, 2015). The link between indirect effects of trade on the environment through income growth is modeled in the Kuznets Curve. In the early stages of economic growth, pollution increases but beyond a certain level of income per capita, this trend reverses (Kuznets, 1955). Grossman and Krueger examined the validity of the Kuznets curve by investigating the relationship between GDP per capita and four environmental pollutants. Drawing from the Global Environmental Monitoring System's data, they observed that this relationship aligns with the Kuznets curve and the turning points for most pollutants are before a country reaches a per capita income of $8000 (Grossman, Krueger, 1995). Beyond income growth, trade can influence environmental outcomes through three channels. The composition effects assert that in the context of globalization, countries will specialize in certain sectors with different pollution composition, which change their environmental landscape and potentially create pollution gap between countries. If a country has a comparative advantage in pollution intensive industries, these sectors will expand, resulting in more environmental degradation. Countries that do not have an advantage in these industries will relocate their factories to other countries with higher comparative advantage, thus reducing pollution at home by transporting it abroad. In addition, trade harms the environment by facilitating more economic activity (the scale effects). On the other hand, it brings environmental benefits via worldwide green technology transfers (the technique effects) (McAusland, 2008)

Therefore, it is important to further investigate the environmental effects of trade in order to design a trade system that aligns with both economic development and environmental protection goals. Previous scholarly research has presented two main theories about the impact of international trade on environmental performance: the "gains from trade" hypothesis and the "race to the bottom" hypothesis.

1.1 The gains from trade hypothesis

Despite environmentalists' growing criticism about the environmental externalities of trade, trade theorists have proposed the gain from trade hypothesis in which trade can contribute positively to the environment through the technique and income effects and policy convergence.

The 2009 Trade and Climate Change WTO-UNEP report argues that the flow of goods and services can engender technological improvements to reduce emissions, which is commonly known as the technique effects. Trade increases the availability and decreases the cost of climate-friendly goods ("OECD Trade and the Environment"). Technology transfer is mostly channeled through multinational corporations and foreign direct investment. When corporations invest in another country, they can bring cutting-edge technology from developed countries to countries where the technology is unavailable.

Moreover, trade has a positive impact on income growth (Andersen, Babula, 2008). With a rising level of development, trade provides greater national capacity to manage environmental quality and citizens with higher income tend to be more concerned about environmental quality and health, thus creating a bottom-up pressure toward the government. However, according to the Kuznets curve, this is only applicable beyond a certain GDP per capita threshold.

In addition, trade deals can facilitate the exchange of policy ideas and introduce effective regulations among trading partners ("An Introduction to Trade"). This phenomenon is characterized by the "California Effects" in which powerful nations prod smaller nations into improving environmental policy through trade forum. Domestic constituents in powerful nations may promote environmental standards abroad. Domestic companies can also form coalitions to lobby their governments to demand stronger policy in weaker nations so that they do not lose competitiveness to foreign companies (Gallagher, 2008). In addition to multilateral governmental forum, multinational corporations can be channels for standard convergence effects. The multilateral organizations and global corporate codes of conduct can improve environmental goals in developing countries (Frankel, 2008).

Some empirical evidence resonates with the gain from trade theory. Anteweiler, Copeland and Taylor (1998) develop a theoretical model estimating the interaction of scale, composition and technique effects of trade. Using data on SO2 from the Global Environmental Monitoring System, they conclude that more trade openness in 109 cities representing 40 countries creates a net reduction in SO2 pollution, keeping all else constant (Anteweiler, Copeland, Taylor, 1998). Moreover, increasing Foreign Direct Investment contributes "positively to the decline in pollution intensity in China's trade, taking production fragmentation into account" (Dean, Lovely, 2008). However, further research on the impacts of FDI on the environment in countries other than China is necessary.

1.2 The race to the bottom hypothesis

The race to the bottom hypothesis states that "to the extent that countries are open to trade and investment, environmental standards will be lower than they would otherwise be" (Frankel, 2008, 19). As domestic regulations may lead to higher production costs, industries are concerned about competition from countries with lower standards and apply political pressure on governments to limit regulations (Frankel, 2008).

Gueye (2010) affirms the competitiveness concern from climate regulations among developing countries in his book *Trade, Climate Change and Sustainable Development*. Gueye asserts that larger developing countries usually have higher inflation rates, which makes their exports less competitive in comparison with small developing countries. As a result, large developing countries are less likely to strengthen climate policies in order to regain a part of the loss competitiveness. Moreover, strong environmental policies serve as non-tariff trade barriers and increase the price of imports, thus hurting domestic consumers and producers who rely on imported components. In order to prevent this scenario, large developing countries are not willing to enforce more regulations (Gueye, 2010).

Similarly, the environmentalist community in developed countries expresses criticism that globalization generates more competitive pressure, culminating in industries lobbying for a decrease in policy stringency (Sheldon, 2006). In developed countries, competition is forecasted to hurt domestic industries "through a loss of market or movement of industries from developed countries with tough environmental standards to less developed countries with weaker environmental standards" (Sheldon, 2006). A prominent example is the relocation of U.S's companies to Mexico due to Mexico's loose enforcement of health, safety and environmental standards (Sheldon, 2006). The New Zealand's government has refrained from including agriculture, its principal trade sector, into the national Emission Trading System and enforcing more demanding environmental standards out of fear of losing competitiveness in the global market (OECD, 2007). Consequentially, developed countries may have fewer incentives to implement tough standards or in a worse scenario, be incentivized to reduce their standards to prevent loss of competitiveness. At the same time, companies base their decisions primarily on where and how they can maximize the productivity of their operations. Thus domestic environmental rules and standards are only one part of the larger set of motivations driving corporate decisions.

Furthermore, there is a strong negative correlation between fossil fuel exporters and fossil fuel subsidies level. The level of fossil fuel subsidies serves as a concrete indicator of concern for competitiveness as the majority of manufacturing activities rely on energy from fossil fuel. In David Deese's Boston College faculty research, countries with substantial exportation of fossil fuel reserve a high percentage of their GDP to subsidize fossil fuel industries (Deese, 2016). This trend applies to not only countries in the MENA region such as Saudi Arabia, United Arab Emirates, Iran and Nigeria but also well-developed Western democracies such as the United States, Canada and Luxemburg. Similarly, prominent Asian export manufacturers and fossil fuel consumers such as China, Thailand and Pakistan have embraced high subsidies. By elevating subsidies, exporting countries strive to strengthen domestic consumption, decrease production costs as well as increase their export competitiveness in comparison to countries with substantial energy and carbon taxes on fossil fuel. However, fossil fuel subsidies are only one piece of national environmental performance. Other factors such as environmental regulations, renewable energy incentives and domestic retail prices of energy must also be taken into consideration in order to evaluate how trade impacts environmental policy.

Perhaps the most interesting case of research on trade openness and environmental policies is between countries currently transitioning towards an open economy. Using trade ratio over GDP as a measure of trade openness, Andonova (2007) examines whether commercial liberalization has affected national environmental funds in the post-communist Central Eastern European Countries (CEECs). In the 1990s, post-communist countries established the government's special environmental funds to finance the implementation of environmental policy. These funds collected revenues from environmental taxes and penalties on polluters. Drawing from OECD environmental data of CEECs from 1994 to 1999, her statistical model concludes that for transitioning countries, opening up to trade lowers environmental funds, holding constant real GDP per capita, economic growth and land area (Andonova, Mansfield, Milner, 2007). A panel model of 14 MENA countries from 1996 to 2012 concludes that trade openness has a long-term positive effects on environmental degradation in these countries (Al-Mulali, Ozturk, 2015). Therefore, empirical results support the hypothesis that trade puts negative pressure on environmental standards.

1.3 Impacts of trade on the global climate

Trade exposure is also expected to influence climate outcomes through the income, scale, composition and technique effects (Tamiotti, Teh, Kulacoglu, Olhof, Simmons, Abaza, 2009). Research concludes that trade openness is positively correlated with CO2 emission, keeping all else constant (Zhang, Gangopadhyay, 2011; Tiwari, Shabaz, Hye, 2012; Halicioglu, 2009; Jayanthakumaran, Liu, 2012). Halicioglu specifically states that trade openness contributes mainly to development and income growth, which led to an increase in CO2 emission (Halicioglu, 2009). Jorgenson and Birkholz's study investigates the link between food and fuel exports and methane emissions. Using four datasets from 1990 to 2005, their fixed effects model concludes that food exports (defined as % of total exports) increases total methane emissions while the relationship between fuel exports and methane emissions is not statistically significant (Jorgenson, Birkholz, 2010).

While most research focuses solely on one pollutant as the dependent variable, few have looked across various pollutants that contribute to local pollution and climate change. Frankel (2008) constructs a model using trade ratio over national income to predict the changes in local pollutants and CO2 emissions. According to his research, holding income constant, openness is estimated to reduce three local pollutants: SO2, NOx and

PM^{26}. On the other hand, openness appears to cause an increase in CO2 emission. The improvement in local air quality can be carried out by substantial national governments' efforts with adequate level of income and effective governmental mechanisms. However, due to the global nature of GHG emissions, national governments cannot address them effectively on an individual basis because of the free rider problem. "Without an effective international governance mechanism, there is nothing to restrain the detrimental effects of trade and growth on the global climate" (Frankel, 2008).

Moreover, the problem is complicated by the difficulty of understanding the main causes of climate change and the delay until recent years in educating the world population about its effects. From 1980s to mid 1990s, worldwide knowledge and awareness about climate change increased significantly. This level fluctuated between mid 1990s and mid 2000s. From mid 2000s to late 2000s, there was rising skepticism and polarization about climate change between liberals and conservatives and between developed and developing countries. From the late 2000s to the early 2010s, the trend moved slightly downward (Capstick, Whitmarsh, Poortinga, Pidgeon, Upham, 2014). On the other hand, upper atmosphere ozone destruction was recognized early due to the sharply increasing number of cancers in countries exposed to the ozone hole such as Australia. As a result, in the mid-1980s, governments around the world recognized the hazards of ozone depletion. In 1987, the Montreal Protocol was ratified to begin phasing out the use of ozone destroying gases ("Climate change and human health – risks and responses. Summary") Consequentially, the free rider problem and the divergent public perception of climate change add another layer to our understanding of the difference in trade impacts on the local environment and the global climate.

2. Empirical questions

2.1 Trade and development vs. the environment and climate

Based on previous research on trade and the environment, it is important to ask the following questions. First, are there differences between the impact of trade openness on climate change and on local environmental outcomes? Due to the free rider problem and the fluctuation of public concern about climate change, my hypothesis is that governments put less emphasis on climate change policy than on decreasing local pollution. I expect that there is a more direct and expected source of political and social pressure on cities and national governments to tackle local air pollution than climate issues. Therefore, trade will worsen the global climate more than the local pollution.

Second, my research investigates how the interaction between trade volume and development level influences pollution. Developed countries have moved from a natural resources and manufacturing economy to a service-focused economy, which results in less manufacturing and industrial pollution. For example, the service industry, which accounts for 38% of U.S. international trade only accounts for 3.7% of total emissions in the U.S in 2002 (Levinson, 2009). Moreover, with higher income, citizens of industrialized countries tend to be more environmentally conscious. These factors create political pressure for governments to commit to stronger environmental standards. On the other hand, developing countries have a comparative advantage in natural resources and labor and less access to clean technology. They tend to oppose strict environmental policy enforcement and favor free trade (Johnson, Urpelainen, 2016). Therefore, we expect that as countries move further along the development and trade openness spectrum, their level of pollution will decrease.

2.3 The role of domestic value added

The basis of concern for national competitiveness revolves around how much countries gain from trade and how strict regulations may reduce those gains. However, assessing trade ratio over GDP alone may bias our understanding of national gains from trade because it has not taken into consideration the global production chain. Even though a country has high trade volume compared to GDP, if the value it adds to the export is low, it may not gain more than a country with lower trade volume but higher value added to the product. Therefore, aother question in my research is how domestic value added as a share of total export value determines countries' environmental and climate performance. Ratio of value added to gross exports (VAX) varies substantially across countries and sectors. Across sectors, VAX is substantially higher in agriculture, natural resources and services than in manufactures. Because manufacturing industries purchase non-manufacturing inputs, manufactures contain value added from non-manufacturing sectors. Therefore, countries that export manufactures have a lower aggregate VAX ratio (Johnson, Noguera, 2011). The effects of a high VAX on environmental pollution are expected to be mixed. While services tend to be cleaner than low value added manufactures, it is uncertain that other high value added sectors such as agriculture and natural resources are less polluting than manufactures. Furthermore, how does the interaction between VAX and country's development level influence pollution? Since developed countries are moving towards a service-intensive economy, I expect that they will have a higher VAX and lower level of pollution (Johnson, et al., 2011).

3. Data description

On the left hand side of my model, I will use the well-tested Yale Environmental Performance Index (EPI), an encompassing environmental performance measurement, as one of the dependent variables. The Yale EPI data strictly measures environmental outcomes of countries, not their policy. I utilized EPI data for the years 2006, 2008, 2010, 2012 and 2014 and for 170 countries. The strength of Yale EPI lies in the breadth of its categories including water and sanitation, air quality, forest, agriculture, fisheries, biodiversity, health impacts and climate and energy, which represent countries' overall environmental efforts. However, the index is limited in its climate and energy data, which relies solely on the trends in carbon intensity and CO2 emission per KwH. Therefore, using climate data from EPI will not allow us to directly examine how trade impacts GHG emissions.

To solve this problem, total GHG emissions including land use data from the World Resources Institute is also included as a dependent variable. The data covers 177 countries during the years 1993-2013. Unlike EPI climate and energy scoring, total GHG emissions take into account not only CO2 but also other GHG such as methane, which provides a more comprehensive and accurate estimate of climate performance.

My model uses trade openness (import and export ratio over GDP) and GDP per capita (current US$) data from the World Development Indicators released by the World Bank as two explanatory variables. Another explanatory data is political rights index from Freedom House. Countries are rated on a scale from 1 to 7 with 1 representing the highest and 7 representing the lowest level of political rights. Political rights are evaluated based on three subcategories: Electoral Process, Political Pluralism and Participation, and Functioning of Government (Freedom in the World 2017. Methodology).

Considering the expanding global production chain, we also include domestic trade in value added (TiVA) as % of gross export data for 59 countries (both developed and developing) from the WTO-OECD joint initiative as an independent variable. Domestic value added content of gross exports includes the value added generated by the exporting industry during its production processes as well as any value added coming from upstream domestic suppliers that is embodied in the exports (OECD, 2015). I retrieved TiVA data for the years 2005 and 2008-2011. Since there is no TiVA data for 2006, 2012 and 2014 (for the analysis of EPI), I eliminated all variables for 2014 from our analysis and used TiVA data in 2005 to match with other variables' 2006 data and TiVA data in 2011 to match with other variables' 2012 data.

4. Methodology

The relationship between the dependent and independent variables are analyzed based on the following country-level fixed effects models:

$$epi_i = \beta_0 + \beta_1 traderatio_i + \beta_2 GDPpercapita_i + \beta_3 GDPpercapitasq_i + \beta_4 political\_rights_i + \beta_5 dva_i + \beta_6 dva\_gdp + \beta_7 trade\_gdp + \beta_8 i.year + \delta_i + u_i$$

$$ghgemissions_i = \beta_0 + \beta_1 traderatio_i + \beta_2 GDPpercapita_i + \beta_3 GDPpercapitasq_i + \beta_4 political\_rights_i + \beta_5 dva_i + \beta_6 dva\_gdp + \beta_7 trade\_gdp + \beta_8 i.year + \delta_i + u_i$$

epi_i is the Yale EPI index of 170 countries for the years 2006, 2008, 2010, 2012 and 2014.

$ghgemissions_i$ is the total GHG emissions including land use of 177 countries from 1993 to 2013. Some countries are eliminated from the original datasets of WRI and Yale EPI due to missing data issue.

$traderatio_i$ is the ratio of exports and imports as % of GDP.

$GDPpercapita_i$ is the GDP per capita in current US$. $GDPpercapitasq_i$ is the square of GDP per capita in current US$. Both variables are included since the Kutznet Curve hypothesizes that the pattern in which income influences trade is a downward U curve (Kuznets, 1955).

$political\_rights_i$ is the Freedom House's political rights index for each country. Empirical literature has concluded that democracy influences environmental standards (Midlarsky, 1998; Steves, Teytelboym, 2013).

dva_i is the domestic trade in value added (TiVA) as % of gross export data for 59 countries. The rise of global value added chains has altered the relationship between trade in intermediate goods and final goods. The total value of exports over GDP does not reflect the domestic value added component of exports. In contrast, TiVA takes into account the value that the domestic economy adds to the exports and discounts the share of component imports. Since countries should only be concerned about the competitiveness of the domestic components of the exports, using TiVA will provide a better understanding of how the competitiveness concern plays into environmental policy implementation (Botta, Kozluk, 2014).

dva_gdp is the interaction term between trade ratio and domestic value added as % of gross export. Developed countries trade more in services and services have a higher value added over export value ratio (Johnson, et al., 2016; Johnson, et al., 2011). Moreover, according to the Kuztnets Curve, developed countries should have better environmental performance (Kutznets, 1955). Therefore, an increase in *dva_gdp* should lead to an improvement in environmental outcomes.

δ_i: the fixed unobserved characteristics within a country.

u_i: other unobserved characteristics.

5. Empirical results

epi	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
traderatio	.0315596	.0274477	1.15	0.251	-.02236	.0854793
GDPpercapitasq	4.65e-09	2.12e-09	2.19	0.029	4.87e-10	8.82e-09
year						
2008	6.882837	.8848532	7.78	0.000	5.144587	8.621086
2010	-6.447798	.8315487	-7.75	0.000	-8.081334	-4.814262
2012	-14.61024	.9687414	-15.08	0.000	-16.51328	-12.70719
2014	-13.08281	.9489109	-13.79	0.000	-14.9469	-11.21873
GDPpercapita	-.000589	.000243	-2.42	0.016	-.0010663	-.0001116
political_rights	.3353876	.5854914	0.57	0.567	-.8147809	1.485556
trade_gdp	1.92e-06	8.91e-07	2.15	0.032	1.69e-07	3.67e-06
_cons	64.20923	3.986907	16.11	0.000	56.37715	72.04131
sigma_u	15.528091					
sigma_e	6.3711485					
rho	.85591182	(fraction of variance due to u_i)				

F test that all u_i=0: F(169, 530) = 6.53 Prob > F = 0.0000

Table 1: EPI analysis without dva

Our first model analyzing the impact of *traderatio* on *epi* (not controlling for *dva)* includes observations of 170 countries during the years 2006, 2008, 2010, 2012 and 2014. The results demonstrate that a 1% increase in trade ratio over GDP leads to a 0.03 score increase in EPI, keeping all else constant. The positive estimate aligns with the gain from trade theory. As the economy opens up more to trade, the environmental outcomes improve. However, this estimate is statistically insignificant. There is not enough evidence to prove the relationship between *traderatio* and *epi*. On the other hand, even though the estimate for the interaction between trade ratio and GDP per capita (*trade_gdp*) is economically insignificant, it is positive and statistically significant at the 5% confidence interval. In other words, countries that are more developed and trade more have higher environmental outcomes. For these countries, the income, technology and composition effects of trade on the environment are outweighing the size effect. The more developed a country is, the better it can take advantage of green technology from trade to decrease pollution. Moreover, developed countries are moving towards service-oriented economies, thus generating less pollution (Johnson, et al., 2016). Most developed countries also trade with each other. They have comparable environmental standards, which minimize concern for competitiveness. In addition, the difference in statistical significance between *traderatio* and *trade_gdp* estimates shows that while trade openness alone does not explain the changes in environmental performance, trade openness in the context of development level influences environmental outcomes.

epi	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
traderatio	-.0196102	.0676092	-0.29	0.772	-.1531783	.113958
GDPpercapita	-.0016429	.0006935	-2.37	0.019	-.0030129	-.0002729
GDPpercapitasq	4.55e-09	2.12e-09	2.15	0.033	3.65e-10	8.73e-09
political_rights	.5043755	1.010969	0.50	0.619	-1.492885	2.501636
trade_gdp	1.10e-06	1.35e-06	0.81	0.418	-1.57e-06	3.77e-06
dva	-.0757902	.2654898	-0.29	0.776	-.6002892	.4487088
dva_gdp	.000011	7.43e-06	1.48	0.140	-3.66e-06	.0000257
year						
2008	7.777682	1.272864	6.11	0.000	5.263025	10.29234
2010	-7.707776	1.007931	-7.65	0.000	-9.699034	-5.716518
2012	-14.73242	1.240957	-11.87	0.000	-17.18405	-12.2808
_cons	94.68218	25.04675	3.78	0.000	45.20007	144.1643
sigma_u	16.383317					
sigma_e	4.5495315					
rho	.92840737	(fraction of variance due to u_i)				
F test that all u_i=0: F(61, 153) = 6.12					Prob > F = 0.0000	

Table 2: EPI analysis with dva

Table 2 shows the results of the impact of *traderatio* on *epi* controlling for *dva*. The analysis contains observations of 59 countries for the years 2005, 2008, 2010 and 2012. Keeping all else constant, *traderatio* and *dva* have a negative correlation with *epi*. On the other hand, the interaction terms *trade_gdp* and *dva_gdp* are positively correlated with *epi*, all else equal. However, all of these estimates are statistically insignificant.

totalghgemis~s	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
gdppercapita	.0001149	.0019105	0.06	0.952	-.0036309	.0038608
traderatio	.1988805	.197713	1.01	0.315	-.1887693	.5865302
gdppercapitasq	-3.30e-09	1.87e-08	-0.18	0.860	-3.99e-08	3.33e-08
trade_gdp	-8.09e-06	6.79e-06	-1.19	0.234	-.0000214	5.22e-06
pr	-7.239062	5.611065	-1.29	0.197	-18.24051	3.762381
year						
1994	1.60628	24.81457	0.06	0.948	-47.04688	50.25944
1995	6.869577	24.63771	0.28	0.780	-41.43681	55.17597
1996	8.764435	24.63396	0.36	0.722	-39.5346	57.06347
1997	16.09593	24.6016	0.65	0.513	-32.13966	64.33153
1998	13.34517	24.63617	0.54	0.588	-34.95821	61.64855
1999	12.61053	24.64995	0.51	0.609	-35.71988	60.94093
2000	15.80048	24.60937	0.64	0.521	-32.45036	64.05132
2001	20.03873	24.55223	0.82	0.414	-28.10008	68.17753
2002	27.30068	24.5101	1.11	0.265	-20.75553	75.35688
2003	33.81233	24.65942	1.37	0.170	-14.53664	82.1613
2004	42.54296	24.90672	1.71	0.088	-6.290881	91.3768
2005	49.42675	25.18182	1.96	0.050	.0535298	98.79997
2006	52.20683	25.37717	2.06	0.040	2.450594	101.9631
2007	59.63588	25.77103	2.31	0.021	9.107414	110.1643
2008	63.06861	26.33818	2.39	0.017	11.42815	114.7091
2009	62.29703	25.67059	2.43	0.015	11.96548	112.6286
2010	71.62152	26.00673	2.75	0.006	20.63093	122.6121
2011	79.94645	26.47415	3.02	0.003	28.03941	131.8535
2012	83.09063	26.63778	3.12	0.002	30.86276	135.3185
2013	88.82507	26.74147	3.32	0.001	36.39389	141.2563
_cons	201.2658	32.85536	6.13	0.000	136.8474	265.6843

Table 3: Total GHG emissions analysis without dva

Table 3 demonstrates the impact of *traderatio* on *ghgemissions* for 177 countries from 1993 to 2013. The correlation between *traderatio* and *ghgemissions* (not controlling for *dva*) is positive. The interaction term *trade_gdp* is negatively correlated with *ghgemissions*, keeping all else constant. Nevertheless, both of these estimates are statistically insignificant.

totalghgemis~s	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
pr	-37.11693	37.96993	-0.98	0.329	-111.8033	37.56941
gdppercapita	.0064546	.0210706	0.31	0.760	-.034991	.0479003
traderatio	2.420208	1.850925	1.31	0.192	-1.220538	6.060953
gdppercapitasq	2.13e-07	7.44e-08	2.86	0.005	6.64e-08	3.59e-07
trade_gdp	-.0000837	.0000378	-2.22	0.027	-.000158	-9.42e-06
dva	26.96735	7.931354	3.40	0.001	11.36648	42.56822
dva_gdp	-.0004241	.0002324	-1.82	0.069	-.0008813	.0000331
year						
2000	105.5504	72.5673	1.45	0.147	-37.18844	248.2893
2005	341.8166	89.89563	3.80	0.000	164.9931	518.64
2008	515.1769	116.2557	4.43	0.000	286.5036	743.8503
2009	416.5625	96.56303	4.31	0.000	226.6243	606.5007
2010	485.2058	105.5969	4.59	0.000	277.4982	692.9135
2011	555.3684	117.6974	4.72	0.000	323.8592	786.8776
_cons	-1371.41	682.2871	-2.01	0.045	-2713.46	-29.3606
sigma_u	1315.8574					
sigma_e	351.23489					
rho	.93348995	(fraction of variance due to u_i)				

F test that all u_i=0: F(58, 339) = 74.73 Prob > F = 0.0000

Table 4: Total GHG emissions analysis with dva

In table 4, I analyze the correlation between *traderatio* and *ghgemissions* controlling for *dva* for 59 countries in 2000, 2005, 2008, 2009, 2010 and 2011. For every 1% increase in *traderatio*, total GHG emissions increase by 2.4 MtCO2e, all else equal. Consistent with Table 1-3, this estimate is not statistically significant. The interaction between trade ratio and GDP per capita (*trade_gdp*) has a minor negative impact on GHG emissions and is significant at a 3% confidence interval. This result aligns with the conclusion about the estimate of *trade_gdp* on *epi* in table 1. The more developed a country is and the more it trades, the higher its environmental outcomes are and the less GHG it emits. Thus, it becomes more environmental and climate friendly. However, the effect is very small.

In addition, *dva* has a positive effect of 26.97 MtCO2e on *ghgemissions*, keeping all else constant. The estimate is significant at a 1% confidence interval. Countries with a high degree of domestic value added to their exports tend to be bigger GHG emitters. As mentioned above, agriculture, natural resources and service sectors have higher value added than manufacturing (Johnson, et al., 2011). The beneficial environmental effects of the service component of high value added exports were compromised by the pollution from other high value added exporting sectors such as agriculture and natural resources. Most countries with high value added exports rely significantly on agriculture (e.g. the U.S., New Zealand, Australia) and natural resources (e.g. Venezuela, Argentina, UAE). Moreover, because of the economic importance of agriculture and natural resources exports, these countries often limit environmental regulations or subsidize these sectors in order to maintain export competitiveness, thus worsening their harmful effects on the environment and climate. For example, major natural resource exporters such as UAE, Iran and Saudi Arabia enact high fossil fuel subsidies. While extracting fossil fuel for exports might be less polluting than burning them to produce manufactures, the high subsidies in these countries lower the cost and create excessive domestic use of natural resources, which consequentially generates more GHG emissions. Similarly, in order to protect domestic production from international competition, agriculture is heavily subsidized and excluded from environmental regulations in major exporting countries such as New Zealand, EU and the U.S. (Deese, 2016).

On the other hand, the interaction term *dva_gdp* has a minor negative impact on total GHG emissions, keeping all else constant. In other words, the more developed a country is and the more value it adds to total export value, the higher its GHG emission level is. This result aligns with my hypothesis that developed countries' high level of value added originates from their transition towards a service-oriented economy, thus decreasing their level of pollution. However, the effect is economically insignificant (close to 0). This can be explained by investigating the components of rich countries' exports. While developed economies have a higher share of services, they tend to be consumed at home, not exported. In fact, richer countries mostly export manufactures, which lower their domestic value added to total export value and offsets potential environmental benefits from trade in services (Johnson, et al., 2011).

6. Caveats

One major obstacle to my analysis is the inconsistency between the Yale EPI, WRI and OECD TiVA datasets. They do not contain observations of the same number of countries in the same years. The Yale EPI and WRI GHG have a wider span of around 170 countries while the OECD TiVA only covers 59 countries. The WRI GHG has the most continuous time range while there are significant time gaps in the Yale EPI and OECD TiVA datasets. The inconsistency of the three datasets complicates the comparison of estimates across the board. Moreover, the smaller number of countries represented in the OECD TiVA may result in less precise estimates.

7. Conclusion

Due to the statistical insignificance of the estimates, there is not enough evidence to conclude that trade openness influences environmental outcomes. Therefore, trade openness is not the principal cause of environmental pollution and anti-trade policy is an ineffective way to solve the problem of environmental degradation. However, the estimates of *trade_gdp* in table 1 and 3 provide some insight into the interaction between the level of development and trade openness. While trade openness by itself has no observed effect on the environment and climate, trade openness in the context of development level helps explain a portion of the changes in countries' environmental and climate performance. As countries improve their development level, more trade openness can lead to better environmental outcomes and less greenhouse gas emissions. For these countries, the income effect of trade overshadows its size effect on the environment. The higher development level also enables countries to take advantage of clean technology to reduce pollution. This result aligns with the Kuztnets Curve and the gain from trade hypothesis.

Moreover, due to the nature of the global production chain, incorporating domestic value added indicators into the discussion of trade and the environment provides scholars with more insights into the environmental impacts of globalization. Since each country contributes to exports on a different scale, analyzing trade ratio over GDP alone cannot lead to a complete understanding of national concern for export competitiveness and willingness to enforce environmental regulations. My research concludes that higher level of domestic value added results in more GHG emissions. Even though high value added service sector is not polluting, the harmful effects of other high value added sectors such as agriculture and natural resources offset the beneficial impacts of trade in services. This is interesting as the volume of global trade in services has exceeded that of both agriculture and natural resources. In 2014, trade in total commercial services and other commercial services were valued at 4,940 and 2,585 US$ billions while that of agriculture and natural resources were only 1,765 and 3,783 US$ billions (WTO, 2014). However, agriculture contributes to 31% of GHG greenhouse gas emissions (OECD, 2015). As a result, even though the volume of trade in agriculture and natural resources is smaller than services, their high rate of GHG emissions make high-value added countries a bigger contributor to climate change. Moreover, major exporters of agriculture and natural resource products do not create an incentive for these sectors to decrease pollution. The high level of government subsidies given to agriculture and natural resources due to their economic importance in national strategies further encourages industries to rely on dirty technologies and domestic consumers to over-consume.

Therefore, the efforts to reduce environmental footprints from globalization should not be pointed towards limiting trade. Instead, they should be focused on improving the level of development around the world so that countries can use their increasing income and technology transfer to enhance environmental outcomes. Trade can facilitate this development process. In addition, more research is necessary to understand how the level of value added to exports influences environmental outcomes. As countries strive to contribute more to their exports, it is important to balance between the three major sources of high value added: agriculture, natural resources and services. Scholars need to investigate how the interaction between export composition and level of value added impacts the environment in order to guide countries towards becoming stronger and more sustainable economies.

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