Senior Project
Department of Economics

"*It's Not Easy Being Green*: The Effect of International Trade on the Environment"

Chris Meldrum
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Advisors: *Francesco Renna*

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Abstract:

In this paper, I investigate the effect of international trade on a nation's environment. The motivation behind this topic is two-fold. First, there is still a strong disagreement in current literature concerning what effect international trade truly has. Secondly, nearly all existing literature only uses one type of pollutant at a time as a proxy for the environment. To differentiate this paper, I incorporate the Environmental Performance Index (EPI), a measurement of the whole environment, to capture a larger view of the nation's environment. I then proceeded to test components of the EPI. The results of the Fixed Effect analysis indicate that increased international trade actually worsens some parts of the environment. Degradation of some aspects of the environment due to international trade is almost four times stronger in low income countries.

Introduction:

In today's world, there is the ever increasing fear of environmental disaster caused by the continually developing world. An ever present rallying point for opponents against globalization is that it will worsen the environment. The claim was used extensively during the passage of the North American Free Trade Agreement, as opponents to the international trade agreement feared pollution intensive industries would move to Mexico because of less strict environmental regulations. Furthermore, the Intergovernmental Panel on Climate Change (IPCC) indicates that there is a 90 percent chance that human activity has been the primary force behind the increase of the Earth's climate over the last century.[1] The main cause of this environmental damage is due in part by the burning of fossil fuels in industrial uses. The continuing trade liberalization has many questioning whether the negative externalities such as pollution will outweigh the production gains that are achieved because of specialization.

The majority of the gases being released by the industrial sector include CH_4, CO_2, and N_2O. Over the past 250 years, these three gases abundance in the atmosphere have increase by 148 percent, 36 percent, and 18 percent, respectively.[2] While, some policies are being instated around the world by various countries to help maintain or lower the current use of fossil fuels, many countries in the developing world are expected to increase their dependence on fossil fuels. The industrial sector consumed 51% of globally produced energy 2007.[3]

Trade has increasingly been one of the primary avenues for economies to continuously experience economic growth. Globalization has allowed nations to tap into markets and further exploit any comparative advantage that they have gained from internal developments. As one

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[1] The IPCC was established in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO).
[2] http://www.epa.gov/climatechange/downloads/Climate_Basics.pdf
[3] http://www.eia.doe.gov/oiaf/ieo/world.html

study found[4], world trade has increased almost five times faster than total world output in the past fifty years. The growing importance in global markets has caused trade to repeatedly been named a primary culprit in environmental degradation. Thus, it is growing increasingly important to look at the connection between the field of international trade and the environment to find policy changes that could be mandated to secure the health of the world. If it is found that trade does hurt the environment, there will be questions that would have to be asked by policy makers such as: "Is more utility gained from world trade or lost from environmental degradation?" and "Are nations willing to reduce the financial benefits from trade to improve the environment?" It is the goal of this paper to aide in the growing debate.

Existing Literature:

The seminal work in economic literature concerning the interaction between growth and the environment is the paper by Grossman and Krueger (1995). The work further cements the theory of the environmental Kuznet Curve into economics by finally incorporating "reliable data and a common methodology" (354). The curve is an inverse U-shape that explains the relationship between environmental quality and per capita GDP. Thus pollution rises as a result of an increase in per capita GDP in low income nations but pollution decreases as income rises in high income nations. At a certain level of income natives start demanding cleaner air and water. The pollutants that did show this effect found the vertex of the parabola to be between $5000 and $8000 (in 1985$s). Furthermore, as income per capita approaches $8000 pollution actually starts to decrease as income continues to rise.

Frankel and Rose's (2005) contribution to literature appears to be quickly solidifying its role in environmental economics. The goal of their empirical work is to find if the liberalizing of

[4] Santos-Paulino and Thirlwall (2004)

foreign trade will in fact hurt the environment. At the time of their research it was widely accepted within the economic theory that opening up borders would in fact loosen some country's environmental policies in order to attain and/or maintain comparative advantage in a certain good. However, they find that liberalizing trade increased GDP per capita; this indirectly improves the environment through the Kuznet Curve theory. Three types of air impurities, NO_2, SO_2, and PM (particulate matter) serves as the study's main dependent variables. They find that using OLS analysis initially, both NO_2 and SO_2 decrease as a nation pursues a more open economy, holding income constant. When the authors test their hypothesis using instrumental variables (IV) in order to overcome endogeneity problems their results were fairly similar.

The literature contribution by Chintrakarn and Millimet (2006) expand upon Frankel and Rose's (2005) work by creating a similar model to work inter- and intrastate trading within the United States; the authors used gross state product (GSP) to control for size of the economy. The authors encountered less variance in their data collection due to the EPA's strict regulation. Figures for various pollutants, such as the one's Frankel and Rose tested for, as well as others such as carcinogens and hazardous air pollutants (HAPs) have to be recorded under Federal law. They also separate potential environmental damage into five categories which are air, water, underground, land, and total which is an aggregate of all the categories. The majority of their work shows that there is no adverse environmental effect due to increase trade. They do find that increased trade does increase the amount of land pollutants, a variable that Frankel and Rose (2005) did not heavily test. They also found that some variables were not significant when they aggregated the different categories. However, the conclusion drawn is primarily the same as many others found before them. Having to chose specific, very narrow dependent variables, such as a particular gas, is not an overall indicator of the effect of trade on the environment. The

economist's last contribution to economic literature is finding that geographic variables are highly statistically significant for sub-national trade in gravity models.

Ghosh and Yamarik (2006) bring into the field the involvement of regional trading agreements (RTAs) on an environment. The significance of the exogenous variable of RTAs is due to their ever increasing appearance in international trade. RTAs serve as an agreement with a group of countries to reduce tariffs and quotas to foster increased trade. With hundreds of RTAs currently being enforced and more being constructed their purpose could have an even greater effect on the environment, whether positive or negative. They used both OLS and IV analysis to overcome potential weaknesses that could appear in either method. They found that increases in world trade indirectly improve the environment. Lastly, they found RTAs do not have a direct impact on the environment but do have an impact on the Kuznet Curve.

Unsatisfied with other's endogenous variables for environment, because of the narrow view, Cagatay and Mihci (2006) sought a new way to impact the literature surrounding the relationship between international trade and the environment. The team attempts to create a more robust gravity models[5] using an index of environmental sensitivity performance (IESP) based off regulations by the OECD. They construct a proxy that measures a nation's pollution generated during manufacturing and also the nation's attempts to improve the environment. While constructing this they found that for the most part, developed countries had higher IESP numbers, correlating to them attempting to increase environmental quality as they continue their industrial activities. Their research found that environmental strictness has an effect on patterns of trade flow. In other words, countries with similar goals in environmental quality are more likely to trade with one another.

[5] A type of regression to estimate the amount two countries are likely to trade based off similar qualities (i.e. income levels, common language, and distance from one another).

Due to CO_2 being a global externality it has received little attention from academic work. Managi (2004) conducted research on the greenhouse gas because of its importance to international policy making. He expands upon previous work by increasing the testable dataset to 63 countries, with a mixture of both developing and developed countries. When Managi solely examines CO_2 he finds that international trade has harmful effects on the environment. However, a potential reason for this result is the fact that Managi (2004) used more data from developing countries which according to the Kuznet Curve will produce more pollutants as their GDP per capita increase.

Data and the EPI:

The majority of the papers reviewed in the previous section rely heavily on individual components of environmental health. The authors look primarily at gases highly associated with industrial connections. Except for Chintrakarn and Millimet, the others look at one component of the environment at a time. Yet, their attempt to combine various forms of pollution into one variable was not found to be statistically significant. Cagatay and Mihci do incorporate a unifying variable for overall environmental health, yet only use it in gravity models. As such, this author feels it would be an important step in the existing literature, and a great tool for policy implications to use indexed value in the model initially developed by Frankel and Rose.

This paper relies upon all three publications of the Environmental Performance Index (EPI), dually developed by Yale and Columbia. It is designed to benchmark how nations are progressing on the United Nations Millennium Development Goals. These environmental goals include reducing CO_2 emmisions, further sustainable development, and improving the lives of individuals in slums. The index is released biannually starting in 2006, the most recent edition

from 2010. The index is broken into various parts concerning water and air quality, greenhouse gas emissions, and the strength of a nation's environmental policies. The EPI has two main components, Environmental Health and Ecosystem.[6] Environmental Health measures the environments effect on humans. While Ecosystem measures the degradation of the environment and depletion of natural resources.

Each country in the index is ranked on a scale of 0 to 100, with the latter being the best. In the 2010 edition of the EPI, Iceland receives the title of best environment with a grade of 93.5. This is primarily because the small nation is powered mostly by renewable resources and with a population of less than a quarter of a million there is not a heavy strain on the land. On the other side of the spectrum, Sierre Leone received a score of 32.1. This is because of the citizen's high rate of illness from the poor environmental health of the nation.

Theoretical Background:

The relationship between environment and international trade and growth has a very firm footing in current literature. The most important to this paper is the EKC, first described above. However, it is integral to note that there are various types of curves, as pointed out by Dasgupta et al (2002). They note that there are five types of curves, ranging from the "revised curve" which is more optimistic about the decrease in pollution after the vertex, to the "new toxic curve" with supporters believing that while some toxins will be regulated or banned, industry will create new one and so there is never any reduction of pollutants.

Another underlying theory is the pollution haven effect pushed by Copeland (2000). The pollution haven effect states that a nation with a comparative advantage in a pollution intensive good will produce more of that good as it opens itself to free trade. He concludes that free trade,

[6] A full composition of the EPI is in Appendix A

with no environmental policy within any treaty such as one that exists within the European Union, stimulates a nation to pollute more. Thus, the nation that imports the pollution intensive good, will be an exporter of clean goods. Despite this outcome, it can be considered to be Pareto Optimal because the rich nation has a higher demand for environmental quality. The author's defense of the pollution haven effect can be linked back to the Rybczynski Theorem which in an environmental context states that a nation that produces a pollution intensive good more efficiently will do so.[7]

The last theoretical backbone of this research is the very fact that the effect trade has on the environment is ambiguous. This is due in part to the reasoning that there are actually three effects. The first is called the "scale effect" which simply states that as GDP rises, so will pollution. Another effect is the "technique effect" which is the belief that industries will use cleaner and more efficient means of producing goods. The last component is the "composition effect" which is the change in the environment due to the changing composition of goods being produced in an economy.

Model:

In order to conduct to research, and perform regression analysis, this paper's econometric model is based off the one first developed by Frankel and Rose. The following equation is estimated:

$$Env_{it} = \beta_0 + \beta_1 \ln(GDPpcap)_{it} + \beta_2[\ln(GDPpcap)_{it}]^2 +$$

$$\beta_3 Openness_{it} + \beta_4 Polity_{it} + \beta_5 \ln(landpcap_i) + \varepsilon_{it}$$

where *Env* is the index value using the EPI, *ln(GDPpcap)* is the natural log of per capita GDP for country *i*, *openness* is the ratio of imports and exports to GDP, *polity* is an index measure of how

[7] T.M. Rybczynski (1955)

democratic a country is, and *ln(landpcap)* is the per capita land area. Per capita GDP and per capita GDP squared both appear in the model in order to capture the EKC if it is present. *Polity* is included because it is believed a more democratic nation will have a better environment, thus it should have a positive relationship. The data comes from the Polity IV Project and ranks countries on their governmental structure, ranging from +10 for a very democratic nation to -10 for an autocratic one. It is the standard variable used in international economic literature. *Ln(landpcap)* is expected to have a negative relationship, which is to state that as a country is less densely populated it should be more environmentally sound. Subscript *i* is an indicator for a specific country in time period *t*.

Results and Analysis[8]:

The mean EPI score for a nation over three years of the index is 65.52. This is approximately the grade that the United States received in the 2010 index. Environmental Health did score higher than EPI which implies Ecosystem[9] had a lower quality. The mean country included in the index appears to be fairly democratic. Three sets of regressions were run using the equation introduced in the previous section. Pooled OLS is the method used for the first batch of regressions.

In the equation (I), all of the variables are highly statistically significant. However, the variable of importance has the sign which is not expected. This implies that the environment actually gets worse, by over five points on the EPI index, as a nation becomes more open. In equation (II), the environmental health segment of the EPI is the new dependent variable. All of the variables are larger in absolute value and statistical significance, except for polity. Once

[8] The results for all the econometric work can be found in Appendix B to this paper.
[9] Ecosystem is comprised of many components leading to a vast amount of variance between countries. With little significance in the results they are not reported in this paper.

again, openness is negative implying environmental quality worsens as nations enter more into world trade. From this point, I employ a one-way fixed effect model to overcome some of the statistical issues with panel data sets.

With the inclusion of the One-Way Fixed Effect method, in equation (III) openness reduces trade by a very small amount, only about 1.2%, yet it is not statistically significant thus the model is of little importance to the research question. In equation (IV), the dependent variable is once again environmental health. The variable of interest becomes statistically significant yet is still negative. The coefficient's growth in magnitude means that environmental health is much more reactive to international trade than the EPI as a whole. Due to the continued presence of the negative operator in front of the variable of interest, it provides evidence for the pollution haven hypothesis. Thus, the next logical step is to specifically look at low to low-middle income nations. One-Way Fixed Effects is still used and the results are as follows:

This output is not as statistically sound as previous models. The variable of interest is still negative and the coefficient has grown. Due to the fact that on the scale I am using, larger numbers are better, my data should present a "reverse" EKC. It finally appears with equation (V). As the economy in low income nations grow their environment worsens, up to a certain per capita GDP at which case it will improve. The last equation, once again environmental health, shows strong significance for openness. The coefficient also is much larger than in the previous models, by nearly a factor of four. This shows that the environmental health in lower income countries are affected much more due to international trade than in wealthier nations. A large increase in the level of trade for a low income nation produces a fourteen percent decrease in a nation's environmental health. Once again these results showcase the "reverse" EKC but they are no longer significant.

Conclusions:

International trade has the promise of being highly beneficial to countries due to production gains in comparative advantage. However, there is ongoing debate whether such gains come at the degradation of the environment. Thus, it is part of an ongoing, new field of economics to attempt to provide answers in order to better establish the median between complete conservationist policy and continued growth. Some authors, such as Grossman and Krueger are cautiously optimistic on the subject stating, "We hope to see the low-income countries turn their attention to preservation of the environment at earlier stages of development than has previously been the case" (372).

The contribution of this paper is twofold. First, it incorporates an index into the literature, a variable which is drastically underused. While a single pollutant can impart the effects of trade on just the emission of that one pollutant, it fails at signaling the aggregate of the environment. Secondly, this paper finds there are harmful effects to environment health due to international trade. Nations' attempts to be more competitive in this new global economy are forcing them to degrade their environment to find their niche. While this is not the expected effect, economic theory does support the results. The pollution haven effect is evident in the results of the model. Furthermore, if one were to examine only the low to low-middle income nations, the negative effects of international trade are stronger still. The effects of international trade on low income nations are more powerful by nearly a factor of four.

That being said, there is always methods that could be used to improve or expand this paper. In two years, when another EPI is released, the new information will offer more observations, strengthening any research. With such few years of data, the model may not have the ability to truly pick up on effects caused by international trade. It took China more than four

years to become the second most powerful economy in the world and all of the effects of its vast industrialization cannot be calculated in simply a four year span. More years of data will better catch what is truly happening between the environment and international trade. Lastly, while Fixed Effect is a strong method for working with panel data sets, two stage least squares would be ideal due to its ability in finding casualty. There is a substantial endogeneity issue with the model which needs to be overcome with two stage least square. However, because of time constraints I was unable to incorporate this method into my research.

Work Cited

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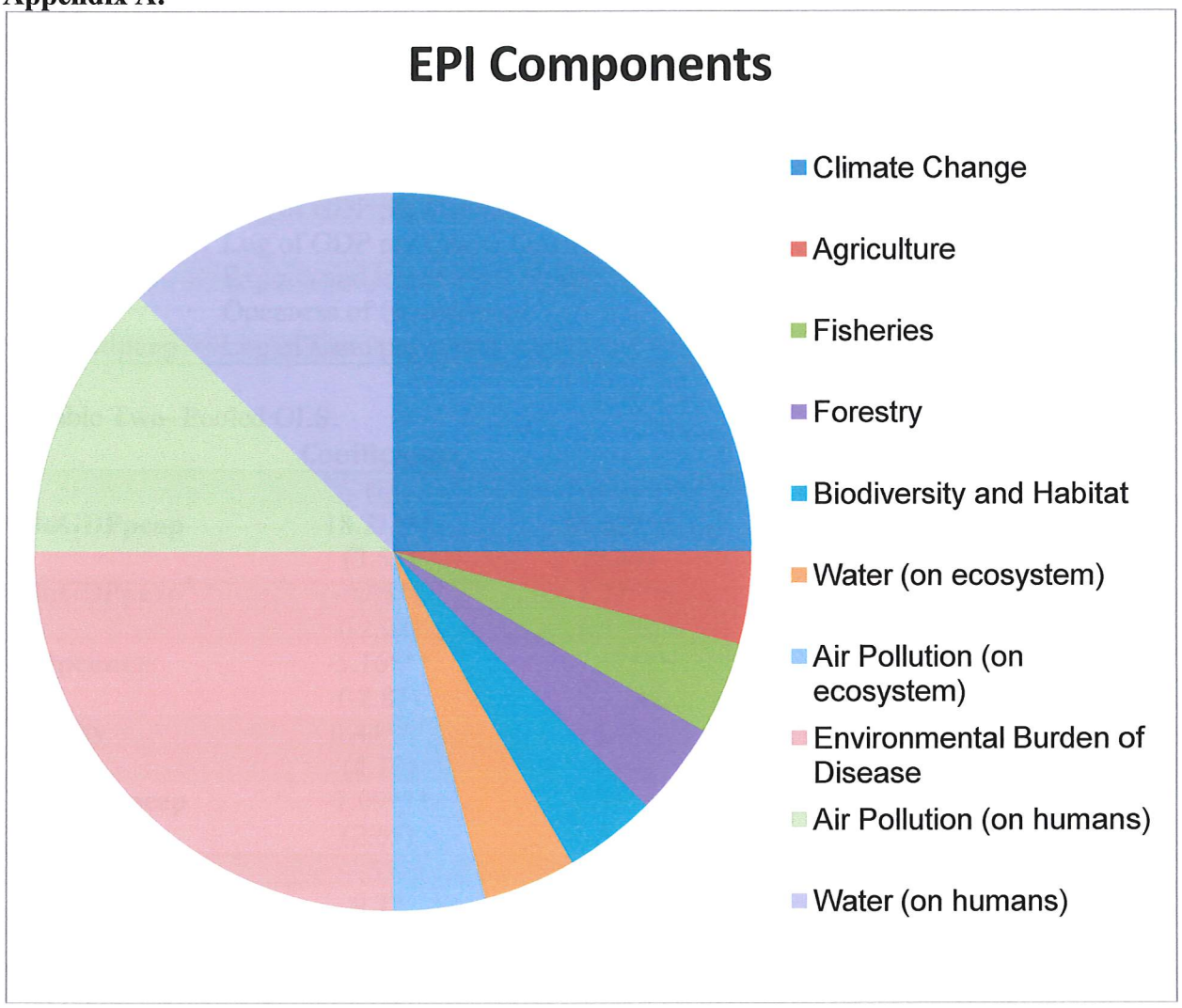
Appendix A:


EPI Components
Climate Change
Agriculture
Fisheries
Forestry
Biodiversity and Habitat
Water (on ecosystem)
Air Pollution (on ecosystem)
Environmental Burden of Disease
Air Pollution (on humans)
Water (on humans)

Appendix B

Table One- Descriptive Statistics:

Variable	Definition	N	Mean	Std Dev
EPI	EPI	336	65.52	14.25
Envhealth	Environmental Health	336	67.07	27.15
lnGDPpcap	Log of GDP per Capita	336	8.66	1.31
lnGDPpcap^2	Log of GDP per Capita Squared	336	76.68	22.71
Openness	Exports and imports per capita	336	.49	.36
Polity	Openness of Government	336	4.21	6.34
lnlandpcap	Log of Land per capita	336	-3.98	1.31

Table Two- Pooled OLS:

	Coefficients	
	(I)	(II)
lnGDPpcap	18.21***	56.62***
	(3.53)	(8.49)
lnGDPpcap^2	-0.63**	-2.22***
	(-2.08)	(-5.70)
Openness	-5.16***	-7.47***
	(-2.81)	(-3.14)
Polity	0.44***	.24*
	(4.72)	(1.94)
Lnlandpcap	-1.09***	-2.95***
	(2.65)	(-5.53)
Adj-R^2	.53	.79
RSME	9.72	12.57
Observations	336	336

Figures in Parenthesis are t-values
*Statistically Significant at 90%
**Statistically Significant at 95%
***Statistically Significant at the 99%

Table Three- One-Way Fixed Effects:

	Coefficients	
	(III)	(IV)
lnGDPpcap	21.71***	60.17***
	(-3.97)	(10.37)
lnGDPpcap^2	-.87***	-2.46***
	(-3.64)	(-7.25)
Openness	-1.21	-3.65*
	(-0.80)	(-1.70)
Polity	0.47***	0.26***
	(6.34)	(2.50)
Lnlandpcap	-1.04***	-2.90***
	(3.23)	(-6.26)
Fixed Effect	Yes	Yes
R^2	.72	.84
F-Value	102.61	55.07
Number of Countries	112	112

Figures in Parenthesis are t-values
*Statistically Significant at 90%
**Statistically Significant at 95%
***Statistically Significant at the 99%

Table Four- One Way Fixed Effects for Low Income Countries:

	Coefficients	
	(V)	(VI)
lnGDPpcap	-26.04*	-15.11
	(-1.83)	(-.62)
lnGDPpcap^2	2.28***	2.62
	(2.40)	(1.61)
Openness	-4.76	-14.05***
	(-1.21)	(2.09)
Polity	.27***	.17
	(2.69)	(.98)
Lnlandpcap	-2.01***	-3.74***
	(-4.19)	(-4.56)
Fixed Effect	Yes	Yes
R^2	.59	.70
F-Value	51.88	26.76
Number of Countries	58	58

Figures in Parenthesis are t-values
*Statistically Significant at 90%
**Statistically Significant at 95%
***Statistically Significant at the 99%