Senior Project
Department of Economics

"The Former Soviets: Trade, Income, and Their Environment"

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Abstract

The former Soviet Union countries (FSUCs) have been excluded from the research looking into trade, income, and the environment. According to the World Bank, the FSUCs have nearly cut their CO2 emissions in half since 1990 and have made significant progress lowering their NOX emissions over the same time period. With this data, we are presented with an opportunity to reexamine what we know about trade, income, and the environment. Using reduced form Environmental Kuznets Curve (EKC) models (models do not account for causality), this paper examines the significance of trade and the changes in peak EKC and analyzes their role in the changes of the FSUC's environment. What is revealed is that trade is significant in lowering CO2 and NOX emissions, but not significant for decreasing Energy Use. The results also find that the EKC peaks are much lower than what was reported by Grossman and Krueger in their 1994 work. This result suggests that their work should be updated to reflect our current global environment, such as our changes in technologies.

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Contents

I. Introduction

The Soviet Union was a nation that was very well known for its pollution. In an Institute for Art Management exhibit, photographer Gerd Ludwig articulates that the Soviet environment was "a beleaguered environment bears witness to a legacy of irresponsibility." His exhibit contains real world images of the former Soviet Union and their lack of regard for the environment[1]. Since the Soviet Union's collapse, it has divided into 15 countries that have all gone their independent ways as far as governments, trade, and environmental policies. A few of these countries have made more progress than others in cleaning up their respective environments. This is an excellent opportunity to investigate the causes of how they have cleaned up their respective environments. There are several instruments that theory has outlined as possible sources for cleaner environments. Trade freedom has been examined as significant force in lowering pollution concentrations (Antweiler, Copeland, Taylor, 2001, among many others). There has also been evidence put forward by Grossman and Krueger that there is a relationship between environmental quality and per capita income. The former Soviet Union countries' (FSUC's) situation presents an opportunity to evaluate and update what we know about the relationship between trade, income, and the environment.

Because of their Former Soviet origin, which was an environmentally negligent regime, and their much cleaner environments today we have the privilege to look at a recent set of data. The FSUC's have been mainly excluded from these works because of data concerns. Now that these countries have been collecting pollution data since their inception it is possible to empirically examine if trade has a significant effect on the environment in the FSUCs. According to the World Bank, these former soviet countries have made much progress in lowering their

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[1]http://www.gerdludwig.com/stories/soviet-pollution-a-lethal-legacy/#id=album-37&num=content-308

CO_2, NOX emissions, and energy use over the past 20 years[2]. Empirical evidence has been found by many researchers that openness to trade results in positive effects on the environment. There is also the work of Grossman and Kruger and their Environmental Kuznets Curve to consider. The purpose of this paper is to provide new empirical evidence to test if trade is significant in lowering environmental degradation in the FSUCs and the peak of the EKC is lower for the FSUCs than what was previously found in 1994 by Grossman and Kruger. I will use a methodology that has been used consistently throughout the literature to do my analysis.

II. Literature Review

The early literature on trade and the environment focused on the gains from trade and the environmental policies. For example, Pethig (1976) through the Ricardian model showed that countries with weak environmental policy tended to have high exports of pollution intensive goods. This was assuming that countries were identical except for exogenous differences in environmental regulation policy. The more recent studies have attempted to find the relationships between trade and the environment. The results of these studies have found some solutions to the policy debates that happen in many governments today. This literature has found several important considerations to establishing the relationship that trade has on the environment. One of these considerations is the link between per capita income and the environment. The work of Grossman and Krueger (1994) used pollution and income per capita data in order to test the Environmental Kuznets Curve. The curve is known to have an inverse "U" shape indicating that at a certain amount of per capita income, the population of a country will begin to demand higher environmental standards. During the manufacturing focus of an economy you find the beginning of the inverse "U" shape; until it reaches its maximum point. It is at this point (the maximum

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[2]See figures 1 and 2 in Appendix A

point) in the curve that we see countries shift from an industry focused economy to service based economy and during this phase you see the curve in a decreasing pattern as pollution becomes lower as per capita income decreases. Grossman and Krueger conclude that most turning points will vary from country to country, however in most cases they saw that the peak in the EKC happened as a country reached a per capita income of around $8,000 (in 1985 US dollars). Grossman and Kruger admit in their paper that they find little evidence to support that environmental quality deteriorates with economic growth, however, the discovery of this EKC relationship between incomes and environmental quality are very important to the literature.

With that discovery in mind, and the relationship of trade and income being a dual causal relationship, some researchers began to take a critical look at trade and its effect on the environment. Antweiler, Copeland, and Taylor (2001) explore the relationship between trade openness and how it affects pollution concentrations. Their theoretical model breaks up trade impact into three effects: scale (as global economic activity increases environmental damage will occur), technique (changes in technology and managerial processes), and composition (specialization of production).Then they examine these effects using data on SO_2. They conclude that international trade creates relatively small changes in the pollution concentrations when it comes to the composition effect. The overall contribution from this paper is: free trade is good for the environment. This is an important find for the literature and leads me to believe that trade, with a focus on the opportunities that it provides rather than trade policy, should be significant when examining the trade's effects on the environment.

In recent years, Ederington, Levision, and Minier (2004) looked into the environmental effects of trade agreement; particularly the North American Free Trade Agreement (NAFTA) between Mexico, Canada, and the United States. They believe that the mechanism through which trade agreements can affect the environment is through the change of the composition of industries. This is often referred to as the pollution haven hypothesis (PHH). The PHH is a theory that says when poorer countries open themselves to trade and have low environmental standards become havens for high pollution goods. According to David Ricardo's theory of comparative advantage, freer trade leads to increased specialization. This, in conjunction with the Heckscher-Ohlin theory (factor endowments), could lead to more pollution heavy industries being in some countries more than others. In this paper, the authors hypothesize that because of the United States' exposure to international trade grants pollution reducing benefits. Using industry level data on imports, they examine whether the shift in the composition of industries can be linked to trade liberalization. They concluded that no such connection exists. There could be a few reasons for finding no such connection. The focus of this paper was on the North American Free Trade Agreement which only looked at the impact of that agreement on the United States. Since the United States is considered a high income country and we have a strong environmental policy. Had Ederington, Levision, and Minier examined a different set of countries that have lower incomes, you may see that there is evidence of the pollution haven hypothesis present. The impact of trade on the environment was shown to have little effect on the environment in the case of the United States. Although the PHH has a strong theoretical foundation, other authors have looked in to the affects of the PHH and have found little evidence to support it empirically.

This leads to a paper by Lovely and Popp (2008) who are researching to discover why poorer countries are regulating their environmental pollution levels much earlier that the early adopters of environmental standards. Lovely and Popp focused specifically on the regulation of power plants that utilize coal, and ask how much does the availability of environmentally friendly technology influence the adoption rate of environmental regulation in poorer countries? Building a general equilibrium model and a data set containing SO2 and NOX regulations, Lovely and Popp attempted to identify the triggers that cause the decisions to regulate emissions. They test the models predictions using a Hazard regression econometric model. Their results support their hypothesis: exposure to international trade leads to environmental regulation for poorer countries at a lower income per capita. Also, they found that if producers are able to shift the burden of costs of production from themselves to others (consumers, government, etc.) the likelihood of the adoption of these environmental regulations is greatly increased. Lovely and Popp's paper contributes to the literature in two ways. First, it shows that trade is a significant force in affecting environmental quality because it aids in the process of adopting international environmental regulations and encourages efficiency in order to compete in the market. This is an example of the pollution haven effect. The pollution haven effect refers to the ability to increase the amount of environmental regulation in order to have an effect on trade flows. And second, this paper demonstrates that the findings of Grossman and Kruger may still hold true as far as the income-environment relationship. As countries expose themselves to international trade they adopt new technologies and standards as a result. If this is the case then we may see that countries that have opened themselves to trade should have lower EKC peaks than the $8,000 (in 1985 US dollars) concluded by Grossman and Kruger. The pollution haven effect puts forward the idea how trade can help the environment through the international community encouraging the adoption of environmental standards through the exposure to international market and the desire to compete.

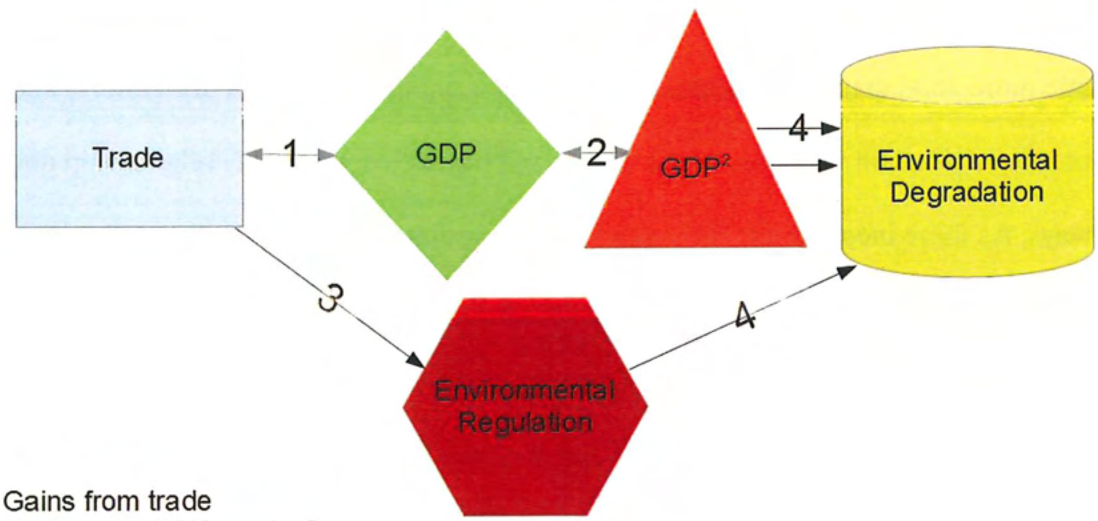
III. Methodology

A. Theoretical Model

In my theory am looking to examine how trade openness affects environmental degradation and energy use[3] in the former Soviet Union countries and replicating Grossman and Kruger's work on the Environmental Kuznets Curve. Trade does not affect environmental quality directly (Frankel and Rose, 2005). It does so through other means. One is through increasing GDP and incomes. The gains from trade theory is born from comparative advantage (arrow number one in theoretical map) denotes that a country that opens itself to trade will be able to consume more good than its production possibilities frontier will allow. Furthermore, trade promotes specialization which increases output and higher incomes. This relationship does work both ways. As these incomes rise they should reach a point where there will be a demand for improved environmental quality. This is through the environmental Kuznets curve (arrow number two). As shown earlier, the EKC is the relationship between environmental regulation demands and income per capita. Grossman and Kruger (1994) found that the increases in income can promote the pollution haven hypothesis in countries that are poor, however, once the countries income per capita reaches a certain point their environmental quality begins to increase. The other mean is through environmental regulations and the pollution haven effect. Lovely and Popp (2008) found that an openness to trade aids in the process of adopting environmental regulations. These regulations can lead to technological innovations that reduce pollution and emissions. This is the pollution haven effect (arrow three). According to the theory trade should be a significant variable in these processes. These factors together contribute to the environmental quality improving (arrow four).

[3] Energy Use is included as a dependent variable because it is used in economic activities and produces by products that contain an array of pollutants.

Theoretical Map



1. Gains from trade
2. Environmental Kuznets Curve
3. Pollution Haven Effect
4. Demand for better environmental Quality.

B. Empirical Model

In order to examine the relationship between income per capita and the environment, Grossman and Kruger estimated two reduced form equations. They chose these two reduced form equations for two reasons. First, the reduced form of equations provides a clearer illustration of the effects of a country's income on the environment. And second, the reduced form helps them avoid having to collect data on regulation and technology. These reasons are also advantageous to my research with the FSUCs because finding data on regulations, technology is still difficult to measure, and it is a very simple model. The first equation is:

$$(1) \quad P_{it} = \beta_1 GDP_{it} + \beta_2 GDP^2_{it} + \beta_3 GDP^3_{it} + \beta_4 LGDP_{it} + \beta_5 LGDP^2_{it} + \beta_6 LGDP^3_{it} + \beta_7 X_{it} + \varepsilon_{it}$$

The dependent variable is a pollutant, measured by concentration. GDP is represented in per capita terms, and LGDP are lagged GDP per capita. The X variable represents the variables generated for the random effects controls. The random effects model is used to control for serial correlation issues. The Second Equation is:

$$(2)\quad P_{it} = GDP_{it}\,(\beta_1 + \beta_4) + GDP_{it}^{\ 2}\,(\beta_2 + \beta_5) + GDP_{it}^{\ 3}\,(\beta^3 + \beta_6) + X_{it}\beta_7$$

Equation 2 is used to create the visual Environmental Kuznets Curve graphs. Each graph is an indicator the level of GDP that the citizens of the FSUCs begin to demand better environmental quality. With this model I will be testing to see if the peak of this curve is below the levels that Grossman and Krueger predicted in 1994. The method for calculating the peak is done by using calculus. From equation 2, the derivative is calculated and set equal to zero. The resulting equation is a quadratic equation.

$$(3)\quad 0 = 3\,(\beta^3 + \beta_6)GDP^2 + 2\,(\beta_2 + \beta_5)GDP + (\beta_1 + \beta_4)$$

Solving this equation leads to two answers. One of those answers is the peak and the other is a valley. The Hypothesis is:

H_0: Income per capita peak < \$8000 1985 US dollars

H_1: Income per capita peak > \$8000 1985 US dollars

The Empirical model for testing if trade is significant to the 10 percent level in lowering environmental degradation will draw from the work of Korves, Martinez-Zarzoso, and Voicu (2012). Their empirical model is:

$$(I)\quad Ln(ED)_{it} = \beta_0 + \beta_1\,Ln(GDP)_{it} + \beta_2[Ln(GDP)]^2_{it} + \beta_3\,Ln(Trade)_{it} + EUMem + \delta_t + \mu_i + \varepsilon_{it}$$

This model uses the Environmental Kuznets curve frame work with the addition of a variable for trade to test whether trade has a significant effect on environmental degradation. The dependent variable is environmental degradation, GDP is GDP per capita, GDP squared is GDP per capita squared, trade is represented as a percentage of GDP (imports plus exports divided by GDP), δ_t is the time variable for the fixed and random effects control, and μ_t are the country specific effects variables. All variables in this model are logged except for the effects variable. This model will allow me to test the hypothesis that trade is significant in the lowering of environmental degradation. The hypothesis is:

H_0: Trade P-value < 10% and $-\beta$ (negative parameter estimate)

H_1: Trade P- value >10% or $+\beta$ (positive parameter estimate)

This empirical model is excellent for my research for two reasons. The first reason is because it contains all of the variables that I need from my theoretical model. Next, is for is simplicity. Similar approaches using this model have been made by Antweiler, Copeland, and Taylor (2001). This model has been consistently used throughout the literature evaluating the effect of trade on the environment. This model is designed for a panel dataset, and via fixed and random effects models I can account for unobserved heterogeneity and serial correlation of panel data sets. Also using the Hausman test I can determine if the random effects model is consistent (if the test provides a chi-squared value lower that 5 percent, I will use fixed effects parameter estimates). Using the Wald statistic for groupwise heteroskedascity and the Wooldridge test for serial correlation, I can confirm the presence of both conditions. Therefore, I will use robust standard errors in all results.

IV. Data

Data will be collected from the World Bank and dummy variables will be placed in the model in order to account for the unobserved heterogeneity. The theory that I will be testing is the theory that free trade is significant in improving environmental quality. The data used will be in the case of the 15 countries of the former Soviet Union. Data used will be from the years 1990-2010 and has all been collected from the World Bank's world development indicators. The variables are as follows:

CO2 emissions:

Carbon dioxide emissions are the byproducts that come from the burning of fossil fuels and the manufacturing of some products.

NOX emissions

According to the World Bank, Nitrous Oxide emissions are from agricultural biomass burning, industrial activities, and livestock management.

Energy use per capita

Energy use per capita is defined as the use of primary energy before transformation to other end use fuels.

Real GDP per capita

Real GDP per capita is a country's gross domestic product divided by the midyear population. It should be noted that this indicator is calculated without making any deductions for depreciation of assets or for the depletion of natural resources. It is given in constant 2000 US dollars in order to adjust for inflation. Increases in GDP should result in the increase of all environmental effects because of the increase in incomes, and therefore consumption of goods. Within the EKC hypothesis tests this variable is expected to be positive and significant.

Real GDP per capita (squared)

This data is simply the real GDP per capita data about but squared. Please note that in the

Logged formations of the data it is first logged, then it is squared. This is to avoid linear combination mathematical issues. This variable should have a similar effect on the environment as GDP. The EKC relationship to pollutants should show that this variable is negative and significant. In trade testing, I would still expect this relationship to still be present.

Real GDP per capita (cubed)

Real GDP cubed is the Real GDP per capita data cubed. Unlike the others this variable did not need to be logged. This variable is only used in the EKC relationship tests.

Real GDP per capita lagged

This variable is the Real GDP per capita as described above but it is the average of the past three years of per capita incomes. This variable begins in 1993 and continues until 2010. It begins in 1993 because this is the first year that three previous years were available to do the lagged calculations.

Real GDP per capita squared lagged

Defined as Real GDP per capita squared and lagged in the same way remarked above. This variable's parameter estimates differ from pollutant to pollutant in Grossman and Kruger's works. It is a reasonable assumption that this will still be the case in my results.

Real GDP per capita cubed lagged

Real GDP per capita cubed and lagged. This variable, too, should vary depending on the pollutant.

Trade Openness

Trade openness is a countries imports plus their exports all divided by GDP. This method of calculation is used to look at trade as a percentage of their GDP in order to get a sense of how much trade participation a country has. As trade openness increases we should see decrease in the environmental degradation variables.

Year

In the empirical model there is a variable for time. This variable is used to account for time specific fixed effects that control for unobserved heterogeneity.

European Union Membership

Indicates a countries participation in the European Union on a year to year basis.

Data Table:

Variable	Label	Definition [Mean : Standard Deviation]	Source
CO2 Emissions	lnCO2	Kilotons per capita [1.28 : 1.02]	World Bank: Development Indicators
NOX Emissions	lnNOX	Kilotons per CO2 equivalent [8.31 : 1.41]	World Bank: Development Indicators
Energy Use per capita	lnEngPC	Kilograms per oil equivalent per capita [7.48 : 0.774]	World Bank: Development Indicators
Real GDP per capita (logged) [lagged]	GDP , (lnGDP) , [LGDP]	In constant 2000 US dollars, Logged for Trade test, Lagged for EKC [6.94: 0.93]	World Bank: Development Indicators
Real GDP per capita squared (logged) [Lagged]	GDP2 , (lnGDP2) , [LGDP2]	GDP first logged then squared, Lagged for EKC [48.95 : 12.94]	Derived from GDP
Real GDP per capita cubed [lagged]	GDP3 , [LGDP3]	GDP cubed, Lagged for EKC [See Appendix B[4]]	Derived from GDP
Trade openness	lntrade	As percent of GDP [4.52 : 0.36]	World Bank: Development Indicators
European Union Membership	EUMem	Indicated EU membership	Europa.eu

[4] Number is extremely large

V. Results

A. Environmental Kuznets Curve:

For these estimations equation one was used along with an OLS and random effects regressions. It is difficult to draw many conclusions from the parameter estimates because of multicolineraity between GDP per capita and the lagged GDP per capita variables. With that being said all variables in all models but five are significant up to the 10 percent level. The GDP variable was positive and significant for NOX emissions. Carbon dioxide had a negative parameter estimate for GDP but maintained its significance. In the Energy use model GDP was not significant. GDP2 had a different story to tell in all three models. For carbon dioxide it was positive and significant. Its significance was expected but it was also expected to be negative. GDP2 for nitrous oxide was significant and negative, consistent with expectations. The GDP2 variable for energy use was insignificant, defying expectations. The GDP3 variable was a difficult variable to predict. The GDP3 variable is positive and significant to the one percent level for all models. I anticipated that the lagged variables would follow the expectations of the non-lagged variables. I was surprised to find that all three lagged variables held to no obvious patterns except significance remaining the same. The lagged GDP variable was the opposite sign for CO2 and NOX, however was consistent for energy use. Lagged GDP2 had the opposite sign in all three cases. Lastly, lagged GDP3's signs held true for CO2 and flipped for NOX and energy use. Table is shown below and can be found in appendix B: table 3

The graphs constructed from equation 2 are the intriguing part of the analysis. The graphs were created by multiplying the current and lagged coefficients by their corresponding GDP variables. Each graph shows at what income levels that pollution emissions begin to decline. The levels are different for different pollutants. All, however, are well below $12802.97 ($8,000 1985 US dollars adjusted to 2000 US dollar levels). The levels of income are as follows:

- CO2 emissions peak (Figure 3) - \$2479.84
- NOX emissions peak (Figure 4)- \$1159.04
- Energy use per capita peak (Figure 5)- \$4627.26

These levels are far below what Grossman and Krueger found in their 1994 paper. This outcome was expected, however, not to this degree. It should be noted that this is just a small sample of countries that are situated within a relatively close geographical area, but there are representatives of every income level the dataset.

There is another set of questions that these graphs bring to light. Is the EKC really and inversed-U shaped relationship? And if the shape is not an inverted-U, what does the shape of the graph tell us about the relationship between income and the environment? The graph for energy use per capita is the only graph where the inverted parabola shape holds true. The graphs for Energy use and CO2 were curves, but not parabolas. There is a peak; however, there are also valleys. There is an opportunity for further research to reexamine this relationship on a larger data set of the entire world to see if the valleys remain, or if the inverted U shape is still the shape of the EKC. I believe these results still show that there is a relationship between income and the demand for environmental regulations, but the results challenge the idea that the shape of that relationship is an inverted U.

Table 1: Environmental Kuznets Curve regression results

Dependent Variable	Co2 emissions		NOX Emissions		Energy Use per capita	
Independent Variables	OLS	RE	OLS	RE	OLS	RE
GDP	-0.00447 0.24	-0.00402 0.0005***	71.23821 0.0211**	61.95197 0.0021***	0.84195 0.352	0.618644 0.1249
GDP2	5.39477E-07 0.6435	2.0803E-07 >.001***	-0.01995 0.1064	-0.02091 0.0074***	-0.00018678 0.5469	-0.00021 0.1316
GDP3	2.2752E-11 0.823	1.67E-11 >.001***	0.00000161 0.2289	1.972E-07 0***	1.349E-08 0.6519	1.66E-08 0***
LagGDP	0.01612 0.0001***	0.008447 0.0001***	-33.78919 0.2001	-37.2205 0.0043***	0.42109 0.6456	0.040401 0.9139
LagGDP2	0.00000455 0.0003***	-0.00000147 0***	0.00871 0.4002	0.011811 0.0207**	-0.00007122 0.8216	0.000102 0.436
LagGDP3	3.63317E-10 0.0012***	8.26E-11 0***	-7.24377E-07 0.5152	-0.0000011 0***	3.38958E-09 0.9116	-1.13E-08 0.01***
Constants	-1.63648 0.0031***	2.215967 0.0177**	-12473 0.1597	-2102.23 0.8252	1135.25178 .0001***	1603.783 0***
N	266	265	71	73	305	306
R2	0.4333	0.3233	0.2612	0.2082	0.1801	0.1408

Notes: *, **, * represents 10%, 5%, and 1% significance respectively.**

B. The Significance of Trade in Environmental Degradation:

a. Carbon Dioxide

My first model was dedicated to the effects of trade liberalization on the carbon dioxide levels. In this model we can reject the null hypothesis of the Hausman test, thus we know that the random effects model is consistent and should be used for analysis. The GDP variable's coefficient is positive and significant and the GDP2 variable is negative and significant, which is expected. Both are significant to at least the five percent level. The trade variable in this model is significant to the one percent level. What these result are indicating is that we can fail to reject the null hypothesis. An increase in trade openness leads to a decrease in CO2 emissions by .17881%. Membership in the European Union was found to be highly insignificant. This result is the opposite of what Korves et al. (2012) discovered in their research. A reason for this discrepancy could be because of a small data set is centered within the same geographical area. The table of the parameter estimates and their P values are below. This same table can be found in appendix B.

Table 2 -A: Results for trade CO2 emissions pollutant regressions

Dependent Variable	CO2 emissions		
Independent Variables	OLS	FE	RE*
GDP	5.74114 0.0001***	1.471755 .0088***	1.595493 .0041***
GDP2	-0.36352 0.0001***	-0.09036 .0261**	-0.09768 0.0152**
Trade	0.20761 0.1025	-0.17882 .0040***	-0.17083 .0058***
EUMem	-0.08278 0.7328	0.013911 0.8879	0.014529 0.8826
Constants	-21.65461 0.0001***	-2.98219 0.01398	-4.21721 .0340**
N	266	267	267
Hausman Test P-val		0.1302	
R2	0.5495	0.9503	0.1492

Notes: *, **, * represents 10%, 5%, and 1% significance respectively.**

b. Nitrous Oxide

The next model was devoted to Nitrous Oxide emissions. Similar to the CO2 model, we reject the null in the Hausman test and used the results of the random effects model. The regressors model's results were insignificant, except for the trade variable. 26.93 percent of all variance from the mean was explained by this model. Within this model the variable for trade openness is negative and significant to the one percent level. In this instance we also fail to reject the null. The full table of parameter estimates is available in table 4 of appendix B and below.

Table 2-B: Results from trade NOX pollutant regressions

Dependent Variable	NOX Emissions		
Independent Variables	OLS	FE	RE*
GDP	2.84877 0.3159	0.414405 0.6968	0.557617 0.5957
GDP2	-0.15607 0.4487	-0.00923 0.9042	-0.01939 0.7977
Trade	-1.13968 0.0171**	-0.39982 .0133**	-0.41347 .0093***
EUMem	-1.33787 0.0807	-0.12706 0.4383	-0.13297 0.4156
Constants	1.41953 0.8906	9.628989 .0197**	7.22048 .0705*
N	71	72	72
Hausman Test P-val		0.2393	
R2	0.3117	0.9803	0.2693

Notes: *, **, * represents 10%, 5%, and 1% significance respectively.**

It should be noted that there were many holes in the World Bank's nitrous oxide data. Out of the 315 possible data points, only 72 had complete observations.

c. Energy Use

The final model that I chose to run was one that estimated the effects of trade liberalizations on the amount of energy used per capita. I chose to run a model on energy use per capita because the byproducts of energy use tend to be greenhouse gasses and other pollutants. In this model, only 9.57 percent of variances from the mean could be explained. There were no significant variables in this model outside of the constant term. The constants are highly significant in this model signaling that there is a variable, or variables that are not observed in this model that are highly contributing to energy use. Therefore, we can reject the null hypothesis for this model. These results are consistent with the results of Korves, Martinez-Zarzoso, and Voicu (2012) who also found their trade coefficient to be insignificant and their constants being highly significant to the 1 percent level. A table of the Parameter estimates can be found below and also in appendix B.

Table 2-C: Results from trade Energy Use per Capita regressions

Dependent Variable	Energy Use per capita		
Independent Variables	OLS	FE	RE*
GDP	-4.22185 .0001***	0.910593 .0758*	0.77541 0.1258
GDP2	0.33568 .0001***	-0.04956 0.1846	-0.03915 0.2887
Trade	-0.57904 .0001***	-0.08126 0.1841	-0.08602 0.1579
EUMem	-0.86342 .0001***	-0.02786 0.7718	-0.04475 0.6403
Constants	22.98392 .0001***	4.058472 .0287**	4.403408 0.0156**
N	305	307	307
Hausman Test P-val		0.1094	
R2	0.2994	0.8919	0.0957

Notes: *, **, * represents 10%, 5%, and 1% significance respectively.**

VI. Conclusions and Limitations

A. Conclusion:

The purpose of this research project is to investigate the significance of trade openness on the environment and examine the per capita income peaks of the FSUCs. While there can be no straight forward answer to the significance of trade openness question because the results are different for each pollutant, however, I have presented evidence that trade is an important piece of the puzzle when it comes to nitrous oxide and CO2 in the case of the FSUCs. The EKC curve is an important discovery as far as the relationship between incomes and the environment and I believe that my research confirms this relationship, and further confirms the findings of Lovely and Popp (2008): poorer countries are regulating sooner. The levels are different for each pollutant analyzed and are well below half of what Grossman and Kruger found in their 1994 work. This is much lower than what was expected, but is an extremely interesting result. I believe that further research could be done by updating their findings for a larger dataset of countries. Trade openness does not contribute to lowering the levels of energy use per capita. It is important because of the acceptance of global environmental standards and encouraging the increase of incomes via specialization and increased trade. Trade openness is an important piece of the environmental quality puzzle but it is far from the most significant, or the most explanatory. There are many empirical studies that have been done to find that free trade is a significant variable and account for the endogeneity of trade in order to sort out causality (Frankel and Rose, 2005).

B. Limitations

Although I use a robust model to help me estimate my theory there are still some notes and limitations to my study. First, my study only looks at the 15 countries that made up the former Soviet Union. This was a gap in the literature that I believed deserved to be studied especially because of the legacy of pollution that the Soviets left behind. Second, results are different depending on what pollutant you are researching, Many pollutants are by products of different economic activities and my study only looks at a few. Furthermore, as noted earlier, my nitrous oxide emissions data only had 72 usable observations. Endogeneity is an issue when it comes to the relationship of trade and GDP. Increasing GDP increases outputs, which could possibly not be consumed it a country is already consuming all that it can. These extra outputs would likely be traded, which leads to increased trade. The reduced form of the equations also has a limitation. That limitation is that causality cannot be found through these equations. Further research is possible if these limitations are corrected and a clearer picture is illustrated about what we know about trade and the environment.

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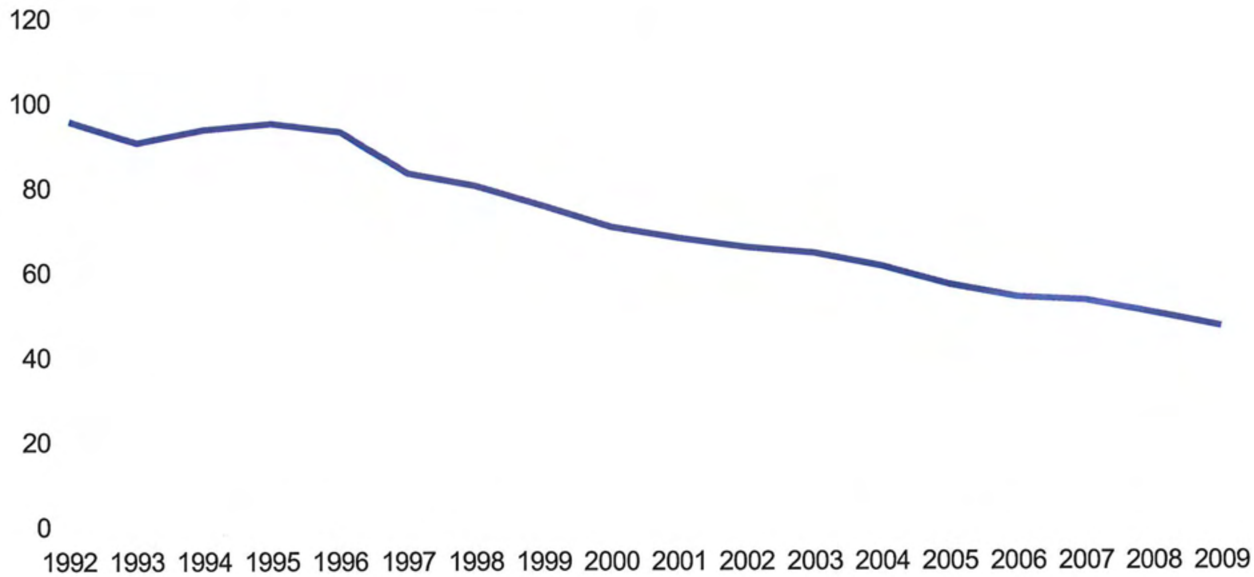
Appendix A: Graphs

Figure 1: CO2 Emissions for the 15 former Soviet Countries over 17 years since the separation of the Soviet Union.



Source: World Band Economic indicators.

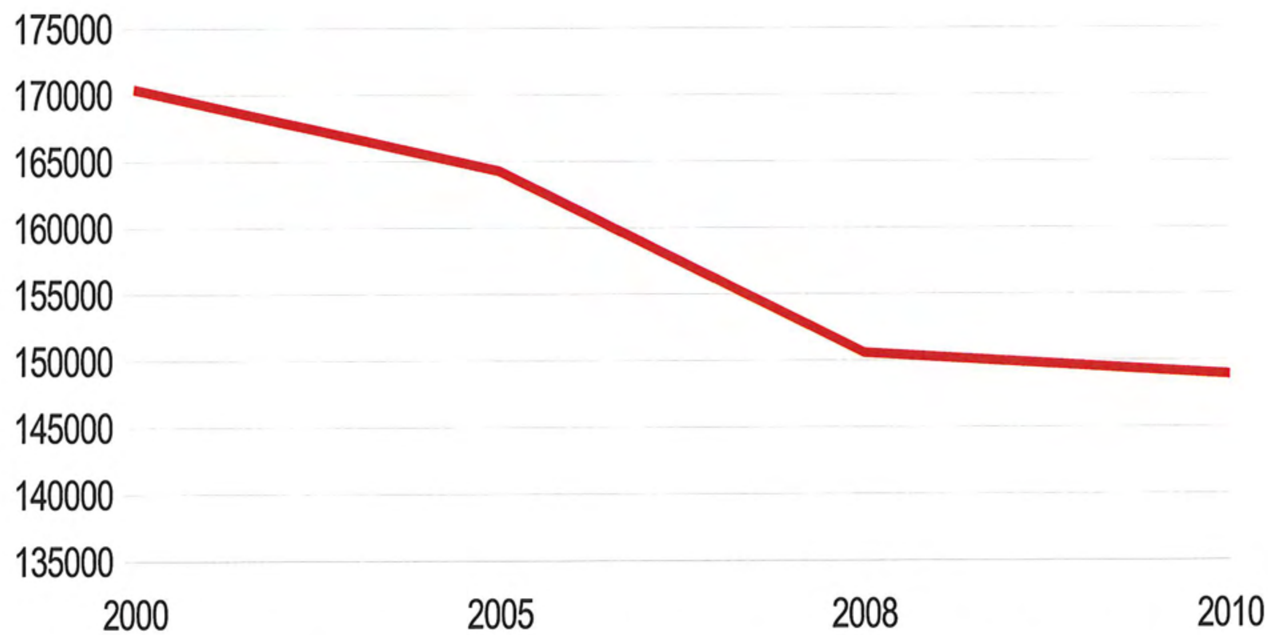


Figure 2: NOX emissions of the 15 former Soviet countries since the 15 years since the separation of the Soviet Union

Source: World Band Economic indicators.

Figure 3. EKC graph for Carbon dioxide emissions for the FSUCs

Peak: $2479.84

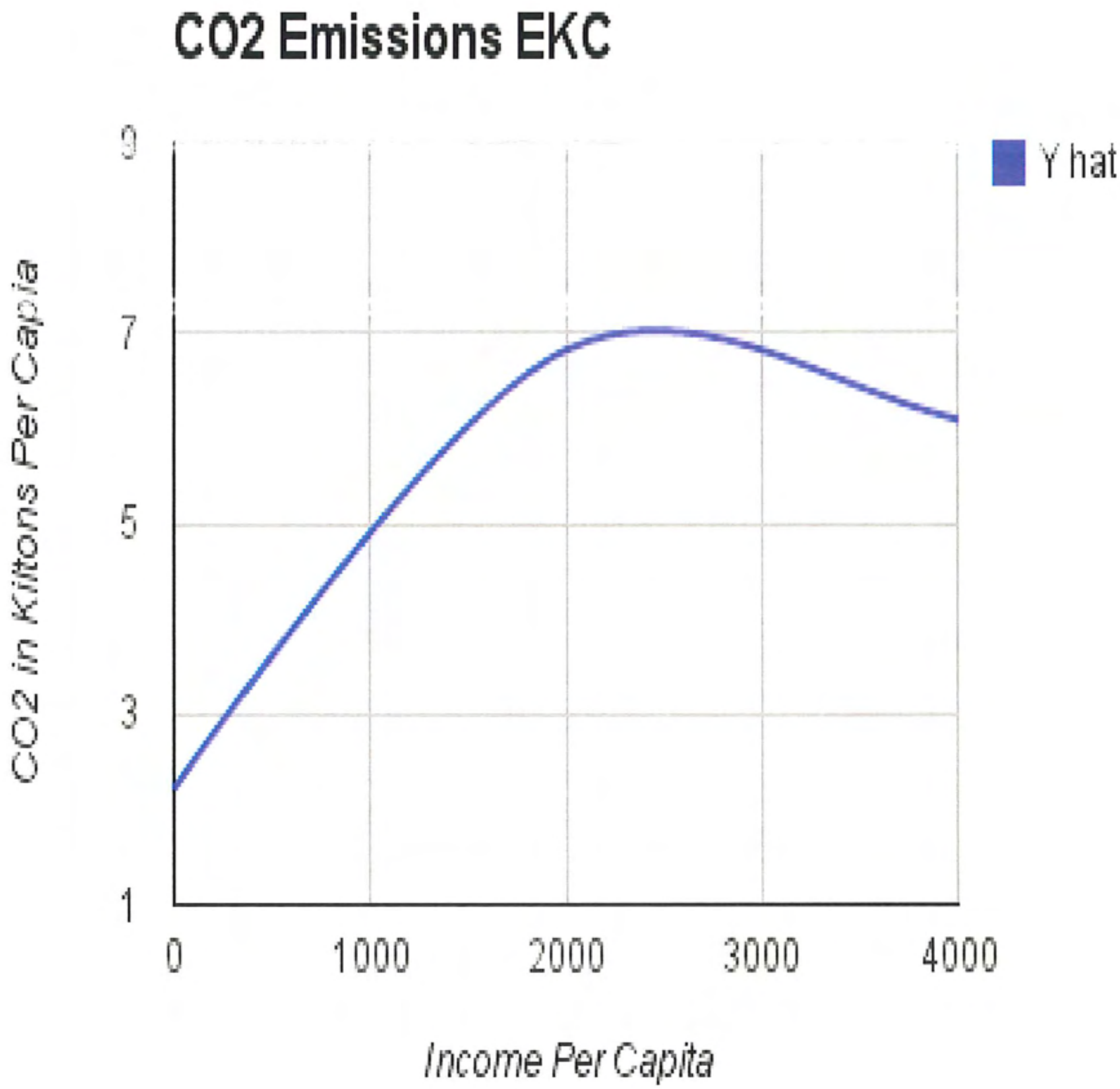


Figure 4. EKC graph for Nitrous Oxide Emissions

Peak: $1159.04

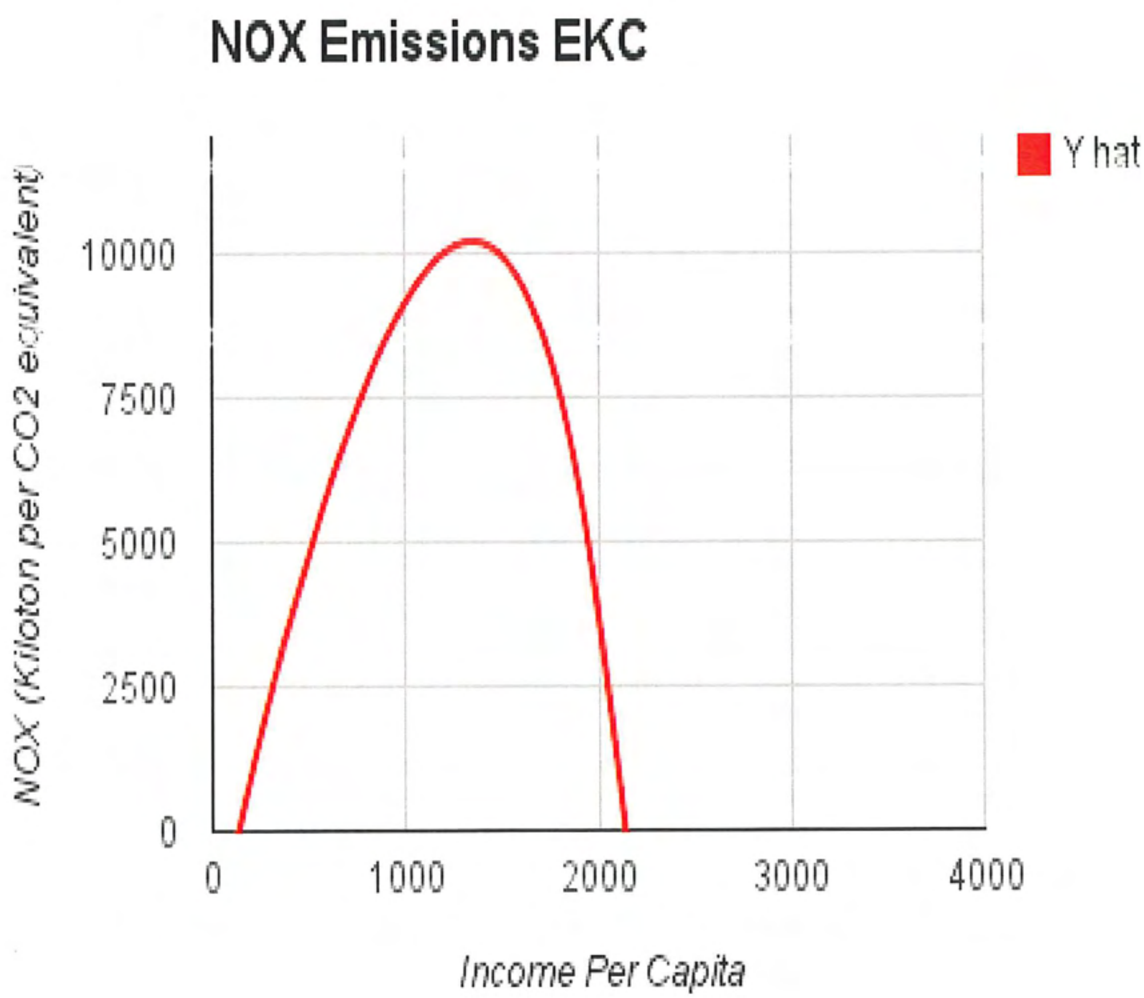
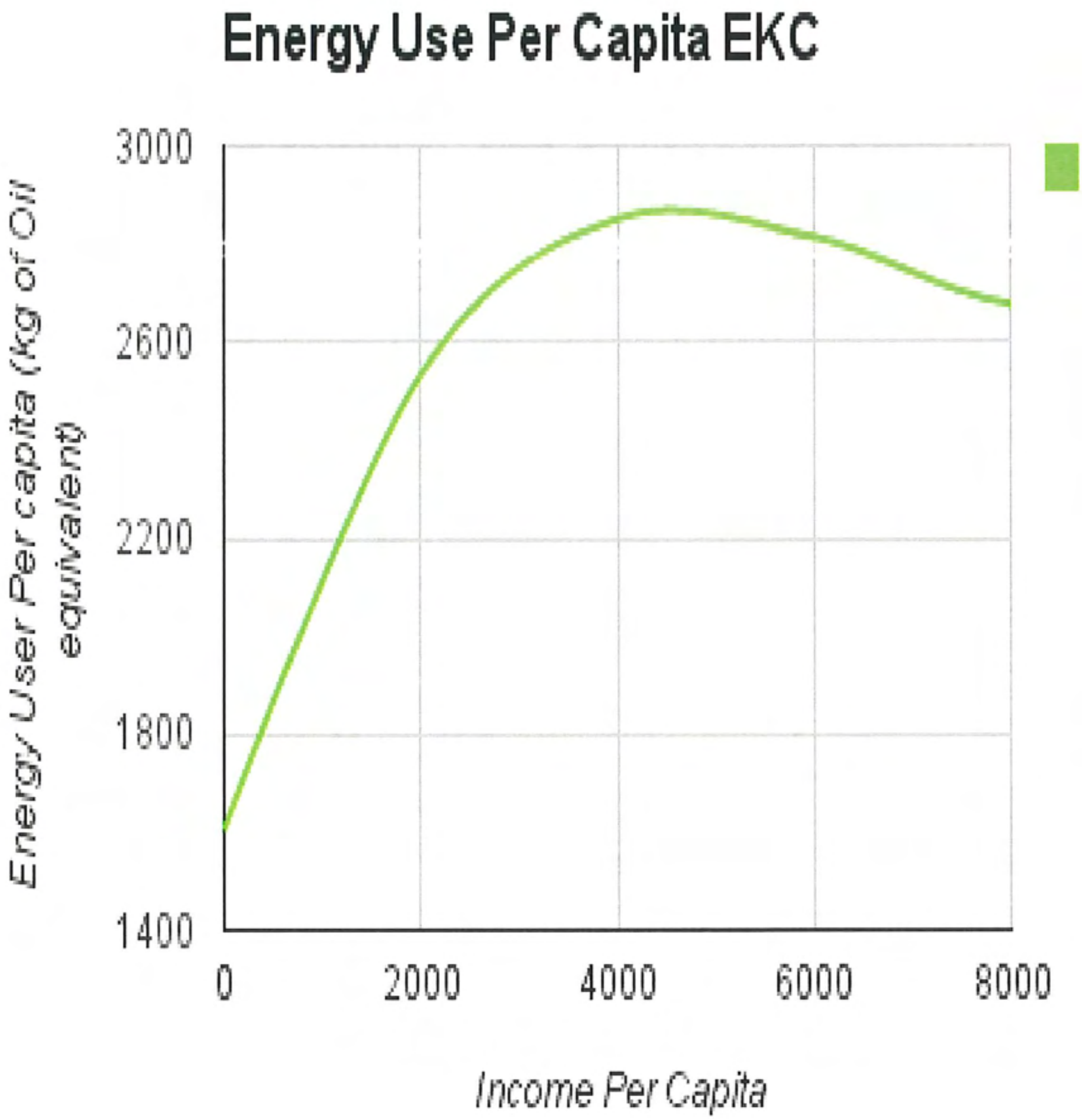


Figure 5. EKC graph of Energy Use per capita

Peak: $4627.26



Appendix B: Tables

Results:

EKC results (Table 1)

Dependent Variable	Co2 emissions		NOX Emissions		Energy Use per capita	
Independent Variables	OLS	RE	OLS	RE	OLS	RE
GDP	-0.00447	-0.00402	71.23821	61.95197	0.84195	0.618644
	0.24	0.0005	0.0211**	0.0021	0.352	0.1249
GDP2	5.39477E-07	2.0803E-07	-0.01995	-0.02091	-0.00018678	-0.00021
	0.6435	>.001***	0.1064	0.0074	0.5469	0.1316
GDP3	2.2752E-11	1.67E-11	0.00000161	1.972E-07	1.349E-08	1.66E-08
	0.823	>.001***	0.2289	0	0.6519	0
LagGDP	0.01612	0.008447	-33.78919	-37.2205	0.42109	0.040401
	0.0001***	0.0001	0.2001	0.0043	0.6456	0.9139
LagGDP2	0.00000455	-0.00000147	0.00871	0.011811	-0.00007122	0.000102
	0.0003***	0	0.4002	0.0207	0.8216	0.436
LagGDP3	3.63317E-10	8.26E-11	-7.24377E-07	-0.0000011	3.38958E-09	-1.13E-08
	0.0012***	0	0.5152	0	0.9116	0.01
Constants	-1.63648	2.215967	-12473	-2102.23	1135.25178	1603.783
	0.0031***	0.0177	0.1597	0.8252	.0001***	0
N	266	265	71	73	305	306
R2	0.4333	0.3233	0.2612	0.2082	0.1801	0.1408

Trade Openness results (Table 2)

Dependent Variable	CO_2 emissions			NOX Emissions			Energy Use per capita		
Independent Variables	OLS	FE	RE*	OLS	FE	RE*	OLS	FE	RE*
GDP	5.74114 0.0001***	1.471755 .0088***	1.595493 .0041***	2.84877 0.3159	0.414405 0.6968	0.557617 0.5957	-4.22185 .0001***	0.910593 .0758*	0.77541 0.1258
GDP2	-0.36352 0.0001***	-0.09036 .0261**	-0.09768 0.0152**	-0.15607 0.4487	-0.00923 0.9042	-0.01939 0.7977	0.33568 .0001***	-0.04956 0.1846	-0.03915 0.2887
Trade	0.20761 0.1025	-0.17882 .0040***	-0.17083 .0058***	-1.13968 0.0171**	-0.39982 .0133**	-0.41347 .0093***	-0.57904 .0001***	-0.08126 0.1841	-0.08602 0.1579
EUMem	-0.08278 0.7328	0.013911 0.8879	0.014529 0.8826	-1.33787 0.0807	-0.12706 0.4383	-0.13297 0.4156	-0.86342 .0001***	-0.02786 0.7718	-0.04475 0.6403
Constants	-21.65461 0.0001***	-2.98219 0.01398	-4.21721 .0340**	1.41953 0.8906	9.628989 .0197**	7.22048 .0705*	22.98392 .0001***	4.058472 .0287**	4.403408 0.0156**
N	266	267	267	71	72	72	305	307	307
Hausman Test P-val		0.1302			0.2393			0.1094	
R^2	0.5495	0.9503	0.1492	0.3117	0.9803	0.2693	0.2994	0.8919	0.0957

Summary Statistics:

EKC Summary Statistics (Table 3)

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP	310	1556.906	1501.349	122.0949	7072.436
GDP2	310	4670733	8761537	14907.15	50000000
GDP3	310	19800000000	51500000000	1820087	3.54E+11
LagGDP	309	1552.721	1461.005	123.8716	6808.89
lagGDP2	309	4676897	8477464	15349.47	46400000
LagGDP3	309	19800000000	49500000000	1902683	3.17E+11
CO2emissions	270	5.392155	4.100865	0.2992727	15.89545
Nitrousoxi~s	75	12308.3	24249.24	461.6	150941.5
EnergyusePC	315	2279.419	1392.223	335.5184	6315.931

Trade Openness Summary Statistics (Table 4)

Variable	Obs	Mean	Std. Dev.	Min	Max
lnGDP	310	6.935291	0.9266783	4.804798	8.86396
lnGDP2	310	48.95423	12.94033	23.08609	78.56979
LnTrade	307	4.521437	0.3577935	3.101382	5.296691
lnCO2	270	1.280014	1.019761	-1.2064	2.766033
LnNOX	75	8.314927	1.407167	6.134699	11.92465
LnENPC	315	7.483901	0.7741069	5.815677	8.750831

Appendix C: SAS Code

```
data one;
set FSUc;

/* Variable Creation and Manipulation*/
lngdp = log(gdp);
lngdp2 = lngdp**2;
lntrade = log(trade);
lnco2 = log(co2_emissions);
lnNOX = log(nitrous_oxide_emissions);
lnEngPC = log(energy_use_pc);
GDP2 = gdp**2;
GDP3 = gdp**3;
LGDP = lag(GDp);
LGDP2 = lag(GDP2);
LGDP3 = lag(GDP3);

 /*For European Union membership variables*/
EuMEM = 0;
if country_name = 'Estonia' and year = 2004 then EuMem = 1;
if country_name = 'Estonia' and year = 2005 then EuMem = 1;
if country_name = 'Estonia' and year = 2006 then EuMem = 1;
if country_name = 'Estonia' and year = 2007 then EuMem = 1;
if country_name = 'Estonia' and year = 2008 then EuMem = 1;
if country_name = 'Estonia' and year = 2009 then EuMem = 1;
if country_name = 'Estonia' and year = 2010 then EuMem = 1;

if country_name = 'Latvia' and year = 2004 then EuMem = 1;
if country_name = 'Latvia' and year = 2005 then EuMem = 1;
if country_name = 'Latvia' and year = 2006 then EuMem = 1;
if country_name = 'Latvia' and year = 2007 then EuMem = 1;
if country_name = 'Latvia' and year = 2008 then EuMem = 1;
if country_name = 'Latvia' and year = 2009 then EuMem = 1;
if country_name = 'Latvia' and year = 2010 then EuMem = 1;

if country_name = 'Lithuan' and year = 2004 then EuMem = 1;
if country_name = 'Lithuan' and year = 2005 then EuMem = 1;
if country_name = 'Lithuan' and year = 2006 then EuMem = 1;
if country_name = 'Lithuan' and year = 2007 then EuMem = 1;
if country_name = 'Lithuan' and year = 2008 then EuMem = 1;
if country_name = 'Lithuan' and year = 2009 then EuMem = 1;
if country_name = 'Lithuan' and year = 2010 then EuMem = 1;

proc corr;
proc means;
run;

/*OLS*/
data two;
set one;
if year = 1990 then delete;
if year = 1991 then delete;
if year = 2010 then delete;

proc reg;
      model lnCo2 = lngdp lngdp2 lntrade EuMem;
      model CO2_emissions = GDP GDP2 GDP3 LGDP LGDP2 LGDP3;
proc panel;
```

```
id country_name year;

/*Trade significance models*/
       model lnCo2 = lngdp lngdp2 lntrade EuMem /fixone robust;
       model lnCo2 = lngdp lngdp2 lntrade EuMem /Ranone robust;

       /*EKC models*/
              model CO2_emissions = GDP GDP2 GDP3 LGDP LGDP2 LGDP3 /ranone ro-
bust;
              model CO2_emissions = GDP GDP2 GDP3 LGDP LGDP2 LGDP3 /fixone ro-
bust;
       run;

data three;
set one;

if year = 1991 then delete;
if year = 1992 then delete;
if year = 1993 then delete;
if year = 1994 then delete;
if year = 1995 then delete;
if year = 1996 then delete;
if year = 1997 then delete;
if year = 1998 then delete;
if year = 1999 then delete;
if year = 2001 then delete;
if year = 2002 then delete;
if year = 2003 then delete;
if year = 2004 then delete;
if year = 2006 then delete;
if year = 2007 then delete;
if year = 2009 then delete;

/*OLS*/
proc reg;
       model lnNOX = lngdp lngdp2 lntrade EuMem;
       model Nitrous_oxide_emissions = GDP GDP2 GDP3 LGDP LGDP2 LGDP3;

proc panel;
id Country_name year;

/*Trade significance models*/
       model lnNOX = lngdp lngdp2 lntrade EuMem /fixone robust;
       model lnNOX = lngdp lngdp2 lntrade EuMem /Ranone robust;

       /*EKC Model*/
       model Nitrous_oxide_emissions = GDP GDP2 GDP3 LGDP LGDP2 LGDP3 /ranone
robust;
       model Nitrous_oxide_emissions = GDP GDP2 GDP3 LGDP LGDP2 LGDP3 /fixone
robust;

run;

data four;
set one;
```

```
/*OLS*/
proc reg;
       model lnEngPC = lngdp lngdp2 lntrade EuMem;
       model Energy_use_pc = GDP GDP2 GDP3 LGDP LGDP2 LGDP3;

proc panel;
id Country_name year;

/*Trade significance*/
       model lnEngPC = lngdp lngdp2 lntrade EuMem /fixone robust;
       model lnEngPC = lngdp lngdp2 lntrade EuMem /Ranone robust;

       /*EKC models*/
              model Energy_use_pc = GDP GDP2 GDP3 LGDP LGDP2 LGDP3 /ranone ro-
bust;
              model Energy_use_pc = GDP GDP2 GDP3 LGDP LGDP2 LGDP3 /fixone ro-
bust;

       run;
```

```
/*OLS*/
proc reg;
      model lnEngPC = lngdp lngdp2 lntrade EuMem;
      model Energy_use_pc = GDP GDP2 GDP3 LGDP LGDP2 LGDP3;

proc panel;
id Country_name year;

/*Trade significance*/
      model lnEngPC = lngdp lngdp2 lntrade EuMem /fixone robust;
      model lnEngPC = lngdp lngdp2 lntrade EuMem /Ranone robust;

      /*EKC models*/
            model Energy_use_pc = GDP GDP2 GDP3 LGDP LGDP2 LGDP3 /ranone ro-
bust;
            model Energy_use_pc = GDP GDP2 GDP3 LGDP LGDP2 LGDP3 /fixone ro-
bust;

      run;
```