ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF ARTS AND SOCIAL SCIENCES

ENVIRONMENTAL KUZNETS CURVE AND TRADE LIBERALIZATION

M.A. THESIS

Özgür Şen

Department of Economics

Economics Programme

Anabilim Dalı : Herhangi Mühendislik, Bilim
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İSTANBUL TEKNİK ÜNİVERSİTESİ SOSYAL BİLİMLER ENSTİTÜSÜ

ÇEVRESEL KUZNETS EĞRİSİ VE TİCARİ LİBERALİZASON

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Özgür Şen, a M.A. student of ITU Institute of Social Sciences Graduate School of Istanbul Technical University student ID 412101016, successfully defended the thesis entitled "Environmental Kuznets Curve and Trade Liberalization", which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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Date of Submission : May 02, 2016
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To my father and family,

FOREWORD

Environmental degradation and climate change are the most important side-effects of industrialization. In the near future it will become the reality of our daily lives. Hence its importance will increase as the anticipated detrimental effects are realized. Moreover, institutional structure of global economy and the global trade might have to be reassessed. This thesis aims to contribute to the issue of sustainability from a structural and institutional perspective.

I want to thank my thesis advisor, Ahmet Atıl Aşıcı, for his valuable contributions to my work.

May 2016 Özgür Şen

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ABBREVIATIONS

APP	**:** Appendix
CCE	**:** Common Correlated Effects
CIPS	**:** Cross-sectionally Augmented Panel Unit Root Test
CSD	**:** Cross Sectional Dependence
EKC	**:** The Environmental Kuznets Curve
FDI	**:** Foreign Direct Investment
FGPURT	**:** First Generation Panel Unit Root Testing
GEMS	**:** Global Environmental Monitoring System
GDP	**:** Gross Domestic Product
NAFTA	**:** North American Free Trade Aggrement
SGPURT	**:** Second Generation Panel Root Test

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THE ENVIRONMENTAL KUZNETS CURVE AND TRADE LIBERALIZATION

SUMMARY

This thesis investigates the potential effects of trade liberalization on the functional relationship between pollution and income, namely the Environmental Kuznets Curve, for a sample of 52 developing countries. Using GDP per capita as a measure of income and CO_2 emissions per capita as a measure of pollution, this study shows that trade liberalization has a signicant effect on the hypothesized relationship. Our results indicate that pre-liberalization period is characterized by a linear relationship. However, trade liberalization does not induce the pattern towards an inverted U-shaped relation. Instead, it accelerates income driven pollution. This finding is in line with the pollution haven hypothesis which claims that trade liberalization can be a trigerring factor in the relocation of the dirty industries via foreign direct investment (FDI) from the developed countries to the developing countries where the environmental standards are relatively less strict.

Estimations in the current study are conducted accounting for a potential non-stationarity in the data. The analysis on the (non)stationarity properties of the GDP per capita and emission per capita series indicate that these series are integrated of order one. Therefore, appropriate estimation strategies that can account for this property are employed. These strategies are using fifth-year observations and the Common Correlated Effects estimator suggested by Peseran (2007). Both strategies lead to similar conclusions.

It is shown that trade liberalization has a significant effect on the hypothesized relationship. Our results indicate that pre-liberalization period is characterized by a linear relationship. However, trade liberalization leads to a faster income driven pollution. Hence our results do not support the the environmental Kuznets curve hypothesis.

The economic expansion since the industrial revolution has been associated with a continuously increasing environmental degradation. Since then the question that whether this economic growth is sustainable or not has been one of the main themes in economics. In the environmental Kuznets curve literature, the answer to this question has been investigated by exploring the functional relationship between income and environmental quality. The EKC hypothesis conjectures an inverted-U-shaped relationship between per capita pollution and per capita GDP. That is, pollution increases with increasing income up to a threshold per capita income level which is called the turning point. After this threshold, pollution starts to decline leading to an improved environmental quality. More specifically, environment deteriorates at an increasing rate at the initial stages of economic development due to growing scale of the economy. However, economic growth comes with the remedy. At the later stages of economic development, once the threshold income level is

reached, higher income leads to progress in environment-friendly technologies, public preferences evolves towards an environment-friendly point leading to stricter environmental regulations, and the weight of the dirty goods in the aggregate output decreases. This leads to improved environmental quality.

ÇEVRESEL KUZNETS EĞRİSİ VE TİCARİ LİBERALİZASYON

ÖZET

Bu tezde ticari liberalizasyonun, çevresel tahribat ve gelir arasındaki fonksiyonel ilişkiye etkisi incelenmektedir. Literatürde bu fonksiyonel ilişki "Çevresel Kuznets Eğrisi" adıyla anılmaktadır. Bu tezde 52 tane gelişmekte olan ülke verisi kullanılmıştır. Çevresel tahribat için kişi başı CO_2 emisyon değişkeni, gelir içinse kişi başı GDP değişkeni kullanılmıştır. Çalışma sonucunda ticari liberalizasonun çevre kirliliği ve gelir arasındaki fonksiyonel ilişki üzerinde anlamlı bir etkisi bulunduğu görülmektedir. Sonuçlar ticari liberalizasyon öncesi ilişkinin doğrusal olduğunu, ticari liberalizasyon sonrasında ise Çevresel Kuznets Eğrisi'nin öngördüğü gibi (ters U şeklinde) bir ilişkinin olmadığı, aksine, ülkelerin gelir düzeyi arttıkça çevresel tahribatın da arttığına yönelik bir ilişkiye işaret etmektedir. Bu sonuçlar bizi literatürdeki "Pollution Haven" (Kirlilik Limanı) hipotezinde belirtilen ticari liberalizasyonun gelişmekte olan ülkelerde çevreyle ilgili düzenlemelerin gevşekliğinden dolayı doğrudan yabancı yatırımlar (DYY) vasıtasıyla kirli endüstrileri ülkeye çekerek çevresel tahribatın artışına yol açtığı tezini desteklemektedir.

Bu çalışmadaki analizler serilerin durağan olmama durumu göz öününde bulundurarak yapılmıştır. Yapılan testler sonucu kişi başı gelir ve kişi başına düşen emisyon serileri birinci dereceden birim köke sahip olduğu sonucuna varılmıştır. Bu yüzden serilerdeki durağan olmama problemine duyarlı olmayan tahmin yöntemleri kullanılmıştır. Serilerin durağan olmama problemine çözüm olarak düşündüğümüz bu yöntemler 5 yıllık gözlemlerin kullanılması ve Peseran (2007) tarafından önerilen Ortak Korole Etkiler (Common Corrolated Effects) yöntemleridir. Sonuçları aynı olan bu iki yöntemin birbirini sağladığı noktalar ve birbirlerine karşı üstünlükleri tezde geniş bir şekilde tartışılmıştır.

Tezin sonucunda ticari liberalizasyonun kişi başı gelir ve kişi başına düşen emisyon oranları arasındaki ilişkiye anlamlı bir etkisi olduğu ortaya çıkmaktadır. Bunun yanında ticari liberalizasyon öncesi varsıyan ilişki doğrusal bir fonksiyonla açıklanabilirken liberalizasyon sonrası kişi başı gelirin artışına bağlı olarak emisyonların hızlanarak arttığı görülmektedir. Bu sonuçlar ise bii Çevresel Kuznets Eğrisi'nin öngördüğü sonuçların tam tersi bir sonuca götürmektedir.

Endüstri devriminden itibaren artan ekonomik aktiviteler çevresel tahribatın da artışını birlikte getirmiştir. Dolayısıyla yer yüzünün taşıma kapasitesinin sınırlı olması iktisadi aktivitelerin artarak devam etmesinin çevresel sonuçları açısından sürekliliğini tartışmaya açmaktadır. Çevresel Kuznets Eğrisi ile ilgili yapılan çalışmalarda iktisadi aktivitelerin sürekliliğiyle ilgili çarpıcı sonuçlar ortaya koymuştur. Varsayılan ilişki kişi başı gelir arttıkça çevresel tahribatın azalarak artmasına ve belli bir eşik değerinden sonra ise bu ilişkinin terse dönerek kişi başı gelir arttıkça çevresel tahribatın azalması ile sonuçlanacağını öngörmüştür. Bu ters-U

şeklindeki ilişki düşük gelir ve orta gelir seviyesindeki ülkeler için incelenen bu tezde varılan sonuçlarda yukarıda da belirtildiği üzere ticari liberalizasyonun varsaylan ilişkiye anlamlı bir etkisi bulunduğu ve bu etkinin de varsayılanın aksine çevresel tahribatı hızlandırarak arttırdığı yönünde olmuştur.

1. INTRODUCTION

Over the last decade, many developing countries, such as China, India, and Turkey, has experienced an economic expansion. According to many researchers, this is due to globalization (Scott and Taylor, 2014). While globalization might have many side effects, the discussions concerning trade liberalization and the environment has been at the center of the academic debate and the public discussion. There are many questions revolving around the relationship between free trade, income growth, and environmental pollution: Does free trade induce economic growth in the developing countries? Does trade liberalization shift the developing countries towards a more pollution intensive pathway? Is there a trade-off between income growth and environmental quality, or does income growth comes with the remedy as hypothesized in the environmental Kuznets curve (EKC) literature? This thesis concentrates on the effect of the interaction between trade liberalization and income growth on environmental pollution. The aim is to shed light on this discussion by providing a fresh way to evaluate this triangular relationship. More specifically, in the empirical analysis of the current study, trade liberalization is considered as a shock which might alter the functional relation between income and pollution.

The starting point of this thesis is the EKC relation. In this strand of literature, it is hypothesized that there is an inverted-U shaped relationship between economic activity and environmental pollution. That is, the initial stages of economic development lead to more environmental degradation. However, after a threshold income level, income growth has positive marginal effect on the environmental quality due to factors such as changes in industrial composition, progress in environment-friendly technologies, or changes in public preferences for environmental quality. In their seminal paper, Grossmann and Krueger (1995) find an N-shaped relation for CO_2 emission and a U-shaped relation for the SO_2.

Following Grossmann and Krueger (1995), a substantial body of literature investigating this hypothesis use various pollutants as indicators of environmental degradation, employ different estimation strategies, and study many sub-samples of

countries or regions. The common practice is to regress CO_2 emissions per capita (as an indicator of environmental pollution) on the polynomial terms of GDP per capita (as an indicator of the level of economic activity). This framework is the basis of the empirical analysis of the current study.

The role of trade liberalization in the EKC literature is limited. In general, trade related variables are employed as control variables (eg. Ozler and Obach (2009) and Dasgupta et al. (2002)). On the other hand, the current study investigates environmental consequences of not only the income level and the trade liberalization separately, but also the interaction between these two factors. More precisely, what is investigated is whether there is a change in the functional relation between income and pollution following the date of trade liberalization for a sample of 52 developing countries. The data on trade liberalization date is from Ghani (2012). The thesis introduces liberalization date into the general EKC model as a dummy variable. The interaction of the liberalization dummy with GDP per capita and its higher order polynomial terms form the basis to test the stated hypothesis above. Significance of these interaction terms indicates a change in the functional relation following the trade liberalization. The results indicate that, while there is a linearly increasing relation between GDP per capita and carbon emissions per capita, this relation changes following the trade liberalization. The striking result is that trade liberalization even leads to an accelerated increase in emissions. In other words, trade liberalization is far from creating an environmentally beneficial outcome. This finding can be interpreted as a supportive empirical evidence for the pollution haven hypothesis, since trade liberalization might be a triggering factor leading to the inflows of dirty industries to the developing countries.

Estimations in the current study are conducted accounting for a potential non-stationarity in the data. The analysis on the (non)stationarity properties of the GDP per capita and emission per capita series indicate that these series are integrated of order one. Therefore, appropriate estimation strategies that can account for this property are employed. These strategies are using five-year observations and the Common Correlated Effects estimator suggested by Pesaran (2007). Both strategies lead to similar conclusions.

The rest of the thesis is organized as follows. In Section 2, an extensive literature review is presented. Section 3 describes the dataset employed and presents some

descriptive statistics. A preliminary analysis, to describe the hypothesis to be tested, is provided in Section 4. The empirical model is described in Section 5. Non-stationarity properties of the data series is investigated in Section 6. This section also describes the estimation strategies to account for the non-stationarity. Section 7 presents the estimations results, and Section 8 is the conclusion.

2. LITERATURE REVIEW

This section presents an overview of the preceding literature and explains how the current thesis contributes to this literature. The section starts with the EKC literature, and go on with the literature on the trade liberalization-environment relationship. Final subsection explains the contribution of the current study to the literature.

2.1 The Environmental Kuznets Curve: Income and Pollution

The economic expansion since the industrial revolution has been associated with a continuously increasing environmental degradation. Since then the question of whether this economic growth is sustainable or not has been one of the main themes in economics. In the environmental Kuznets curve literature, the answer to this question has been investigated by exploring the functional relationship between income and environmental quality. The EKC hypothesis conjectures an inverted-U-shaped relationship between per capita pollution and per capita GDP. That is, pollution increases with increasing income up to a threshold per capita income level which is called the turning point. After this threshold, pollution starts to decline leading to an improved environmental quality. More specifically, environment deteriorates at an increasing rate at the initial stages of economic development due to growing scale of the economy. However, economic growth comes with the remedy. At the later stages of economic development, once the threshold income level is reached, higher income leads to progress in environment-friendly technologies, public preferences evolves towards an environment-friendly point leading to stricter environmental regulations, and the weight of the dirty goods in the aggregate output decreases. This leads to improved environmental quality.

There are several explanations for the EKC hypothesis. Grossmann and Krueger (1991) put forward three factors: scale, composition, and technological effects. It is argued that, with the growing scale of economic activity, environmental quality decreases with an increasing natural resource usage and related emission from

economic activity. However, with increasing income, the composition of output and input changes and the economic growth becomes more knowledge based leading to a decrease in emission intensity. This is called the compositional effect. Finally, the technology effect is defined as the progress in the abatement technologies which contributes to environmental quality. While the scale effect is more dominant at the initial stages of the economic development, at the later stages the composition and technological effects compensate for the scale effects.

The early empirical literature following Grossman and Krueger (1991) uses polynomial regressions and applies panel data techniques (Holtz-Eakin and Selden (1995), Cole et al. (1997)). In this strand of literature, the results are mixed. In general, the findings indicate an inverted-U shaped relation for SO_2 but not for CO_2.

The second wave of the EKC literature focuses on the econometric techniques. Taskin and Zaim (2000) employs panel data techniques. They find a significant relationship in favor of the EKC hypothesis. Millimet and Stengos (2003) employ a semiparametric partially linear regression on US state level data for time period 1929-1994 and they find evidence consistent with the EKC hypothesis in particular for nitrogen oxide. Dijkgraaf et al. (2005) employ parametric and non-parametric estimation techniques with a dataset for OECD countries for the period 1960–1997. They criticize the assumption of homogeneity across countries in the panel data estimations Martínez-Zarzoso and Bengochea-Morancho (2004) use a pooled mean group estimation technique. This allows for heterogeneity across countries. Their results indicate an N-shaped relationship between per capita income and carbon dioxide emissions.

Finally the more recent literature focuses on the non-stationarity properties of the emission and GDP series (for example, see De Bruyn et al. (1998) for one of the early discussions). Muller-Furstenberger and Wagner (2007) and Hong and Wagner (2015) argue that if one uses a non-linear functional specification of a nonstationary variable, an appropriate estimation technique is necessary.

2.2 Trade Liberalization and Pollution

The effect of trade on the environment has been studied extensively. Many environmentalists claim that globalization causes a shift of dirty industries to low

income countries, which leads an increase in global pollution while high income countries decrease their pollution level locally. In particular, one of the most well-known arguments in the literature is about the migration of dirty industries from developed countries to developing countries with increasing globalization, known as the Pollution Haven Hypothesis. For example, Taylor and Copeland (2004) argue that international trade causes poor countries which have lax environmental regulations to attract dirty industries, while rich countries with tight environmental regulations specialize on clean service oriented industries. They put forward two concerns about the pollution haven effect. First, trade openness might create the pollution haven effect even the scale of economy in the developing countries doesn't grow. Second, poor countries have to bear the pollution burden of rich countries' consumption. This process together with increasing trade competition between developing countries results in the race to bottom.

The empirical tests of the Pollution Haven Hypothesis are generally based on the investigation of FDI flows, since FDI can be considered as the most important outcome of trade liberalization. These two relationships are the essence for the discussion of the Pollution Haven Hypothesis. He (2006) finds that the total effect of FDI on industrial SO_2 is very small by conducting estimations using a panel data of 29 provinces of China. In the same study, it is stated that the composition effect associated with the FDI inflows and indirectly by trade liberalization is responsible for this small effect.

Besides the harmful effects of liberalization, Gains from Trade Hypothesis states that there might be beneficial effects of liberalization on environmental quality. For example, liberalization might allow companies to interact with each other and may force them apply better practices. The process may occur in two ways. First possibility is that liberalization may lead firms to apply innovative strategies and adopt technological improvements in the advanced economies. That is, liberalization may increase absorption of frontier best practices and technologies. As an example, Pamukcu (2003) argues that, following the trade liberalization in Turkey, Turkish domestic firms are forced to apply more effective technologies to compete with international rivals. Vogel (1995) argues that, when State of California sets higher environmental legal standards for auto pollution, other states in US were forced to

apply similar standards. In particular, international companies played a crucial role in this process via introducing clean techniques from developed countries.

Empirical findings in the literature about the effects of trade on the environment are ambiguous. Some of the findings suggest that international trade has a negative effect on environmental quality. Lopez (1994) finds an inverted U-Shaped relationship between environmental degradation and trade liberalization. Xing and Kolstad (2002) find a weak relationship between trade openness and environmental degradation for both developing and developed countries. Dasgupta et al. (2002) indicate that liberalization leads to the growth of polluting industries in the developing countries such as garment industry. They also find that elimination of government subsidies leads a reduction in the scale of polluting activities in developed countries. Lucas et al. (1993) find that trade-distorting policies increase pollution dramatically in developing countries. Baek et al. (2009) test short and long run relationships among trade liberalization and environment in India and China. They use co-integration analyses and a Vector Error Correction Model (VEC) to estimate the relationship. They find that as trade openness increases environmental degradation increases both in the short run and long run.

There is also evidence that liberalization has a positive effect on environment. Wheeler (2000) argues that trade liberalization may increase efficiency especially in publicly held sectors. Wang and Wheeler (2007) argue that following liberalization and privatization, concentration of polluters such as SO_2 decreases. Eskeland and Harrison (2003) show that foreign production plants use more efficient and cleaner technology than domestic ones. They examine the relationship between trade openness and the environmental degradation in China, and find that environmental degradation decreases with higher openness. Acharyya (2009) examines two important possible consequences of foreign direct investment on environment in the case of India. It is shown that there is a long run relationship between growth and FDI, but not between FDI and environmental degradation, which is a contradictory finding to Pollution Heaven Hypothesis. The author indicates that after the mid-90s, the share of pollution intensive industries has been declining due to less demand for these industries and higher abatement spending for pollution-intensive industries. The decline of the proportion of the dirty industries doesn't mean that their absolute

pollutant effect is declining. It is noted that, at the end of the century, India is going to have the fourth highest CO_2 emission in the world.

This literature focuses on the direct effect of trade liberalization on the environment. In other words, these studies investigate the direct effect of trade openness on either income or environmental quality. In this thesis, a different approach is followed, and it is investigated that whether the hypothesized relationship in the EKC literature is subject to a fundamental change after trade liberalization.

2.3 Trade liberalization, Environment, and Income

The strands of empirical literature, reviewed in the previous subsections, focus on the direct effects of trade liberalization. In other words, these studies investigate the direct effect of trade related variables, such as trade openness, on either income or environmental quality. The current study takes a different approach, and investigate whether the hypothesized relationship in the EKC literature is subject to a fundamental change after trade liberalization. Therefore, in opposed to the previous literature, this study empirically investigates the triangular relationship between trade liberalization, income, and environmental quality in the same empirical framework.

The causality chain in this triangular relationship might take place in many ways. One can also argue that environmental quality might also effect income. In this respect, this study focuses on a specific case. But it is more general then the previous literature. The hypothesis includes not only the direct effect of trade liberalization and income level on pollution, but also the effect of the interactions between trade liberalizationa and income level on pollution. Other potential interactions in this triangular relationship are left as future research. One example is the effect of pollution on ourput. This might be less relevant for CO_2 for the observed period, but it is argued that local pollution, in particular related concerns on water quality, might be relevant for such a concern.

3. DATASET AND DESCRIPTIVE STATISTICS

In the literature, as a proxy of pollution level, the common approach is to use emissions of some greenhouse gasses, such as CO_2, CO, SO_2, ozone, suspended particles, lead, and nitrogen-oxide. Emission of CO_2 is the most common type of pollutant. That is why CO_2 is called global pollutant (Acharyya, 2009). This thesis employs a panel dataset with 51 low and middle-income countries spanning between 1960 and 2008, and investigates the effect of liberalization on the relationship between GDP per capita and CO_2 emissions per capita. CO_2 emissions and GDP per capita datasets are from World Development Indicators (Online database of the World Bank).

Liberalization dates are from the study of Ghani (2012) which are provided in Appendix A, with the country list subject to this study. Trade liberalization dates take into account within-country responses to growth, and also breaks in the growth, investment, and openness. In addition, the data takes into account many characteristics of trade liberalization such as having tariffs less than 40% of exported products, not having non-tariff barriers, whether having export marketing board, whether having a socialist regime, and whether having a significant black market premium on exchange rates. Another important point is that liberalization dates indicate uninterrupted liberalized periods related to the properties stated above.

Low and middle income countries are at the center of focus in the current study. A substantial body of the related literature focuses on high income countries, or does not differentiate between high and low income countries. This approach neglects the development pattern in low and middle income countries, and it is based on the assumption that low income countries will eventually follow the path traced by high income countries. This approach is not suitable to capture specific effects, such as the potential pollution haven-bearing effects, which requires a separate investigation of high and low income countries. The selection of the countries is also restricted by the

data availability for our sample period, during which most of the liberalization processes in developed countries had taken place before the available data period for CO_2 emissions per capita and GDP per capita. For example, CO_2 emissions per capita series starts in 1960, and high income countries' liberalization dates are earlier than 1960.

GDP per capita refers to Gross Domestic Products per Capita constant at 2005 US Dollars. CO_2 emission per capita is defined in World Development Indicators Catalog as those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide metric tons per capita produced during consumption of solid, liquid, and gas fuels and gas arising. In Figure 3.1, a sample of developing country carbon emissions per capita is presented. Carbon emissions per capita patterns have increasing trends but their increasing trends have heterogeneous patterns. Emissions per capita by South Korea and Greece increase dramatically over years. While, in initial years, South Korea's emissions per capita pattern is the lowest second place in the sample, it turns out to be the highest level of emissions in the sample due to the highly spectacular economic development.

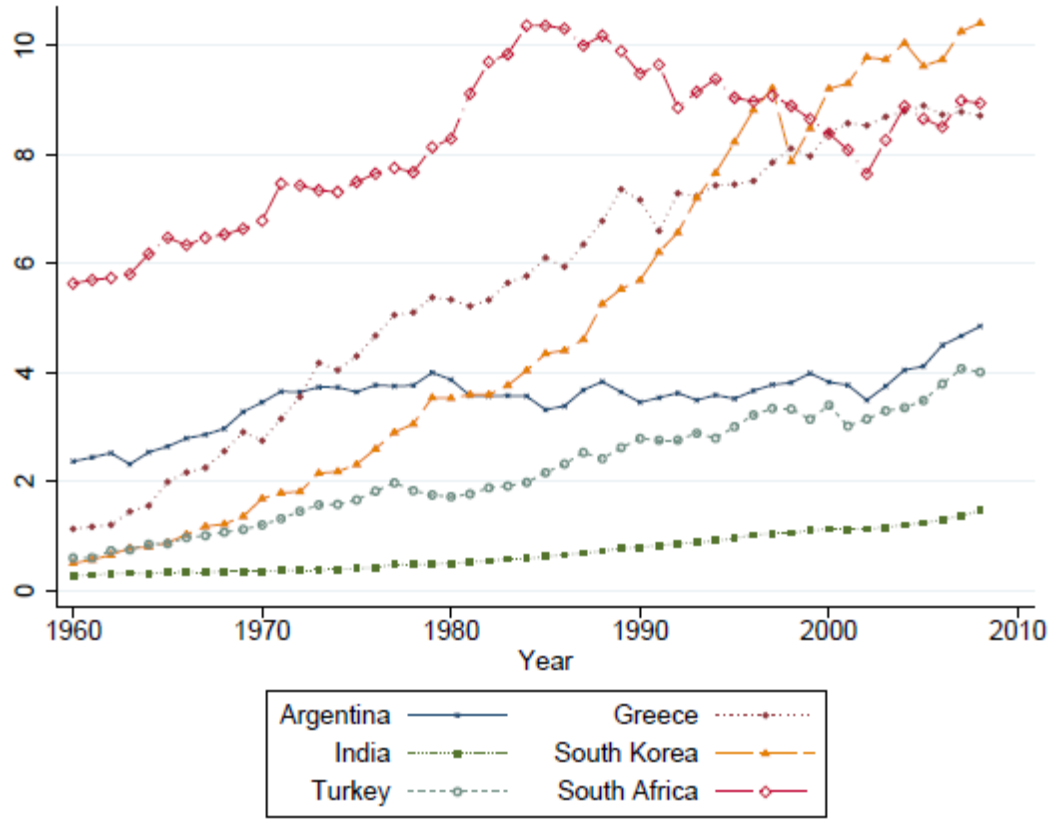

Figure 3.1: Carbon Dioaxide Emissions (Metric tons per capita).

In Figure 3.2, GDP per capita of the same sample of the developing countries are presented. GDP per capita patterns have again heterogeneous increasing trends and some of them are correlated with carbon emission per capita patterns, but for some of them, the correlation is less clear. South Korea's GDP per capita trend seems to be highly correlated with its carbon emissions per capita trend. While carbon emission per capita level is among the highest levels in the sample, South Africa's GDP per capita level is among the lowest levels, which can indicate that low environmental standards may trigger an increase in carbon emission. Argentina and Turkey's GDP per capita patterns have steady increasing trends, correlated with their carbon emissions per capita levels. While Argentina's pattern is floating more, Turkey's GDP per capita pattern is steadier. India's GDP per capita pattern is highly correlated with its carbon per capita pattern until 80s but after 90s carbon per capita pattern increases more dramatically compared to GDP per capita.

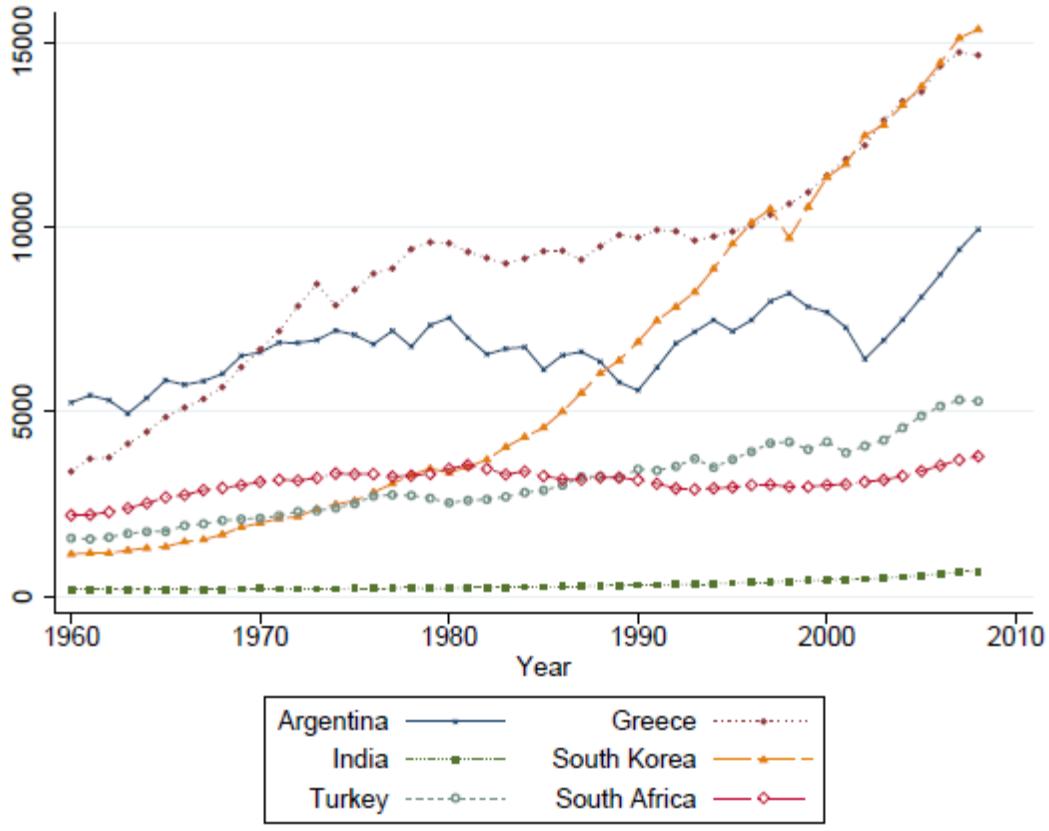

Figure 3.2: GDP Per Capita (in 2000 US$)

In Table 3.1, some descriptive statistics for carbon emissions per capita and GDP per capita levels are presented. For carbon emissions per capita mean value is 2,18

metric tons per capita, while standard deviation is 3 metric tons per capita, and minimum value is 0,01 metric tons per capita, and maximum value is 37,39 metric tons per capita which indicates that mean value is closer to low values and standard deviation is very high due to differences in development processes of the countries. Minimum value is recorded for Ethiopia for the year 1961. Maximum value is recorded for Trinidad and Tobago for the year 2008. Further details about the descriptive properties of the data set are provided in the Appendix.

Table 3.1: Descriptive Statistics

	Mean	St. dev.	Min	Max	Skewness	Kurtosis
Emission pc. (metric tons per capita)	2.18	3.00	0.01	37.39	3.31	21.56
GDP pc. (2000 US $ per capita)	2203.00	2396.62	102.20	15349.85	1.99	7.75
Number of observations is 2499.						

4. DESCRIPTIVE ANALYSES

This section proceeds with some descriptive analysis on the fit between emissions and GDP per capita. The first goal is to provide an intuitive presentation of the hypothesis. Secondly, this section aims to illustrate how taking into account certain econometric problems can lead to different conclusions and motivate our empirical strategy.

As the starting point, Figure 4.1 illustrates the fit between GDP and emission by concentrating on the change throughout the sample period. This strategy eliminates fixed effects by differencing between the initial and final periods and does not suffer from non-stationary problems. The price is the low number of observations. Later, other strategies will be employed in order to illustrate the relationship by trading off the number of observations and other possible econometric problems. In Figure 4.2, it is seen that the relation is positive, and the quadratic and non-parametric (lowess) fit are very close. This shows that, on average, the growth in GDP per capita is associated with a growth in emissions per capita in our sample period.

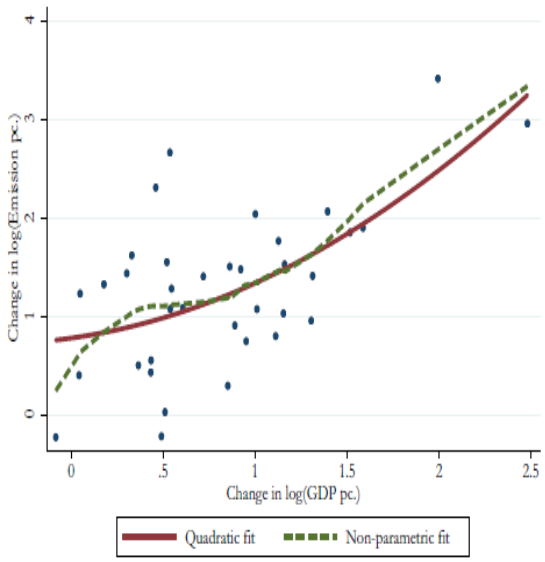

Figure 4.1: Fit Between Emissions Per Capita and GDP Per Capita Growth

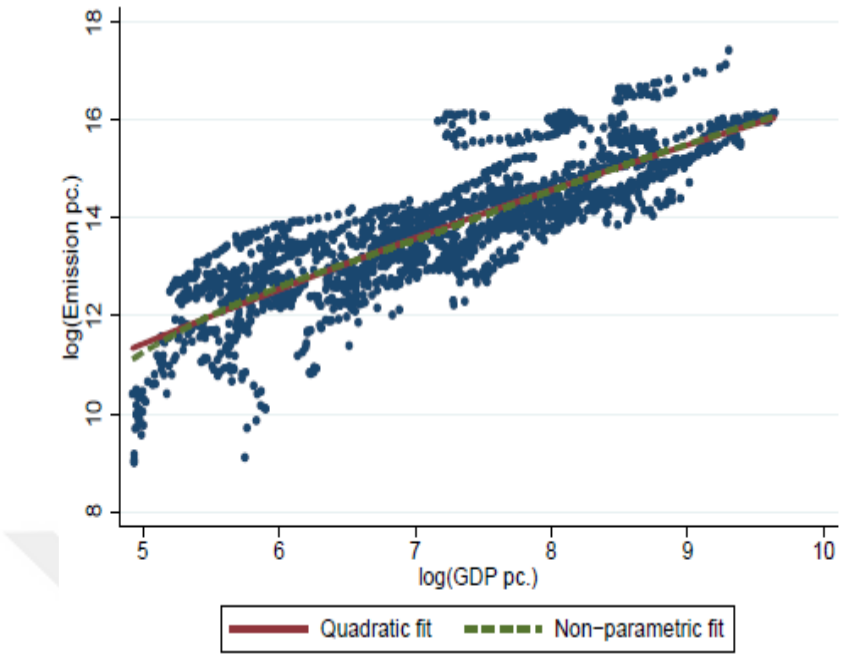

Figure 4.2: Emissions vs GDP Fit

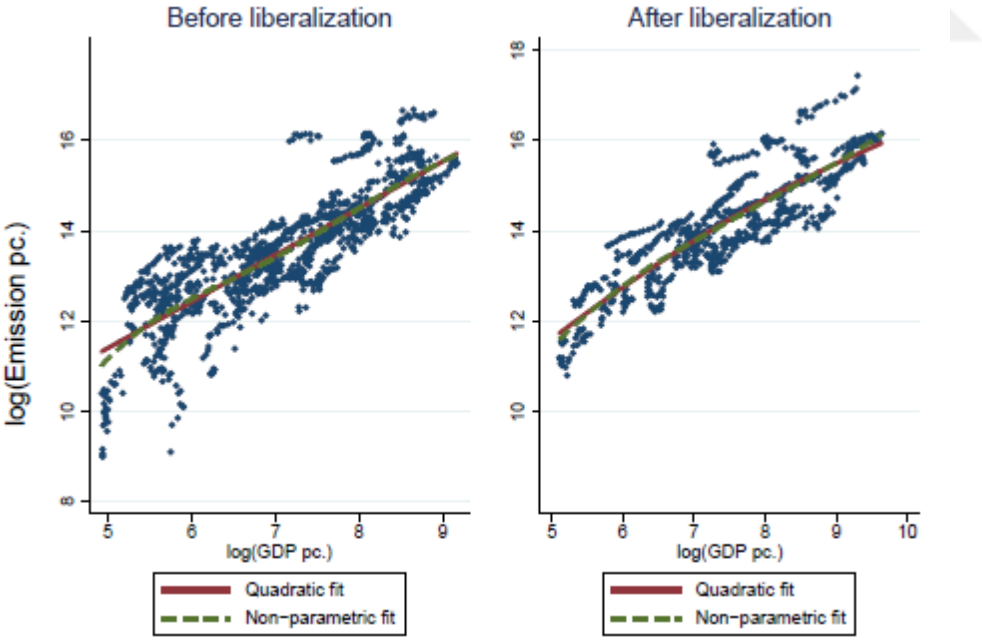

Figure 4.3: Emissions vs GDP Fit For the Pre and Post Liberalization Periods

In Figure 4.2, the scatter plot illustrates the quadratic and non-parametric fit by using our full sample at log-levels of the variables. Firstly, it is apparent that there is no clear slow-down in emissions with the increasing income. Secondly, quadratic and non-parametric fits are very close. As a result, at the full sample, there is a drift towards upward but an EKC relation seems to be unlikely.

The next Figure plots the same diagram for pre- and post-liberalization periods. In Figure 4.3, the fit between emissions and GDP per capita seems to be linearly increasing for the pre-liberalization period. Therefore, there is no sign of a EKC type relationship. On the other hand, in the post liberalization period, there seems to be a drift towards upwards and a slowdown in the rate of increase in the emissions with the increasing GDP per capita. However, this deceleration seems to be a very weak one. One potential problem with this analysis is that it does not take into account country specific effects, which might lead to biased representation. Next, this problem will be handled.

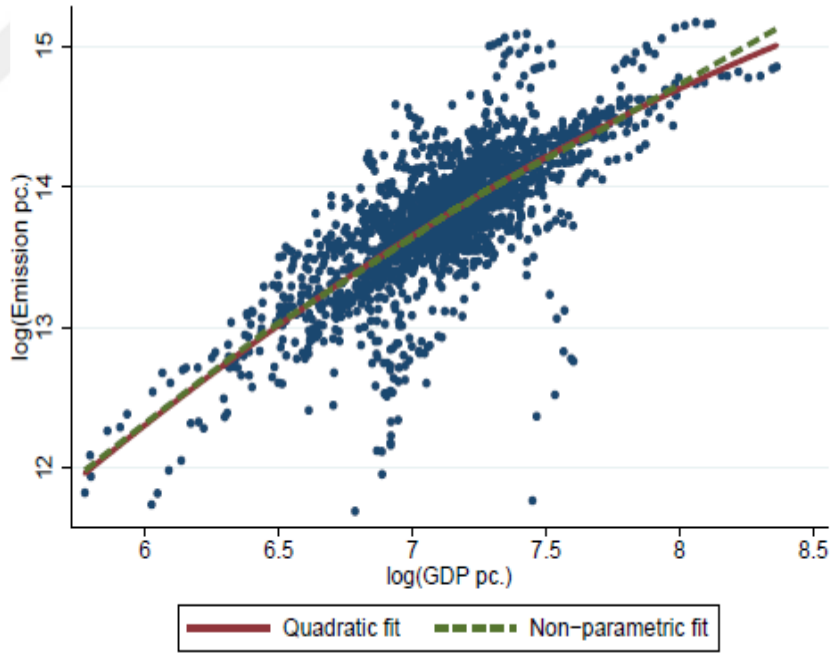

Figure 4.4: Without Country Specific Effects: Emissions vs GDP Fit

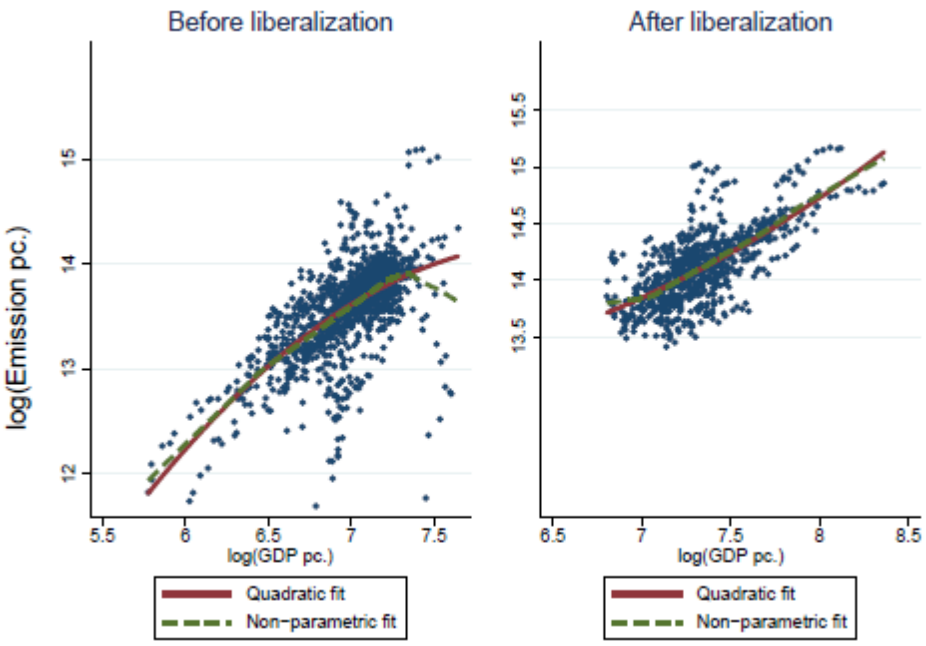

Figure 4.5: Without Country Specific Effects: Pre and Post Liberalization Periods

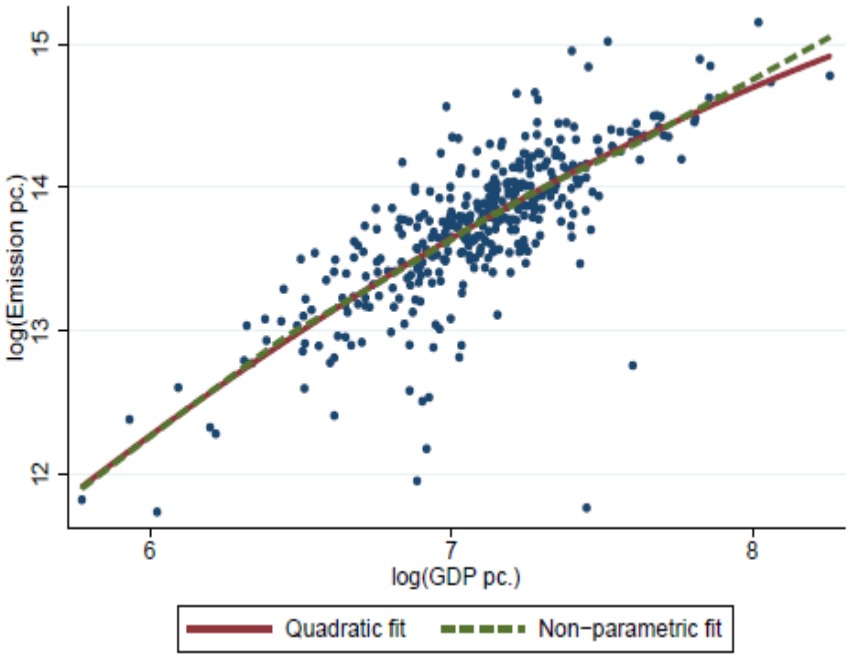

Figure 4.6: Five-Year Observations: Emissions vs GDP Fit

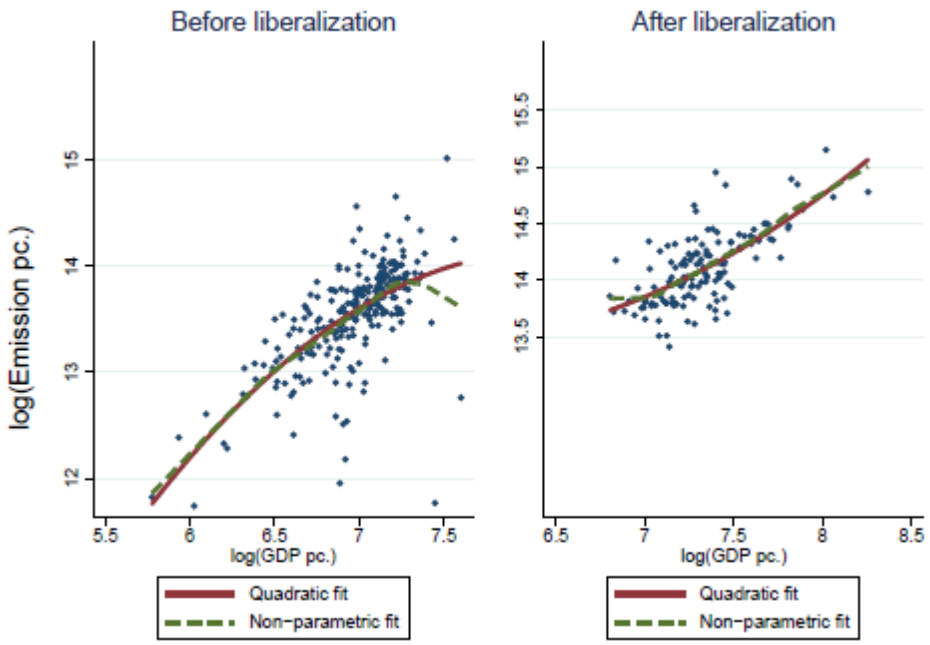

Figure 4.7: Five-Year Observations: Pre and Post Liberalization Periods

In Figure 4.4 and 4.5, the same analysis is repeated by removing the country specific effects via within transformation. The picture is substantially different. The fit for the full sample indicates a slowdown in the emission. This seems to be the case also for the pre-liberalization period. However, in the post liberalization period the relation is reversed. There is a clearly visible acceleration in the emissions with the rising income. This indicates that liberalization associates with higher rate of environmental degradation.

One final potential econometric problem is that GDP and emission per capita series might be non-stationary. One way to deal with this problem is to use five-year observations. In Figure 4.6 and 4.7, the same analysis presented only by using the five-year observations. This does not change the conclusion of the fixed effects analysis.

The results in this section indicate that liberalization in developing countries is associated with a higher rate of environmental degradation due to rising income. Another result is that controlling for fixed effects seem to be important. The non-stationarity in the variables will be analyzed extensively in the following sections.

5. EMPIRICAL MODEL

The initial studies, which hypothesize an inverted-U or N shaped relationship between income and environmental quality, use simple polynomial functions of income to test this hypothesis in a panel setting. Shefik and Bandyopadhyay (1992) find an inverted U-shape relationship by using cubic function with log-linear and log-quadratic functions. In more recent years Millimet and Stengos (2003) use US State Level Data between 1929 - 1994 employing a semi parametric partially linear regression and their findings are supportive for the EKC hypothesis. The traditional EKC is formulized as follows:

$$\ln(Y_{it}) = \alpha_i + \gamma_t + \beta_1 \ln(X_{it}) + \beta_2 [\ln(X_{it})]^2 + \varepsilon_{it} \quad (5.1)$$

where Y indicates emissions per capita and X indicates GDP per capita. The first two terms on the right hand side indicate intercept parameters that span across countries, i, and years, t. Income elasticity of emissions per capita is assumed not to change, even though emissions per capita over countries for certain income level are allowed to change. Stochastic shocks for all countries and time varying omitted variables are indicated by time specific intercepts.

In order to test the effect of liberalization on the income-pollution relationship, the current paper augments the simple EKC model with a dummy variable representing the liberalization date. The model is formulized as follows:

$$\ln(Y_{it}) = \alpha_i + \gamma_t + \beta_1 \ln(X_{it}) + \beta_2 [\ln(X_{it})]^2 + \beta_5 Z_{it} + \beta_3 Z_{it} \ln(X_{it}) + \beta_4 Z_{it} [\ln(X_{it})]^2 + \varepsilon_{it} \quad (5.2)$$

where Z indicates liberalization date which is a dummy variable, denoting the effect of liberalization on the relationship between X and Y via its interaction with X. When a country is liberalized, Z becomes "1". Otherwise for pre-liberalization period Z is "0". In this specification, if $\beta_1>0$ and $\beta_2<0$ then there is an EKC relation prior to liberalization. If β_2 is insignificant, then EKC is not supported. If $\beta_3=0$ and $\beta_4=0$, then the pre-liberalization relationship persists in the post-liberalization period where liberalization doesn't have a significant effect on the relationship between income

and environmental degradation. If any of these two parameters are significantly different from zero, then it means there is a significant change in the income-pollution relationship induced by liberalization. Finally β_5 indicates initial effect of liberalization which will be analyzed in results section.

6. NON-STATIONARY

A recently raised concern about the specification in equation 5.2 is that the emissions and GDP per capita series might be non-stationary. Therefore, this can lead to a spurious regression. In order to understand whether non-stationarity is a series concern in the current study, panel unit tests are applied. Departure point is the first generation panel unit root tests (FGPURT) which ignores cross-sectional dependence.

6.1 First Generation Panel Unit Root Tests

There is a power problem in the univariate unit root tests. In order to test for unit roots, both the information contained in the within and between dimension of the panel can be used. The general model for a single series, y_{it} , is as follows:

$$y_{it} = \alpha_{0i} + \rho_i y_{i,t-1} + \alpha_{1i}t + u_{it} \quad (6.1)$$

Formulation contains individual specific parameters α_{0i}, ρi, and α_{1i}. The term $\alpha_{0i} + \alpha_{1i}t$ is the deterministic trend. The error term u it is assumed to be identically and independently distributed (iid) . The null hypothesis is that all series have a unit root, that is $\rho_i=1$, for all i's. The alternative is that at least one of the series is stationary. In this section, we present results from seven first generation unit root tests in Table 6.1. These tests differ in their assumption about the data generating process. These tests are Levin et al. (2002) (LLC) test, Breitung (2000) test, Im et al. (2003) (IPS) test, two Fisher-type tests, and Hadri (2000) test. Only the Hadri test deviates from other in terms of the null hypothesis. In Hadri test, stationarity of all series is the null hypothesis, and the alternative is non-stationarity of at least one series.

Table 6.1: First generation panel unit root tests

	Log(Emission pc.)	log(GDP pc)	log(GDP pc) ^{2}	log(GDP pc) ^{3}
LLC	0.000	0.600	0.980	1.000
-Trend	0.000	0.089	0.186	0.381
Breitung	1.000	1.000	1.000	1.000
-Trend	0.989	1.000	1.000	1.000
IPS	0.003	1.000	1.000	1.000
-Trend	0.280	0.636	0.663	0.690
Fisher-ADF	0.000	0.000	0.000	0.000
-Trend	0.857	0.906	0.903	0.909
Fisher-PP	0.000	0.995	1.000	1.000
-Trend	0.356	1.000	1.000	1.000
Hadri	0.000	0.000	0.000	0.000
-Trend	0.000	0.000	0.000	0.000

Table 6.1 presents the results of all these tests for the series and the second and third order powers of the GDP per capita series. The results show that the series are very likely to be non-stationary. At least one form of each test (in terms of including deterministic trend or not) indicates non-stationarity. Next, the degree of non-stationarity is investigated. In Table 6.2, the same tests are applied to the first differences of the series. It is seen that most of the tests indicate that emissions and GDP per capita series are stationary in first differences. That is the series are integrated of order one (I(1)). However, the tests for the second and third order powers of GDP per capita series are likely to be integrated at a higher order.

According to the first generation unit root tests, that are applied in this section, there is a severe non-stationarity concern. However, FGPURTs have the drawback of assuming cross-sectional independence, which is not really a realistic assumption for most of the macro panel series. In the next subsection, this is the concern is analyzed.

Table 6.2: First generation panel unit root tests on the first differenced series

Differenced Series:	log(Emission pc.)	log(GDP pc)	log(GDP pc) ^{2}	log(GDP pc) ^{3}
LLC	0.000	0.000	0.000	0.000
-Trend	0.000	0.000	0.000	0.000
Breitung	0.000	0.000	0.000	0.000
-Trend	0.000	0.000	0.000	0.000
IPS	0.000	0.000	0.000	0.000
-Trend	0.000	0.000	0.000	0.000
Fisher-ADF	0.000	0.000	0.000	0.000
-Trend	0.000	0.000	0.000	0.000
Fisher-PP	0.000	0.000	0.000	0.000
-Trend	0.000	0.000	0.000	0.000
Hadri	0.000	0.000	0.000	0.000
-Trend	0.317	0.000	0.000	0.000

6.2 Cross-sectional Dependence (CSD)

The data generating process in equation (6.1) can be transformed into an Augmented Dickey-Fuller form as follows:

$$\Delta y_{it} = \gamma_{0i} + \varphi_i y_{i,t-1} + \gamma_{1it} + u_{it} \text{ , (6.2)}$$

where $\varphi_i = \rho_{i-1.}$ If the individual series are correlated across cross-sections, then the error term u it might not satisfy the standard assumption of being iid across cross section units

Table 6.3: Cross Sectional Dependence Tests

	Breusch and Pagan (1980)	Friedman (1937)	Frees (1995,2004)	Pesaran (2004)
log(GDP pc)	0.000	0.000	0.000	0.000
log(Emission pc)	0.000	0.000	0.000	0.000

The first type of cross-sectional dependence assumes weak dependence, where there are only cross correlations in the errors. We conduct several tests to investigate the presence of this type of cross-sectional dependence in our series. The null hypothesis for all tests is cross-sectional independence. In Table 6.3, results strongly reject the null, and indicate that the error terms, u_{it} in equation (6.2), are correlated across cross-sectional units.

The second specification incorporating cross-sectional dependence is a factor model, assuming strong dependence. The Pesaran test in the last column of Table 6.3 also accounts for such a cross-sectional dependence.

As a result, the cross-sectional independence assumption of FGPURTs seems to be invalid. Therefore, second-generation panel unit root tests (SGPURT) are required in order to investigate non-stationarity. This task is undertaken in the following subsection.

6.3 Accounting for Cross-Sectional Dependence in Testing Unit Roots

There is a strong evidence of cross-sectional dependence. Hence, second generation panel unit root tests (SGPURT) are applied which allows cross-sectional dependence. In this class of tests, augmented IPS (CIPS) test, suggested by Pesaran (2007), is employed. This class of tests assumes that a common factor structure accounts for the correlations actoss cross-sectional units. Pesaran (2007) proxy the common factor by the cross-section averages of the series and its lags. Therefore, the model is augmented with cross-sectional averages. So, the model for a individual series becomes:

$$\Delta yit = \Upsilon_{0i} + \Phi_{iyi,t-1} + b_i\bar{y}_{t-1} + c_i\bar{y}_t + \Upsilon_{1it} + \varepsilon_{it} \quad (6.3)$$

where the regressions can be augmented with the lags of Δy_{it} and $\Delta\bar{y}_t$ in order to deal with serial correlation. Here presence of a unit root, φ i =0 for all i, is tested against the stationary alternative.

Table 6.4: Pesaran (2007) CIPS test

	Intercept	Trend
log(Emission pc)	0.353	0.418
log(GDP pc)	0.370	0.248
log(GDP pc) square	0.514	0.931

Results of Pesaran (2007) test is given in Table 6.4. It is seen that the presence of a unit root cannot be rejected, so the series are likely to be non-stationary. In Table 6.5, these tests are applied to the first differences of the series. All tests rejects the null of nonstationarity, indicating that the first differenced series are stationary. Therefore, all the series seems to be integrated of order one.

Table 6.5: Pesaran (2007) CIPS test on the first difference series

	Intercept	Trend
log(Emission pc)	0.000	0.000
log(GDP pc)	0.000	0.000
log(GDP pc) square	0.000	0.000

6.4 Estimation Strategies Under Non-Stationarity

This section describes the estimation strategies that are employed in the current thesis. Since the series are likely to be non-stationary due to the results presented in the previous sections, the rest of the analysis use estimation strategies that can account for this property. Nevertheless, the results from regressions under stationarity are presented in the Appendix C as robustness checks. The first estimation strategy is "Common correlated effects" estimator suggested by Pesaran (2006), which is described in the following subsection. The next subsection describes estimations by employing only 5^{th} year observations. The common property of these estimation strategies is that they can account for non-stationarity properties of the series.

6.4.1 Using five year observations

The first estimation strategy employed is to use five-year observations. That is, starting from the initial period, the analysis uses observations at 1960 and the following fifth years. This strategy eliminates the persistence of country specific effects in the series, and therefore it is less likely to suffer from non-stationarity. The analysis conducts these estimations by controlling for fixed effects and eliminates the common time effects by using time dummies. Equation (5.2) is estimated by also employing this method among the alternatives. As an alternative, we employ panel data estimation by using common correlated effects (CCE) estimator as described in the next subsection. CCE estimator allows us to control cross-sectional dependence. On the contrary, the use of five-year observations has the drawback of allowing cross-sectional dependence.

6.4.2 Common correlated effects estimator

Common correlated effects estimator is a non-stationary panel estimation technique. In panel fixed effect estimations of equation (5.2), cross-sectional independence is assumed, which is unrealistic in country level studies. Pesaran (2006) suggests the CCE (Common correlated effects) estimation as a remedy. CCE is a mean group estimator. That is, it first runs separate regression for each time series, and then averages the estimated parameters ie. coefficient estimates or standard errors. Therefore, it is better suited for the environments where there is heterogeneity in the hypothesized relationship across cross-sections. Here, the regression is augmented by cross-sectional averages of both the dependent and independent variables as follows:

$$y_{i,t} = \beta_i' x_{i,t} + b_i \bar{y}_t + c_i \bar{x}_t + e_{it} \qquad (6.4)$$

Where $\bar{y}_t$ and $\bar{x}_t$ denotes the cross-section averages of corresponding variables. Kapetanios et al. (2011) show that the CCE estimation can account for non-stationary. Therefore, we employ this estimation strategy due to the potential non-stationary in the series. We estimate equation (5.2) by employing this method among the alternatives.

While CCE estimation is a successful estimator in dealing with heterogeneity and non-stationary, it has some disadvantages. In CCE estimation every added covariate introduce two additional parameters to estimate. This reduces the degrees of freedom.

7. RESULTS

7.1 Estimations by Using Five-Year Data

In Table 7.1 regression results by using five-year observations are presented. The regressions control for country specific fixed effects, and control for common time effects by using time dummies. The first column presents the regular EKC estimation. The result does not support the EKC hypothesis, since the quadratic term is insignificant. In the second column, the regression interacts the terms of GDP per capita with the liberalization dummy. The results are different. Now, while the EKC hypothesis is not supported in the pre-liberalization period, the quadratic term in the post-liberalization period is significant and negative. This supports the EKC hypothesis. This result is drastically different than the one presented in the scatter plots. One reason is that in the scatter analysis, we split the samples. This means that we also need to allow the intercept and the trend to be different across our sub-samples. This is done in the third column by introducing the liberalization dummy. This is the full specification and the results from this full specification will be discussed extensively (estimation methodology in order to interpret the interaction terms is discussed in detail in Section 5).

Table 7.1: Fixed Effects Estimations with Five-Year Observations

	1	2	3
GDP pc	1.117***	0.715*	1.056**
	(0.346)	(0.402)	(0.431)
GDP pc Square	-0.016	0.015	-0.009
	(0.023)	(0.028)	(0.030)
(GDP pc)(Lib.)		0.102**	-0.676*
		(0.042)	(0.366)
(GDP pc sq.)(Lib.)		-0.011**	0.042*
		(0.005)	(0.026)
Liberalization			2.756**
			(1.288)
Observations	472	472	472
Robust standard errors are in parentheses. Time effects are controlled with time dummies. * p<0.10 , ** p<0.05 , *** p<0.01			

The results in column 3 are surprising: the linear term is negative for the post-liberalization period indicating that the effect of linear term is still postive but lower than the pre-liberalization period. However, the quadratic term is positive. This indicates that as income rises, environmental degredation will get faster. That is, as income grows, the relation starts to evolve to more environment deteriorating point compared to the pre-liberalization date. This finding is at odds with the intuition provided by the EKC hypothesis, while it is in-line with the explanations provided in the trade and environment literature. Especially, the pollution haven hypothesis (Stock and Watson, 2004) provides a very intuitive explanation. According to the pollution haven hypothesis, dirty industries in the advanced economies move to developing countries where environmental regulations are not so strict. Therefore in the long-run, developing countries may experience a pollution intensive growth. It is possible that such an outcome can be clearly triggered by liberalization of developing countries, which is in line with the estimated pattern by our full specification.

As discussed previously, liberalization seems to have a deteriorating effect on environment. This can be seen in Figure 7.1. Note that the differences in the levels of the curves are not interpretable, as the intercept term is different for each country. The prediction indicates that, on avergare, a developing country starts with the dashed line and switches to the upper nonlinear curve at the half-way (since the average income is 7.1 USD $ per capita in logarithms). The figure reveals another important point that cannot be deducted from the estimation table at the first sight. Here, it is seen that in the range of GDP per capita levels spanned by the sample countries, the initial seemingly beneficial effect of liberalization (due to negative coefficient of interaction between GDP per capita and liberalization date) is never experienced.

The overall conclusion is that trade liberalization leads to a faster income driven pollution, which is a result in line with the pollution haven hypothesis.

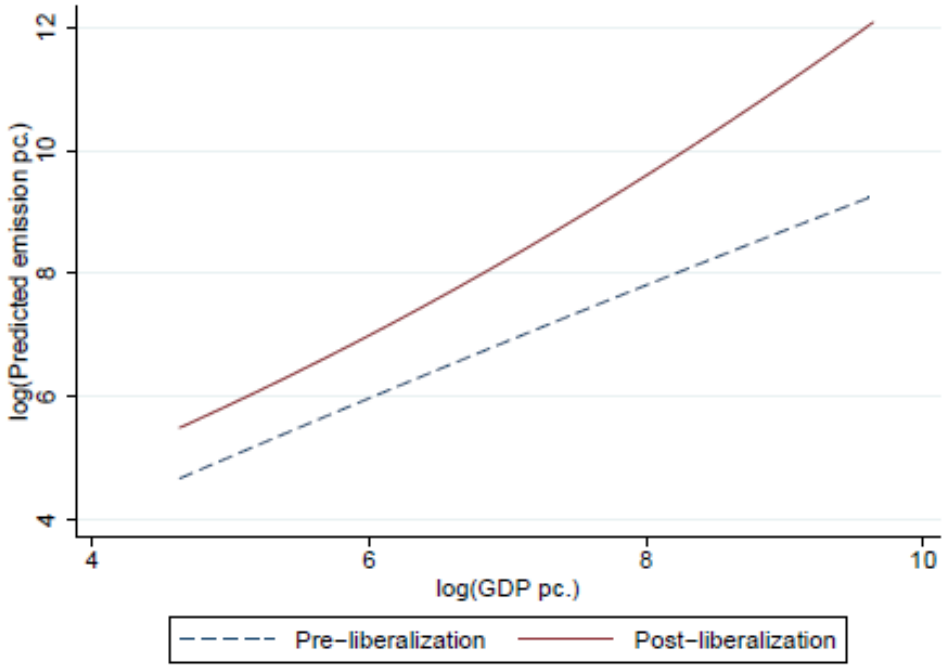

Figure 7.1: Estimated Functions: Using Five-Year Observations

7.2 CCE Estimations

This section presents the results from the CCE estimations. In CCE regressions, it is not possible to control for time dummies, since it is a mean group estimator running separate regressions for each cross-section and then averaging over the estimated parameters. For this reason, in CCE estimations, one can control for common time effects by using country specific time trends. The results are presented in Table 7.2

The first column presents the regular EKC estimation. The result does not support the EKC hypothesis. Interestingly even the linear term is insignificant. This might be related to the mean group estimator aspect of the CCE estimator. That is, running separate regression for each series reduces the power of the estimator. Nevertheless, the analysis goes on by adding our variables of interest to the regression in column 2. In particular, we add the interaction of liberalization dummy with GDP pc. and GDP pc. square. This does not change the results. In column 3, a liberalization dummy is also included in the regression which leads to a supportive evidence for the EKC hypothesis. However, there is no significant difference in the income and pollution relationship between the pre- and post-liberalization periods.

Table 7.2: CCE Regressions

	(1)	(2)	(3)
GDP pc	2.131	2.286	6.579*
	(2.862)	(3.598)	(3.419)
GDP pc square	-0.088	-0.066	-0.494**
	(0.199)	(0.256)	(0.240)
(GDP pc)(Lib.)		0.341	-1.834
		(0.218)	(13.039)
(GDP pc sq.)(Lib.)		-0.046	0.005
		(0.032)	(0.868)
Liberalization			6.970
			(49.270)
Observations	1890	1890	1890
Robust sandard errors are in parentheses. Time effects are controlled with country specific time trends.			
* p<0.10 , ** p<0.05 , *** p<0.01			

In the current context, the power problem of the CCE estimation can be circumvented by splitting the sample. That is, by running separate regressions for the pre- and post-liberalization periods. First of all, CCE estimation runs separate regressions for each cross-sectional unit, which reduces the degrees of freedom substantially. Secondly, all regressions are augmented by cross-sectional average of covariates, therefore, every added individual regressor requires to estimate two additional parameters. Note that, running separate regressions for each subsample is equivalent to our full-specification in our baseline estimations. In other words, the basic model given by equation 5.1 is employed but the sample is restricted either with post- or pre-liberalization periods.

It should be noted that, in the table below, interaction term of the liberalization dummy with GDP per capita can be interpreted in two ways. First, whether liberalization has a significant effect on the relationship between GDP per capita and emissions per capita. Secondly, due to estimate linear regression and interaction term of GDP pc. Liberalization is insignificat its effect is positive or negative on emissions.

In table 7.3 first two columns present the results for pre-liberalization period. Inclusion of the second order term distorts the results leadig to a conclusion that there is no correlation between income and pollution, and all correlation arises from

factors common to all regions. This is not plausible. Considering this problem and the previous results, we regard the first column and third column as more reliable estimations, indicating a linear relationsip between GDP pc and emissions per capita for both pre and post liberalization period. The important result is that the coefficient estimate is higher for the post-liberalization period indicating a faster pollution with the income growth. These results indicate that it might be a good idea to drop the second order terms in our previous regressions and test the significance of the difference between the pre and post liberalization effect of GDP per capita growth. In the fifth column of Table 7.3, this task is undertaken, and a regression for full-sample by including the interaction of GDP per capita and liberalization dummy is conducted. Indeed, it is shown that the difference is significant (note that this last regression does not include split-sample method).

Table 7.3: Nonstationary Regressions

	Pre-Liberalization		Post-Liberalization		Full-Sample
GDP pc	0.832***	-0.149	0.836***	1.738	0.767***
	(0.115)	(3.949)	(0.098)	(5.521)	(0.096)
GDP pc Square		0.046		0.065	
		(0.305)		(0.344)	
(GDP pc)(Lib.)					0.325**
					(0.147)
Liberalization					-2.089**
					(0.999)
Observations	1431	1431	898	898	2329
Standard errors in parentheses Note: Models include country specific time trends. * p<0.10 (7.1) , ** p<0.05 (7.2) , *** p<0.01 (7.3)					

The shape of estimated functional relationships is presented in Figure 7.2 which refers to the estimated function in Table 7.3 - column 5. The curves are interpreted as follows: the income-pollution relation follows the pre-liberalization curve until the liberalization date. Once liberalization occurs, the estimated relation switches to the post-liberalization curve. Note that, the differences in the levels of the curves is not interpretable, since the liberalization date is country specific. Only the estimated pattern is interpretable. In the sample, the average income in logarithms is about 7.1 US $ per capita. Therefore, the prediction indicates that, on average, a developing country starts with the dashed line and switches to the upperline at the half-way.

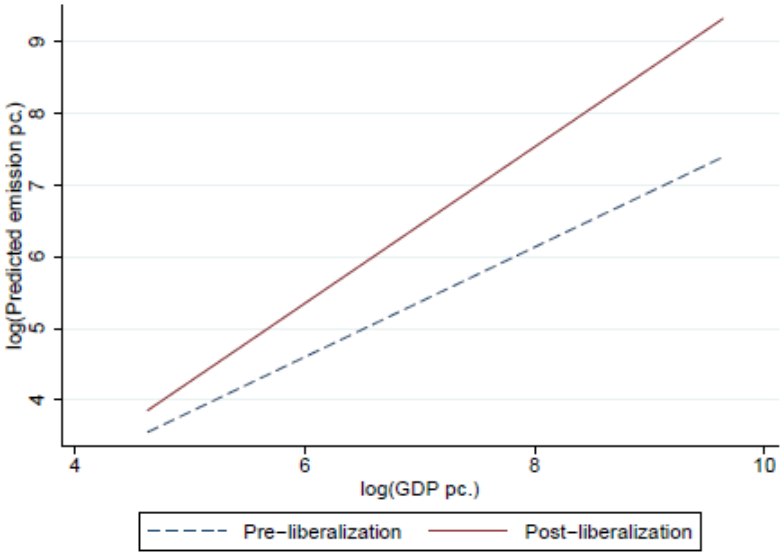

Figure 7.2: Estimated Functions: CCE Estimations with Split-Sample

8. CONCLUSION

This thesis investigates the effect of trade liberalization on the functional relationship between pollution and income. It contributes to the EKC literature by providing and applying a new perspective to the relationship between income, pollution, and trade. In contrast to the previous studies, this thesis considers trade liberalization as a shock to the functional relation between income and pollution. This perspective is introduced to the regressions via a liberalization dummy and its interactions with the GDP per capita and higher order polynomials. This allows to test for a drastic change in the hypothesized relationship following trade liberalization.

It is shown that trade liberalization has a significant effect on the hypothesized relationship. Our results indicate that pre-liberalization period is characterized by a linear relationship. However, trade liberalization leads to a faster income driven pollution. Hence our results do not support the the environmental Kuznets curve hypothesis.

These findings are in line with the pollution haven hypothesis. That is, trade liberalization triggers a relocation of the dirty industries from developed regions to developing regions where environmental standards are relatively less strict. More precisely, these results indicate that when a developing country experiences trade liberalization, they attract the dirty industries in the advanced economies with their low quality institutions and hence lower environmental standards.

These findings have important implications for the design of institutions related to trade and evironment, as well as for the public debate on this relationship. According to the estimations, the affords by international institutions to deal with climate change does not seem to be sufficient. The global cooperation on trade related issues which has been witnessed in the last few decades should be carried over the climate

and environment related issues as part of their agenda, and these issues should be brought forward in the negotiations.

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APPENDICES

APPENDIX A: Liberalization Dates

Table A.1: Liberalization Dates

Country Name	Country Code	Lib. Date	Country Name	Country Code	Lib. Date
Albania	ALB	1992	Latvia	LVA	1993
Argentina	ARG	1992	Lithuania	LTU	1993
Armenia	ARM	1995	Macedonia, FYR	MKD	1994
Azerbaijan	AZE	1995	Malaysia	MYS	1988
Bangladesh	BGD	1996	Mexico	MEX	1989
Benin	BEN	1990	Moldova	MDA	1994
Bolivia	BOL	1985	Morocco	MAR	1984
Botswana	BWA	1979	Mozambique	MOZ	1995
Brazil	BRA	1990	Nepal	NPL	1991
Bulgaria	BGR	1991	Niger	NER	1994
Cameroon	CMR	1993	Nigeria	NGA	1995
Chile	CHL	1990	Pakistan	PAK	1990
Colombia	COL	1991	Panama	PAN	1996
Costa Rica	CRI	1986	Paraguay	PRY	1989
Cote d'Ivoire	CIV	1994	Peru	PER	1991
Czech Republic	CZE	1991	Philippines	PHL	1988
Egypt, Arab Rep.	EGY	1995	Poland	POL	1990
El Salvador	SLV	1989	Portugal	PRT	1986
Ethiopia	ETH	1996	Romania	ROU	1992
Georgia	GEO	1996	Slovak Republic	SVK	1991
Ghana	GHA	1985	Slovenia	SVN	1991
Greece	GRC	1987	South Africa	ZAF	1991
Guatemala	GTM	1988	Sri Lanka	LKA	1991
Honduras	HND	1991	Tajikistan	TJK	1996
Hungary	HUN	1990	Tanzania	TZA	1995
India	IND	1992	Thailand	THA	1987
Indonesia	IDN	1989	Trinidad and Tobago	TTO	1992
Jamaica	JAM	1989	Tunisia	TUN	1989
Jordan	JOR	1992	Turkey	TUR	1989
Kenya	KEN	1993	Uruguay	URY	1990
Korea, Rep.	KOR	1992	Venezuela, RB	VEN	1990
Kyrgyz Republic	KGZ	1994	Zambia	ZMB	1993
Zimbabwe	ZWE	1993			

Source: Ghani (2012), Does trade liberalization effect energy consumption?

APPENDIX B: More on Data Description

In the sample, the value of the skewness is 3,31 which indicates very high level of skewness as can be seen in the left side of the figure B.1. Most of the values for carbon emissions per capita take value lower then 0,5 metric tons per capita while mean value is 2,18 ; minimum value is 0,01 and maximum value is 37,8 metric tons per capita. Besides that very few values spread on the very high values. Using logarithm process distribution turns out to be close to normal distribution. Converted normal distribution is presented on the right side of the FigureB.1. Another statistics, Kurtosis, measure tailedness of a normal distribution. Positive values of the statistics indicate peak distributions while negative values indicate flatter distributions. Kurtosis statistic of the sample for carbon emissions per capita is 21,56 which indicates very peak distribution. This can be seen in Figure B.1 and logarithmic transformation also accounts for this concern.

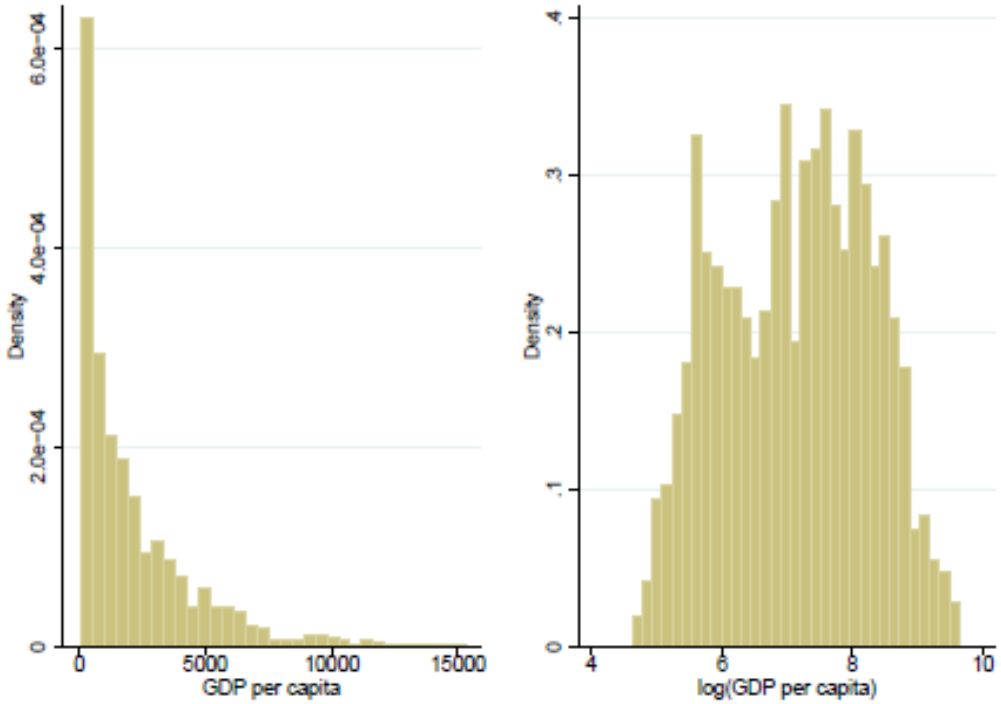

Figure B.1: Distribution of GDP per Capita

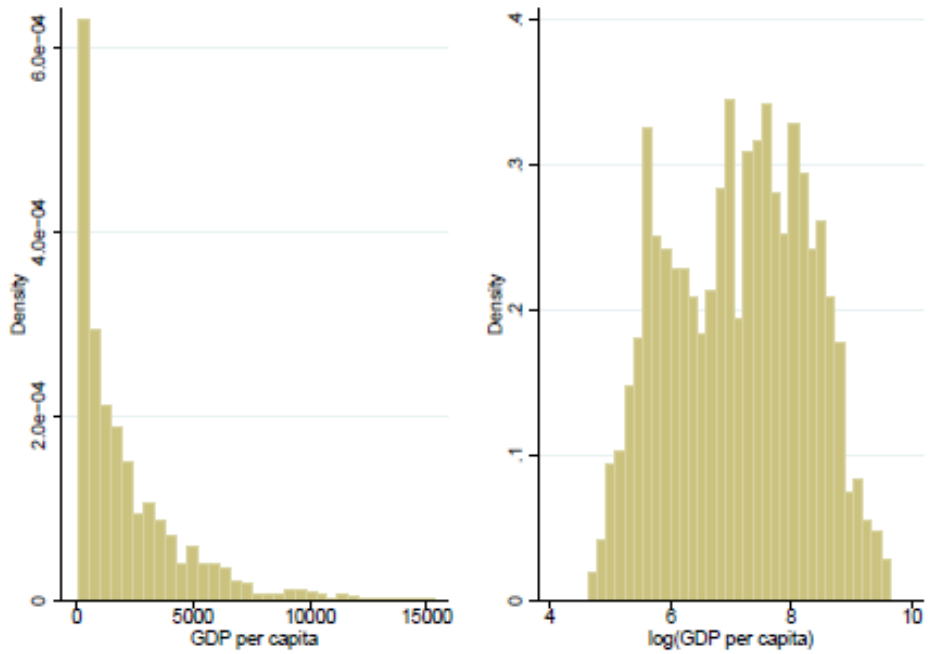

Figure B.2: Distribution of Carbon Emissions

APPENDIX C: Estimations under Stationarity

In empirical studies, mostly panel data techniques are used. When fixed effect models are used, α_i are regression parameters. Besides that when random effect models are used, α_i are considered as components of random disturbance. Random effect models are inconsistent if α_i and the explanatory variables are correlated with each other. Haussmann test can compare slope parameters of random and fixed effect models. If the test indicates significant difference, that means random effect model is not consistent because of the problem of the correlation of α_i and the error term. The results from random effect estimations and fixed effect estimations by using our full sample are presented in Table 11. The estimated coefficients are similar across fixed and random effect specification. The estimated pattern in equation (1.6) is depicted in Figure C.1. The pattern is similar to the results presented in the main-text.

Table C.1: Stationary Regressions

	RE (1.1)	FE (1.2)	RE (1.3)	FE (1.4)	RE (1.5)	FE (1.6)
GDP pc	1.460***	1.415***	1.053***	0.993***	1.276***	1.219***
	(0.148)	(0.150)	(0.173)	(0.176)	(0.185)	(0.187)
GDP pc Square	-0.035***	-0.033***	-0.004	-0.001	-0.019	-0.016
	(0.010)	(0.010)	(0.012)	(0.012)	(0.013)	(0.013)
(GDP pc)(Lib.)			0.032*	0.033**	-0.534***	-0.534***
			(0.017)	(0.017)	(0.152)	(0.152)
(GDP pc sq.)(Lib.)			-0.007***	-0.007***	0.033***	0.033***
			(0.002)	(0.002)	(0.011)	(0.011)
Year	0.008***	0.008***	0.011***	0.012***	0.014***	0.015***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
(year)(Lib.)					-0.018***	-0.018***
					(0.002)	(0.002)
Liberalization					38.160***	38.154***
					(4.203)	(4.199)
AIC	.	1172.8	.	1128.4	.	1046.3
BIC	.	1195.8	.	1162.9	.	1092.3
Observations	2329	2329	2329	2329	2329	2329
Standard errors in parentheses						
Note:						
* p<0.10 (C.1) , ** p<0.05 (C.2) , *** p<0.01 (C.3)						

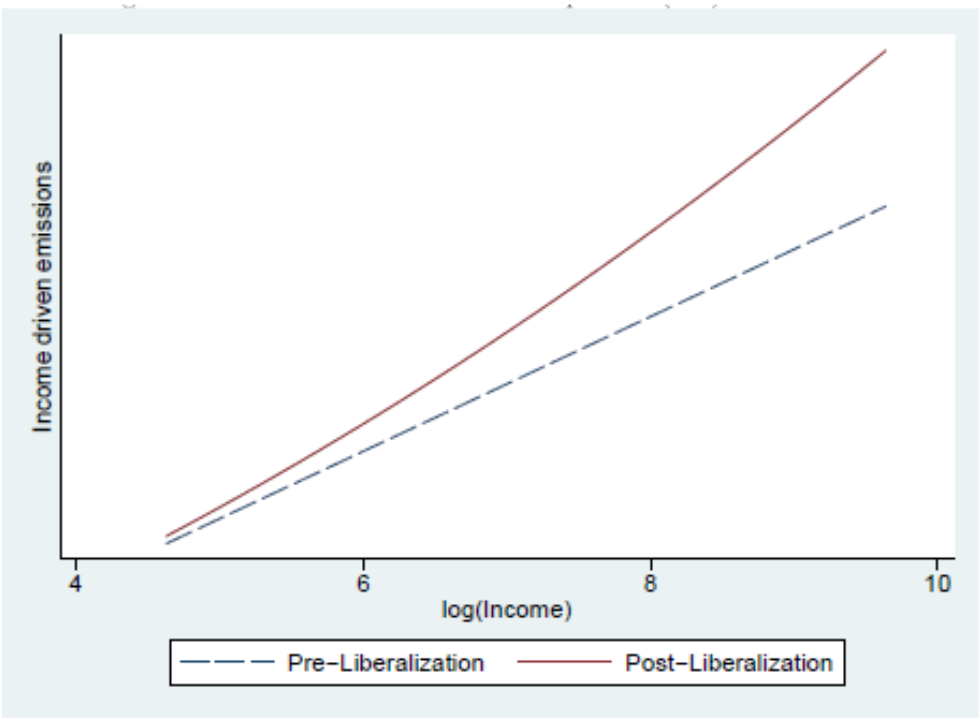

Figure C.1: Estimated Functions - Equation (1.4) of Table 9