The Growth of the Economy and Trees:

A Panel Data Analysis of the Environmental Kuznets Curve

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Abstract

I analyse the relationship between economic development and deforestation by testing this for the Environmental Kuznets Curve (EKC) hypothesis. It hypothesizes that, as the economy develops, deforestation will first increase before it decreases. Empirical evidence for this inverted U-shaped relationship has sometimes been taken to conclude that economic growth is generally good for the environment. This paper addresses this implication by testing the following hypothesis: the relationship between economic growth and deforestation follows an inverted U-shaped relationship. A quadratic fixed-effects regression is first employed to test the model for all countries and later separately for the EU, Latin America, and Asia. The panel data consists of 56 countries over the period 1990 to 2015. Total population, population density, "openness" of the economy, fossil fuel energy consumption, and value of agriculture are included as control variables. The applicable regression coefficients are found to be insignificant and therefore the null-hypothesis cannot be accepted. This result is both consistent and inconsistent with earlier empirical research; the existence of an EKC for deforestation is undecided. Even though the existence is disputed, it is striking the results show that the relationship between economic growth and deforestation is not even statistically significant.

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I. Introduction

It is undeniable that continuous and substantial growth of the economy has had an overwhelming impact on the environment. In response to the growing environmental issues, increasing attention is given to the economy and environment relationship. An important part of the discussion regards whether economic development naturally depreciates environmental quality. Since Grossman and Krueger (1992) discovered an Environmental Kuznets Curve (EKC), it has become a standard feature of environmental policy. The EKC hypothesizes that economic development and environmental degradation follow an inverted U-shaped relationship like one shown in figure 1 of the appendix. I test this hypothesis for deforestation. The inverted U-shaped relationship reflects that, as the economy develops, deforestation will first increase before it decreases. I use panel data of 56 countries from 1990 till 2015 to test the following central hypothesis: economic development and deforestation follow an inverted U-shaped relationship. The model is tested for all countries together and separately for the EU, Latin America, and Asia. A quadratic fixed-effects regression of Gross Domestic Product (GDP) on deforestation is employed, while controlling for total population, population density, "openness" of the economy, fossil fuel energy consumption, and value of agriculture. The results do not support the null-hypothesis that there is such a relationship. This neither contradicts or is coherent with previous research since existence of this particulary shaped relationship is empirically disputed. But, it is surprising there is not even a statistically significant relationship between economic growth and deforestation.

The intuition behind the hypothesis can be explained with economic logic. There are three main reasons for deforestation: conversion of forests to pasture and cropland, harvesting of logs, and gathering of fuelwood. At first, the demand for these increase with economic development. As the economy develops further, modernization leads to a decrease in demand. Environmental quality, which can be measured by the stock of forests, can also be seen as a public good whose quality is degraded. At low levels of economic development, there is barely any demand. However, once the economic development and/or environmental degradation reaches a certain level, the demand increases.

Especially forests, one of the most important measures of environmental quality, have been under pressure. From 1990 till 2015, which is the period I analyse, the net loss was around 129 million hectares. This is about the size of South Africa. The world's forests continue to decline but the annual net loss rate slowed from 0.18 percent in the 1990s to 0.08 percent over the last five-year period (FAO, 2016). There is notable difference in trends for countries at distinct stages of economic development. As can be seen in figure 2 of the appendix, the largest conversion of forests to other land uses from 1990 to 2015 was in developing countries (FAO, 2016). This difference in trends, also shown in Figure 3 of the appendix, might suggest an EKC for deforestation. A representative set of countries in distinct levels of economic development is EU, Latin America, and Asia. The FAO described a positive trend for Asia and Europe but negative for Latin America in 2015. Even though the rate of loss has decreases substantially, Latin America still accounts for the largest loss of natural forests. Asia follows in the amount of loss and the trend is relatively stable for Europe (FAO, 2016). The proportion of the contribution to total GDP is also much higher in low-income countries: 1.4 percent compared to 0.1 percent in high-income countries (FAO, 2016). Many countries with rapidly expanding economies see a decrease in the relative share of forestry and logging at the national level. Unlike Asia and EU, there is increasing employment related to forestry in Latin America (FAO, 2016).

Better understanding of forest trends also increased realisation of their importance (Cropper & Griffiths, 1994). Most national strategies used to be solely focused on economic growth, without any regard to consequences on the environment. Change is evident in, for example, the Paris Agreement on climate change in which a key part is given to forests. Noteworthy is also the enhanced support to assist developing countries (The Paris Agreement, 2017). Despite the increasing demands for forest products and services, the forest area with protected areas and areas certified under an international scheme is increasing since 1990. Over the last 25 years ninety-six percent of the world's forests has become covered by both policies and legislation supporting Sustainable Forest Management (FAO, 2016). The growth was especially fast from 2000 to 2014; the area under international forest management certification schemes increased from 14 million to 438 million hectares (FAO, 2016).

Empirical evidence of an EKC (e.g. Cropper and Griffiths, 1994) has often been interpreted that economic development will naturally lead to an improvement in environmental quality. Beckerman (1992) claimed that the best and probably only way to attain a decent environment is to increase its income. Bartlett (1994) wrote that existing environmental regulation might reduce environmental quality by reducing economic growth. The validity of these conclusions depends on two aspects: the data needs to be generally consistent with the EKC and, if the EKC hypothesis holds, the implication that growth is good for the environment needs to follow. I address the first aspect by testing the existence of an EKC for deforestation. This is a decisive period for the world and sustainable development; almost half of the warming towards the 2 °C threshold from the Paris Climate Agreement has already taken place (European Union, 2016). It is vital to have empirical evidence for an EKC of forests so the future path can be predicted and policies based on false assumptions are avoided.

Forests play a vital role in sustainable development and the well-being of humankind by providing ecological and environmental servies like air and water purification, erosion control, and carbon sequestration (FAO, 2016). They offer green growth opportunities and deliver important long-term ecosystem services (FAO, 2016). 17% of greenhouse gases were caused by deforestation and forest degradation (IPCC, 2007). Deforestation is together with the removal and burning of fossil fuels the force behind climate change (Humphreys, 2006). Being a major cause of loss of biodiversity, it can lead to permanent damage. Not unimportantly, forest also have cultural, religious, and recreational values that are important to many of us. Forest play an important in everybody lives. It is not only for academic interest important to understand the relationship between economic growth and deforestation.

The main contribution of this paper is that new panel-data estimates of the relationship between economic growth and deforestation are presented. Despite the extensive empirical research on the EKC, the existence of it for more unconventional variables like deforestation has not been often researched and is still disputed. Empirical evidence on this relationship is scare, especially in low-income countries, because of the lack of data. It was not until 1946 the FAO started to collect data on forest area and for many countries it was even much later.

The traditional EKC paper employs time-series or cross-sectional data. Straight cross-sectional evidence is problematic due to the unobserved, distinct characteristics of countries at various levels of economic development. When the richest and poorest countries happen to have more trees, it is quick to find an EKC. Use of panel data is made possible by the improvement of forest data. There was a substantial increase of national forest assessments to 83% of global forest area (FAO, 2016). Panel data for economic research possess several major advantages like controlling for omitted variables without observing them to avoid Omitted Variable Bias (Hsiao, 2003).

The paper is organized in the following way: related literature is reviewed in the ensuing section II. This is followed by a description of the data in section III and methodology in section IV. Subsequently, the results are presented and interpreted in section V. The discussion is elaborated in section VI and finally the paper is concluded in section VII.

II. The relationship between economy and environment

Before the EKC, there was not much interest in research on the relationship between economic growth and the environment (Perman, Ma, McGilvray, & Common, 2011). The prevailing and accepted opinion was that they are fundamentally at odds (Cole, 1999). This is formulated in, for example, the Environmental Impact Hypothesis: the general proposition that strong environmental policies have a negative effect on economic growth and development (Meyer, 1992). The EKC challenged the conventional "environment versus economy" thinking and it led to the emergence of a substantial amount of research empirically and theoretically studying this relationship.

Environmental Kuznets curve

The EKC has been regularly researched since the paper by Grossman and Krueger (1991) found empirical evidence of it for SO_2, dark matter (fine smoke), and suspended particulate matter (SPM). The paper by Shafik and Bandyopadhyay's (1992) brought the EKC to prominence by being used in the 1992 World Development Report from the World Bank. They found that urban concentrations of particulate matter and SO_2 conform to the EKC hypothesis but CO_2 emissions and municipal wastes did not. Selden and Song (1994) tested SPM, SO_2, NO_x, and CO and found slightly different results than Shafik and Bandyopadhyay

(1992). Panayotou (1993), whom named the curve after a similar inverted U-shaped relationship from Kuznets (1955), used national data on pollutant emissions per capita and found an inverted U-shaped relationship for SPM, SO_2, and NO_x. On the other hand, the empirical paper by Stern and Common (2001) found results that are not consistent with the existence of the EKC for SO_2. Moreover, their results for the entire world were far less optimistic than for OECD countries.

Empirical literature predominantly shows pollutant specific results and, like Shafik and Bandyopadhyay (1992), use time-series and/or cross-sectional data. Much of empirical evidence is based on a relatively short panel of observations from countries with widely various levels of economic development. For example, the analysis of Grossman and Krueger (1995) involves a period of at most twelve years for sixty-six countries. Limited research is done with national panel data and most of these test national emissions (e.g. Panayotou, 1993). The basic EKC studies estimate the relationship between environmental impact indicators and Purchasing Power Parity (PPP) per capita GDP (e.g. Grossman and Krueger, 1991). Furthermore, most studies apply fixed and random effects estimations of quadratic, log-linear, log-quadratic and/or cubic-polynomial pollution-income relationships (Bartz & Kelly, 2008).

Hilton and Levinson (1998) found evidence for an inverted U-shaped relationship between lead emissions and income but the results are sensitive to the functional form and time period. While most contributions simply extend the contribution of Grossman and Krueger (1995) to other data sets and other environmental degradation indicators, there is also an increase in literature concerned with adequate model specification and sensitivity of the results (Dijkgraaf & Vollebergh, 2001). Papers test effects of possible conditioning variables like population density, energy use, and trade intensity (Stern D. I., 1998). Harbaugh, Levinson, and Wilson (2002) updated and tested data from Grossman and Krueger (1995) for sensitivity by for example including such additional variables. The results were found to be highly sensitive to these additional covariates changes and alternative functional forms. This questions the empirical support for an EKC (Harbaugh, Levinson, & Wilson, 2002).

Environmental Kuznets curve for deforestation

Shafik and Bandyopadhyay (1992), and Panayotou (1993) estimated the EKC for, in addition to other environmental degradation variables, deforestation. The former used change in forest area and annual observations of deforestation between 1961 and 1986. Both measures of deforestation were not significantly related to the income terms (Shafik & Bandyopadhyay, 1992). The latter measured deforestation as the mean annual rate of deforestation in the mid-1980s. Unlike Shafik and Banyopadhyay (1992), an inverted U-shape was found and deforestation was found to be higher in countries with higher population densities (Panayotou, 1993). Antle & Heidebrink (1995) found a U-shape curve similar to Panayotou (1993) for afforestation and national parks. Cropper and Griffiths (1994) also tried to capture the effects of population pressures by including rural population density and the rate of population growth in the equation. They separately estimated the relationship of per capita income and deforestation with pooled cross-section and time-series data for three continents. Latin America and Africa have a statistically significant EKC relationship for deforestation while Asia does not. But, even though the relationship is significantly negative for Latin America and Africa, the magnitude is shown to be small (Cropper & Griffiths, 1994).

Most of the researches on deforestation are, like other environmental degradation indicators, cross country regression studies (e.g. Cropper and Griffiths 1994; Panayotou 1995; Antle & Heidebrink, 1995). Foster and Rosenzweig (2003) specified this lack of systematic cross-country studies over multiple periods in the EKC literature. To address this, they used panel data for developing countries and showed that there is a positive relationship between rates of growth in income and forests. However, this result is exclusive to closed economies (Foster & Rosenzweig, 2003). Another panel data research, on Sichuan's forest cover and GDP per capita, finds a U-shaped relationship (Zhao, Uchida, Deng, & Rozelle, 2011).

The different results demonstrate that the empirics is not conclusive on the existence of the EKC. While it might hold for some variables of environmental degradation, the hypothesis is still undecided for deforestation. This paper extends the existing literature by using the most recent panel data on forests: from 1990 till 2015 for 56 countries. Earlier research, like Stern and Common (2001), shows different results for different areas. Therefore, this paper groups countries into sets with similar economic development and also tests separately for EU, Latin America, and Asia. This is like the approach of Cropper and Griffiths (1994). Furthermore, empirical results were found to be sensitive to additional covariates (e.g. Harbaugh, Levinson & Wilson (2002). This paper takes effects of possible conditioning variables into account by including variables on total population, population density, "openness" of the economy, fossil fuel consumption, and value of agriculture. Variables like population density, energy use, and trade intensity have been used in earlier EKC papers (Stern D. I., 1998). This paper also tests for an alternative functional form given that earlier empirical results were also found to be sensitive to this (e.g. Hilton and Levinson, 1998; Harbaugh, Levinson & Wilson, 2002). This is done by including $(\text{GDP per capita})^3$ and therefore testing it for a cubic formula.

III. Data

The exclusive source of data is the World Development Indicator (WDI) database of the World Bank Group. The unit of observations are countries from the European Union[1], Latin America[2], and Asia[3]. EU, Latin America, and Asia are chosen for their distinct levels of economic development and divers trends in deforestation. The panel data set consists of 56 countries over the period 1990 to 2015, adding up to 1400 observations. The sample was restricted to countries of which the databank offered consistent data. Also, the 25-year period is the longest timespan the data allowed. A long time span is needed since the EKC is focused on a country's economic development. The employed dataset comprises of the following variables: forest area, GDP per capita, total population, population density, import, export, fossil fuel energy consumption, and value of agriculture. The included variables are discussed separately in more detail and their descriptive statistics are included in tables 1, 2, 3, and 4 of the appendix. The tables for the EU (2), Latin America (3), and Asia (4) display the

[1] The EU countries include: Austria, Bulgaria, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden, and United Kingdom.

[2] The Latin American countries include: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, and Uruguay.

[3] The Asian countries include: China, India, Indonesia, Israel, Japan, Kazakhstan, Kyrgyz Republic, Malaysia, Mongolia, Pakistan, Philippines, Republic of Korea, Russian Federation, Saudi Arabia, Sri Lanka, Turkey, Thailand, and Vietnam.

difference in deforestation and economic development. The EU has the highest GDP per capita and lowest rate of deforestation. Asia follows in level of GDP per capita and has a lower rate of deforestation than Latin America. This might suggest an EKC for deforestation. Forest area is the annual data as percentage of total land area. The World Bank Group collected this data from the Food and Agriculture Organization (FAO). It is land under natural or planted stands of trees of at least 5 meters. Trees in agricultural production systems, urban parks, and gardens are excluded (The World Bank Group, 2017). The annual negative change in forest area represents deforestation since it is the removal of forests.

Economic development is operationalized by GDP per capita converted to current international dollars using PPP. It is generally the standard measure of economic development. It makes economic development comparable over time and does not understate the income of poor countries (Lieb, 2004). It is the annual sum of gross value added by all resident producers in the economy. PPP is also almost exclusively used in research on the EKC (e.g. Grossman & Krueger, 1991).

Total population is intuitively included as a control variable because of its impact on the environment. Massive deforestation is associated with rapid population growth (Rosero-Bixby & Palloni, 1998). A growing population exerts pressure on agricultural land, which encourages deforestation. It is also regularly included in earlier EKC research (e.g. Grossman & Krueger 1991). The data is based on annual midyear estimates data of national population censuses. Together with population density, this variable captures the effects of population pressures as was prior done by Cropper and Griffiths (1994).

Population density is collected from annual data on the midyear density of people per square kilometres of land area. The data was transformed to density in one hundred peoples per square kilometres of land area to acquire sensible units. It has the characteristic of a measure for the intensity of land use. Including this variable also follows the footsteps of earlier EKC research (e.g. Harbaugh, Levinson & Wilson 2002; Panayotou 1993).

Import is measured by the annual value of all goods and other market services received from the rest of the world in current U.S. dollars. Export is measured by the annual value of all goods and other market services provided to the rest of the world in current U.S. dollars. Import and export is used to reflect a country's trading behaviour and calculate the "openness" of an economy. These variables are included as EKC results were found to be different for economies with extensive trade (Foster & Rosenzweig, 2003).

Fossil fuel energy consumption is from annual data on the consumption of coal, oil, petroleum, and natural gas products as percentage of the total energy consumption. Total energy use refers to the use of primary energy before it is transformed to other end use fuels. It serves as a control variable because of its role in environmental problems.

Value of agriculture is based on annual data on value added of the agriculture as percentage of GDP. Agriculture includes forestry, hunting, fishing, cultivation of crops, and livestock production. Value added is the net output after adding up all outputs and subtracting intermediate inputs. Value of agriculture reflects a country's economic development; developing countries are often associated with more dependence on agriculture.

IV. Methodology

The data is a "strongly balanced" panel, which is ideal for running the ordinary least squares regression model. The EKC does not hypothesize about causal effects of economic development and deforestation; it is therefore sufficient to analyse whether there is an inverted U-shaped relationship. The basic model of this paper employs a quadratic function, as is done in many earlier empirical papers on the EKC of deforestation (e.g. Cropper & Griffiths 1994). By using panel data, it is possible to control for omitted variables that differ across countries but are constant over time (Stock & Watson, 2015). An example of such a variable is cultural attitudes towards deforestation. To do so, a multiple regression with a fixed effects extension will be used. This model is designed to study the causes of change within a country, which is what the EKC hypothesizes about. This method is extended to also incorporate time fixed effects; this controls for unobserved variables, such as international policies, that change over time but are constant across countries in a given year (Stock & Watson, 2015). Thus, an entity and time fixed-effects regression model is used[4].

[4] Hausman test results for the quadratic model, tested for all countries together, rejects the null hypothesis that the data are generated by random effects.

Variables are typically autocorrelated in panel data since it involves time-series[5]. Robust standard errors are employed to allow both for autocorrelation and for potential heteroscedasticity. These robust standard errors also deal with other minor concerns about failure to meet assumptions like minor problems about normality, and some observations that exhibit large residuals, leverage, or influence. The model is also controlled for variables which are correlated with forested area in the estimating equation which might also be correlated with economic growth.

The Model and Variables

I test for a U-shaped curve, as hypothesized by the EKC, between economic growth and deforestation. The hypothesis states that the relationship between economic development and environmental degradation follows an inverted U-shape. It is tested at a 10%, 5%, and 1% significance level. The coefficients are checked for statistical significance and whether the signs are in accordance with what is expected. The hypothesis is tested by estimating the following multiple linear regression:

$$\begin{aligned} Deforestation_{it} &= \beta_1(GDP)_{it} + \beta_2(GDP^2)_{it} + \beta_3(population)_{it} + \beta_4(popdensity)_{it} \\ &+ \beta_5(openness)_{it} + \beta_6(fossil)_{it} + \beta_7(agriculture)_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \end{aligned}$$

Deforestation	Deforestation which is calculated by - $\frac{F_{i,t} - F_{it-1}}{F_{i,t-1}}$
GDP	ln of GDP per capita
GDP^2	$(\ln \text{ of GDP per capita})^2$
population	ln of Total population
popdensity	Population Density which is the density in one hundred peoples per square kilometres of land area

[5] I tested all models for autocorrelation with the Wooldridge test for autocorrelation in panel data. The results for this test are included in table 5 of the appendix. None of the models had a significant test statistic at the 10% significance level. Therefore, the null-hypothesis which states that there is no first-order autocorrelation could not be rejected.

openness	"Openness" which is calculated by $\frac{(Import+Export)}{GDP}$
fossil	Fossil Fuel Consumption which is the consumption of coal, oil, petroleum, and natural gas products as percentage of the total energy consumption
agriculture	Value of Agriculture which is the value added of the agriculture (forestry, hunting, fishing, cultivation of crops, and livestock production) as percentage of GDP
i	The countries 1, 2, …, 56
t	The number of years 1, 2, …, 25
α_i	The country-specific intercept (country fixed effects)
λ_t	The time specific intercepts (time fixed effects)

The functional form expresses a country's deforestation as a quadratic function of the country's current GDP with time and various controls. Deforestation, which operationalizes environmental degradation in the EKC, is calculated with a formula which is inspired by Cropper and Griffiths (1994):

$$-\frac{F_{i,t} - F_{it-1}}{F_{i,t-1}}$$

$F_{i,t}$ is the annual weighted average forest area of country i in year t as percentage of total land area. F_{it-1} is the lagged value of forest area. Deforestation is measured as the negative growth rate of forests since it is the removal of forests. Figure 4 of the appendix, the histogram of deforestation, shows a normal distribution. β_1 and β_2, the slope coefficients of the population regression line from GDP and GDP^2, are of primary interest. This the net effect of a country's economic development on deforestation. Together, the parameters capture the effect of the variables on deforestation. GDP is first transformed into natural logarithms to reduce large outliers. Figure 5 of the appendix, the histogram of ln(GDP per capita), displays a normal distribution. Following the inverted U-shaped relationship, the relationship between GDP and deforestation is hypothesized to be positive while that of GDP^2 and deforestation is hypothesized to be negative. A rationale behind this is that, in the beginning of economic development, logging and fuelwood uses of forests are likely to increase with income. Eventually agricultural and fuelwood motives for deforestation are likely to decline with per capita GDP.

The model includes the following control variables: total population, population density, "openness" of the economy, fossil fuel energy consumption, and value of agriculture. Total population is transformed into natural logarithm to reduce large outliers. Growth in total population places pressure on a country's environmental sustainability through its growing demand for resources. Population density is added for the similar effect it has on environmental sustainability. The relationships of total population and population density with deforestation are hypothesized to be positive. The next control variable is "openness" of the economy. It is calculated using the following formula:

$$Openness = \frac{(Import + Export)}{GDP}$$

"Openness" has been promoted to reflect the development and diversification of the economy (Meier, 1970). Opening to trade could affect the environment through several channels. After opening to trade, countries may prefer to adopt looser standards of environmental regulation to improve international competitiveness. However, openness may also lead firms to adopt higher environmental standards as well as allow for technological and managerial innovations which help to reduce environmental degradation. Therefore, the effect is hypothesized to be either positive or negative. The next control variable added is fossil fuel energy consumption. Fossil fuels have prominent position in discussions on environmental problems because of the environmental damage they cause. Fossil fuel consumption and deforestation is hypothesized to have a positive relationship. Lastly, value of agriculture is included since the demand of agriculture is one of the main reasons for deforestation. Furthermore, economic development in earlier stages is often characterized by high values of agriculture. Therefore, a positive relationship is hypothesized between value of agriculture and deforestation.

The model is first run for all countries together. The quadratic model with all control variables suggests that something is likely going on in this data since the F-test gives the value 0.0047. The null-hypothesis that all the coefficients in the model are equal to zero is therefore rejected at the 5% significance level. But, a scatter plot on deforestation and GDP, shown in figure 6 of the appendix, does not seem to suggest an inverted U-shaped relationship; it does suggest a positive relationship. The model is also separately estimated for EU, Latin America, and Asia. These groups are chosen for their distinct levels of economic development. Afterwards, the model with all control variables is analyzed by including (GDP per capita)^3, which is inspired by the model from Grossman & Krueger (1991), to check for sensitivity to functional form. This is in consideration of the fact that Hilton & Levinson (1998) determined their results are sensitive to functional form. This cubic formulation allows for more types of shapes: monotonically rising or falling, an inverted U-shape (EKC), a U-shape, an N-shape, and an inverted N-shape.

V. Results

The fixed effects regression results of all countries together are analysed first before separately analysing and comparing the EU, Latin America, and Asia. Special interest is given to (GDP per capita) and (GDP per capita)^2 as these potentially give rise to the hypothesized inverted U-shape. For an inverted U-shape, the relationship between (GDP per capita) and deforestation needs to have a positive sign and (GDP per capita)^2 needs a negative sign. To ease comparison, all the models and their coefficients have been presented in the table and the statistically significant coefficients are marked. The cubic function, with (GDP per capita)^3, is included in the tables as model (7). Indication of the statistical significance level is based on the usual conventions.

All countries

The regression results for all countries together, displayed in table 6, show that none of the quadratic models have statistically significant coefficients for GDP per capita or (GDP per capita)^2; the null-hypothesis that the relationship between economic development and deforestation follows an inverted U-shaped relationship cannot be accepted. Only "openness" of the economy is shown to have statistically significant coefficients; It is statistically significant at the 5% level in models (4) and (5). In model (6) it is statistically significant at the 10%. Focus is given to model (6) since it has the most control variables. For a given country, if "openness" increases across time by 1%, deforestation increases with 0.009%. Including the control variables increases, comparing to model (1), the standard error of GDP per capita from 0.021 to 0.027 current international dollars. The R^2 improves from 0.029 to 0.059 comparing to model (1).

Table 6: Regression Estimates of the relationship between GDP and Deforestation

Dependent variable	Deforestation 1990-2015						
All Countries							
Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP Per Capita	0.000	0.001	0.002	0.000	-0.014	0.003	0.199
	(0.021)	(0.025)	(0.025)	(0.022)	(0.028)	(0.027)	(0.198)
$(\text{GDP Per Capita})^2$	0.000	0.000	0.000	0.000	0.001	0.000	-0.022
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.022)
$(\text{GDP Per Capita})^3$							0.001
							(0.001)
Total Population		-0.002	-0.002	0.005	0.000	-0.003	-0.003
		(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Population Density			-0.001	-0.002	-0.002	-0.004	-0.005
			(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
Openness				0.010*	0.010*	0.009^{+}	0.008^{+}
				(0.004)	(0.004)	(0.005)	(0.004)
Fossil Fuel Energy Consumption					0.000	0.000	0.000
					(0.000)	(0.000)	(0.000)
Value of Agriculture						0.000	0.000
						(0.000)	(0.000)
Intercept	0.009	0.044	0.035	-0.088	0.060	0.046	-0.547
Country effects	yes	yes	yes	yes	yes	yes	yes
Time effects	yes	yes	yes	yes	yes	yes	yes
Summary Statistics							
R^2 (within)	0.029	0.029	0.030	0.063	0.073	0.059	0.064
n	1374	1374	1374	1372	1335	1233	1233

Table 6: Results of fixed effects regression for all 56 countries. Balanced panel with annual data. Heteroscedasticity-robust standard errors are given in parentheses under the coefficients. The individual coefficient is significant at the $^{+}$10% *5% or **1% significance level using a two-sided test
Deforestation is calculated by = - ((forest area – lag of forest area) / lag of forest area). Forest area is the area with forests as percentage of total land area. GDP per capita and total population are in natural logarithms. Population density is in one hundred peoples per square kilometres of land area. Openness is the "openness" of the economy calculated by = (import + export)/GDP. Fossil fuel energy consumption and value of agriculture are in percentages of respectively total energy consumption and GDP.
Source: Author's analysis based on data from the World Development Indicators of the World Bank

EU

The regression results for EU, displayed in table 7, do not accept the null-hypothesis that the relationship between economic development and deforestation follows an inverted U-shaped relationship for the EU. Model (1) of table 7 shows that economic development follows a U-shaped relationship with deforestation. However, this relationship disappears when the control variables are included. The quadratic models (2) till (6) do not have statistically significant coefficients for GDP per capita and (GDP per capita)^2; nor do they have the hypothesized signs. Again, focus is given to the quadratic model (6) since it has the most control variables. The results of model (6) show that the estimated coefficient of total population, population density, and fossil fuel consumption are statistically significant at the 1% level. The total population and population density can be interpreted for a given country as: when total population increases across time with 1%, deforestation increases by 0.053%. When population density increases across time with 1 percentage point, deforestation will decrease with 0.008%. The positive sign for total population is as hypothesized while the sign of population density is opposite of what is hypothesized. Even if fossil fuel consumption is statistically significant, the small economic significance restricts the importance since the coefficient is 0.000. This effect is probably so small because fossil fuel consumption is in percentages. Furthermore, the estimated coefficient on "openness" is shown to be statistically significant at the 5% level. For a given country, if "openness" increase across time by 1%, deforestation increases with 0.006%. Lastly, value of agriculture is not statistically significant at any level. The estimates of model (6) for economic development are more precise than those of model (1) as the standard error for GDP per capita decreases from 0.046 to 0.033 current international dollars. The R^2 also improves as more control variables are included; it increases from 0.202 to 0.357 comparing to model (1).

Table 7: Regression Estimates of the relationship between GDP and Deforestation

Dependent variable:	Deforestation 1990-2015						
EU							
Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP Per Capita	-0.110*	-0.020	-0.015	0.000	0.004	-0.014	-0.281
	(0.046)	(0.035)	(0.037)	(0.036)	(0.031)	(0.033)	(0.446)
(GDP Per Capita)^2	0.006*	0.001	0.001	0.000	0.000	0.001	0.028
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.046)
(GDP Per Capita)^3							-0.001

							(0.002)
Total Population		0.050*	0.058*	0.065**	0.060**	0.053**	0.052*
		(0.021)	(0.024)	(0.022)	(0.020)	(0.019)	(0.020)
Population Density			-0.005*	-0.008**	-0.010**	-0.008**	-0.008**
			(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Openness				0.006*	0.006**	0.006*	0.005*
				(0.003)	(0.002)	(0.002)	(0.002)
Fossil Fuel Energy Consumption					0.000**	0.000**	0.000**
					(0.000)	(0.000)	(0.000)
Value of Agriculture						0.000	0.000*
						(0.000)	(0.000)
Intercept	0.493	-0.750	-0.899	-1.073	-1.027	-0.818	0.078
Country effects	yes	yes	yes	yes	yes	yes	yes
Time effects	yes	yes	yes	yes	yes	yes	yes
Summary Statistics							
R^2 (within)	0.202	0.341	0.366	0.393	0.449	0.357	0.359
n	499	499	499	499	491	466	466

Table 7: Results of fixed effects regression for 20 EU countries. Balanced panel with annual data. Heteroscedasticity-robust standard errors are given in parentheses under the coefficients. The individual coefficient is significant at the $^{+}$10% *5% or **1% significance level using a two-sided test
Deforestation is calculated by = - ((forest area – lag of forest area) / lag of forest area). Forest area is the area with forests as percentage of total land area. GDP per capita and total population are in natural logarithms. Population density is in one hundred peoples per square kilometres of land area. Openness is the “openness” of the economy calculated by = (import + export)/GDP. Fossil fuel energy consumption and value of agriculture are in percentages of respectively total energy consumption and GDP.
Source: Author’s analysis based on data from the World Development Indicators of the World Bank

Latin America

The regression results for Latin America, displayed in table 8, show that GDP per capita and (GDP per capita)^2 do not have a statistically significant relationship with deforestation in any of the quadratic models. Thus, the null-hypothesis that the relationship between economic development and deforestation follows an inverted U-shaped relationship cannot be accepted for Latin America. In fact, none of the models have a statistically significant coefficient. Focus is again given to the quadratic model (6) since it includes the most control variables. The results of model (6) for economic development are more precise than those of model (1); the standard error for GDP per capita decreases from 0.094 to 0.061 current international dollars. The R^2 also improves by increasing from 0.063 to 0.195 comparing to model (1).

Table 8: Regression Estimates of the relationship between GDP and Deforestation

Dependent variable	Deforestation 1990-2015						
Latin America							
Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP Per Capita	-0.066	-0.019	-0.025	-0.010	-0.040	-0.016	-0.597
	(0.094)	(0.074)	(0.070)	(0.065)	(0.062)	(0.061)	(0.974)
(GDP Per Capita)^2	0.003	0.000	0.001	0.000	0.001	0.000	0.066
	(0.005)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.110)
(GDP Per Capita)^3							-0.002
							(0.004)
Total Population		-0.075	-0.080	-0.082	-0.092	-0.093	-0.093
		(0.051)	(0.055)	(0.056)	(0.058)	(0.060)	(0.061)
Population Density			0.009	0.006	0.011	0.007	0.005
			(0.019)	(0.017)	(0.019)	(0.023)	(0.022)
Openness				-0.006	-0.005	-0.008	-0.006
				(0.007)	(0.007)	(0.007)	(0.007)
Fossil Fuel Energy Consumption					0.000	0.000	0.000
					(0.000)	(0.000)	(0.000)
Value of Agriculture						0.000	0.000
						(0.000)	(0.000)
Intercept	0.332	1.339	1.449	1.427	1.725	1.621	3.320
Country effects	yes	yes	yes	yes	yes	yes	yes
Time effects	yes	yes	yes	yes	yes	yes	yes
Summary Statistics							
R^2 (within)	0.063	0.157	0.160	0.166	0.180	0.195	0.197
n	425	425	425	424	410	397	397

Table 8: Results of fixed effects regression for 18 Latin American countries. Balanced panel with annual data. Heteroscedasticity-robust standard errors are given in parentheses under the coefficients. The individual coefficient is significant at the $^+$10% *5% or **1% significance level using a two-sided test
Deforestation is calculated by = - ((forest area – lag of forest area) / lag of forest area). Forest area is the area with forests as percentage of total land area. GDP per capita and total population are in natural logarithms. Population density is in one hundred peoples per square kilometres of land area. Openness is the "openness" of the economy calculated by = (import + export)/GDP. Fossil fuel energy consumption and value of agriculture are in percentages of respectively total energy consumption and GDP.
Source: Author's analysis based on data from the World Development Indicators of the World Bank

Asia

The regression results for the Asia, displayed in table 9, show the null-hypothesis that the relationship between economic development and environmental degradation follows an inverted U-shaped relationship cannot be accepted for Asia. Despite that all the coefficients for GDP per capita and (GDP per capita)^2 of the quadratic models have the hypothesized sign, none of them are statistically significant. The only statistical significant coefficients are found for "openness" in model (4), (5), and (6). These are all significant at the 1%

significance level. Again, to focus on model (6): the estimated coefficient shows that for a given country, as "openness" varies across time by 1%, deforestation increases by 0.022%. The standard error for GDP per capita increases from 0.028 to 0.030 current international dollars comparing to model (1). The R^2 improves by increasing from 0.039 to 0.182 comparing to model (1).

Table 9: Regression Estimates of the relationship between GDP and Deforestation

Dependent variable:	Deforestation 1990-2015						
Asia							
Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP Per Capita	0.030	0.034	0.037	0.009	0.010	0.036	0.130
	(0.028)	(0.030)	(0.035)	(0.028)	(0.036)	(0.030)	(0.298)
(GDP Per Capita)^2	-0.002	-0.002	-0.002	-0.001	-0.001	-0.002	-0.013
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.034)
(GDP Per Capita)^3							0.000
							(0.001)
Total Population		-0.012	-0.008	-0.003	-0.006	-0.008	-0.009
		(0.014)	(0.008)	(0.010)	(0.010)	(0.009)	(0.011)
Population Density			-0.003	-0.002	-0.001	-0.009	-0.009
			(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
Openness				0.020**	0.020**	0.022**	0.021*
				(0.006)	(0.007)	(0.007)	(0.007)
Fossil Fuel Energy Consumption					0.000	0.000	0.000
					(0.000)	(0.000)	(0.000)
Value of Agriculture						0.000	0.000
						(0.000)	(0.000)
Intercept	-0.121	0.083	0.009	0.023	0.073	0.002	-0.265
Country effects	yes	yes	yes	yes	yes	yes	yes
Time effects	yes	yes	yes	yes	yes	yes	yes
Summary Statistics							
R^2 (within)	0.039	0.044	0.046	0.174	0.171	0.182	0.183
n	450	450	450	449	434	370	370

Table 9: Results of fixed effects regression for 18 Asian countries. Balanced panel with annual data. Heteroscedasticity-robust standard errors are given in parentheses under the coefficients. The individual coefficient is significant at the +10% *5% or **1% significance level using a two-sided test
Deforestation is calculated by = - ((forest area – lag of forest area) / lag of forest area). Forest area is the area with forests as percentage of total land area. GDP per capita and total population are in natural logarithms. Population density is in one hundred peoples per square kilometres of land area. Openness is the "openness" of the economy calculated by = (import + export)/GDP. Fossil fuel energy consumption and value of agriculture are in percentages of respectively total energy consumption and GDP.
Source: Author's analysis based on data from the World Development Indicators of the World Bank

Within the three sets, EU has the most coefficients which are statistically significantly different from zero. For the quadratic model (6), these are total population, population density, “openness” of the economy, and fossil fuel energy consumption. For the quadratic model (6), Asia only has a statistically significant coefficient for “openness” of the economy. That “openness” of the economy is the only statistically significant coefficient in Asia, as well as for all countries together, displays the importance of a country’s trading behaviour. Being more open to trade could lead to more deforestation because countries try to improve international competitiveness by adopting looser standards of environmental regulation. Latin America does not have any statistically significant variables. That forest plantations are more important there might explain why. Deforestation will not be easily influence by other factors. This might also explain why the EU has the most statistically significant coefficients; forest plantations are not very important in the EU.

The main result is derived from the quadratic model (6). The results for all countries, EU, Latin America, and Asia are considered. None of these have statistically significant coefficients for GDP per capita and GDP^2 per capita. Therefore, they have the same implications for the main hypothesis: there is no empirical evidence that economic development and deforestation follows an inverted U-shaped relationship. This is both in line and not in line with earlier research since the empirical results on the EKC of deforestation are not conclusive on the existence. Lastly, the results show that the coefficients are found to be not robust to changes in functional form as they all change after employing the cubic model (7) with $(\text{GDP per capita})^3$. This is in line with some earlier research on the EKC (e.g. Hilton and Levinson, 1998; Harbaugh, Levinson, and Wilson, 2002)

However, that the null-hypothesis cannot be accepted doesn’t mean that there is no relation between the two variables. There is still a chance a type II mistake occurs, which is the mistake of not rejecting the null-hypothesis while it should be rejected. Furthermore, the estimation of the coefficients is not optimal due to the small sample size per group. It is possible that the existing data on deforestation is simply insufficient to detect the true relationship between economic growth and environmental degradation. The countries might not have reached the turning point level of GDP per capita yet. Other critical aspects are considered in the discussion hereafter. Even if there is no statistically significant inverted U-shaped relationship, the results are not taken to conclude that economic development is necessarily always bad for the environment. This paper only concludes that the available empirical evidence is not suitable to support the existence of an EKC for deforestation.

VI. Discussion

Policy Implications

Even though association is interesting, only causal effects should lead to policy prescriptions. Most of the EKC evidence, including this report, is derived with reduced-form models. These are assumed to capture the structural model in which income influences the composition of GDP, the environmental policy, technology, and how these affect environmental degradation (Bartz & Kelly, 2008). But, because the empirical evidence relies on reduced-from regressions, drawing conclusions about why the shape arises should be avoided. To develop efficient policies, it is especially necessary to understand the structure and causes of the relationship. Theoretical papers do this by analyzing the mechanisms by which an EKC can be explained; the degree of complexity is displayed by the many different explanations (e.g. Andreoni & Levinson, 2001; Arrow, et al., 1995; Suri & Chapman, 1998; Jahiel, 1998; Lieb, 2004). Theory does not give a clear prediction on the relationship between economic growth and environmental degradation across countries or over time. Copeland and Taylor (2003) explain that the relationship between economic development and environmental degradation is not straightforward. The EKC is only one of many possible outcomes (Copeland & Taylor, 2003; Harbaugh, Levinson, & Wilson, 2002). The different causes suggest an intricate and diverse relationship which also makes it wrong to accept the optimistic interpretations that economic growth is good for the environment. Furthermore, despite that the results of this paper only make conclusions about association, the data displays a statistically insignificant relationship between economic development and deforestation. Hasty and unfounded actions like substituting environmental policies by policies that promote national economic growth are discouraged; evidence on which they build is not solid or well understood.

Methodological and data limitations

Despite my hardest efforts, there are still treats to the internal and external validity of this research. External validity is harmed when the chosen countries are not representative for other countries in similar stages of economic development. Even if countries in Africa have similar GDP per capita with Latin America, it might not be appropriate to simply extend the results due to fundamental differences between these groups. Furthermore, empirical papers testing different indicators of environmental degradation give mixed results. The results cannot be used to make conclusions about other indicators of environmental degradation since the generalizability of the EKC is doubtful. Internal validity is threatened by biased and inconsistent estimators. Limitations in methodology and/or data can bring them about and these are discussed afterwards.

The model from this research did not consider long- and short-term effects. This could for example determine whether the changes are sustainable and what the effects are over time. Most researchers argue that environmental policy is a major driving force behind the EKC. When income rises, environmental regulations become stricter. However, it takes time before the regulations are worked out and debated over in the parliament. After that it takes more time before the effects of the new regulations become measurable. The results can be sensitive to variations in the data and permutations of the econometric specification like extending the lag structure of GDP per capita as a dependent.

Furthermore, there can be heterogeneity bias. For the fixed effects approach, there is the requirement that everywhere the relationship is the same. A paper by Dijkgraaf and Vollebergh (2001) tested the assumption of homogeneity in panel EKC models and find that the crucial assumption of homogeneity across countries is strongly rejected for CO_2. These findings suggest that panel-based estimations of the inverted U-shaped relationships for CO_2 are inconsistent. Time-series estimates present a strikingly different pattern; individually, some countries confirmed the EKC hypothesis (Dijkgraaf & Vollebergh, 2001). A lack of homogeneity is highly probable for deforestation. There are differences in local circumstances and there is also the absence of (coordinated) policies against deforestation in the past. Time-series estimates might be more appropriate in that case.

A problem, which is not specific to panel data, is selection bias. The countries were solely chosen based on whether they were in the EU, Latin America, or Asia. However, it is imaginable that for example poor countries with high levels of deforestation are less consistent in their collection and reporting of forest data due to inabilities. There could be a bias if there is more missing data for poor countries with high or low levels of deforestation.

There are mainly three reasons why data on deforestation has drawbacks; firstly, there can be errors and undercounting. A change in forest area can be caused by a revision or update of data instead of actual change. This even happens in high-income countries although there is still lower quality of information in developing countries (The World Bank Group, 2017). Measurement is difficult due to the multiple dimensions of deforestation. Change in forest area is a continuous process of forest expansion (gain) and deforestation (loss). Even with high-resolution satellite imagery, it is a difficult change to monitor. Furthermore, forest area change dynamics differ across national circumstances and forest types (FAO, 2016). Despite that data on forest area is all collected from the FAO, there can still be differences in collection between countries. Secondly, countries which seem to improve have already cut down most of their original forest (Shafik & Bandyopadhyay, 1992). Thirdly, crucial differences in biodiversity are lost in data. Natural forest, which conserve biodiversity and natural characteristics, are being replaced with planted forests which are often only established for production and/or protection of soil and water. Quality of forests is also important, not just the aggregated quantity, as maintaining biodiversity is crucial for the long-term health and productivity of the world's forests and consequentially us (FAO, 2016).

Recommendations

Since the results are shown to be sensitive to applying the cubic function, it might be interesting to test for other functional forms. Excluding the cubic term is favourable to the EKC hypothesis but the relationship between economic development and environmental degradation does not necessarily need to follow an inverted U-shape. The cubic function allows for more shapes and it can simply be skipped if it is not significant. Furthermore, it might be interesting to consider long- and short-term effects by including lagged GDP.

VII. Conclusion

In conclusion, the main hypothesis that the relationship between economic growth and environmental degradation follows an inverted U-shape cannot be accepted. The results of the regression models do not show statistically significant relationships between GDP per capita, GDP^2 per capita and deforestation. This both corresponds and does not correspond with earlier research; empirical research is not conclusive on whether there is an EKC for deforestation.

The existence of the EKC for only a selected few variables of environmental degradation has been wrongly taken to conclude that economic development is naturally good for environmental quality. Knowledge on the EKC for deforestation is not only of academic curiosity; it has important implications for national and international environmental policy. Research on the relationship between economic development and deforestation will give a sound basis for policy, investment, and management decision-making at the national, regional, and global level. This is critical as everybody is dependent on the many important services which forests provide, especially considering the increasing environmental problems.

This paper cannot make statements about which policies should be made. Limitations of this research, such as that of the reduced-form approach, hinder this. However, the results are concluded to not support the EKC hypothesis for deforestation. The optimistic conclusion that economic growth will solve deforestation is shown to be based on a hasty and false assumption of the existence of an EKC. Furthermore, the mechanisms by which an EKC can be explained are not well understood. Environmental policy for deforestation should not be substituted by policies that promote national economic growth with the belief that it will reduce environmental degradation. Being wealthy does not automatically lead to a flourishing garden.

VIII. References

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IX. Appendix

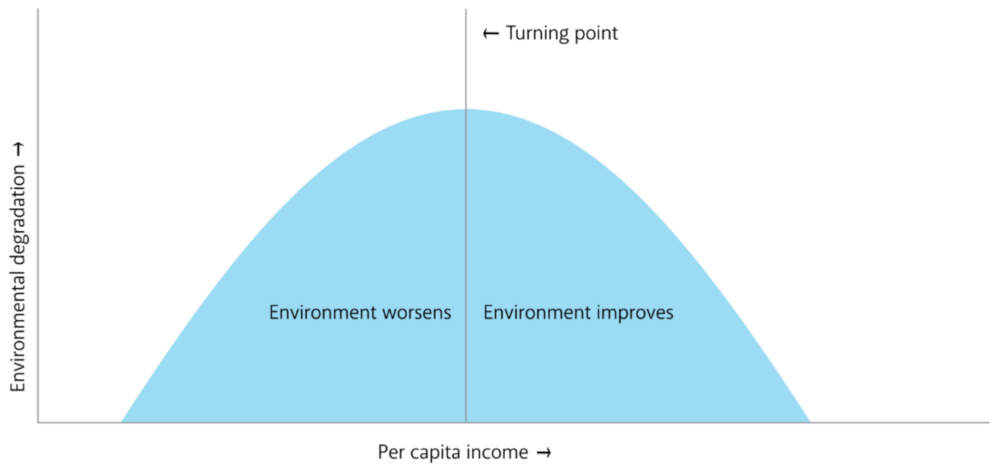

Figure 1: Environmental Kuznets Curve
Source: (Ho & Wang, 2015)

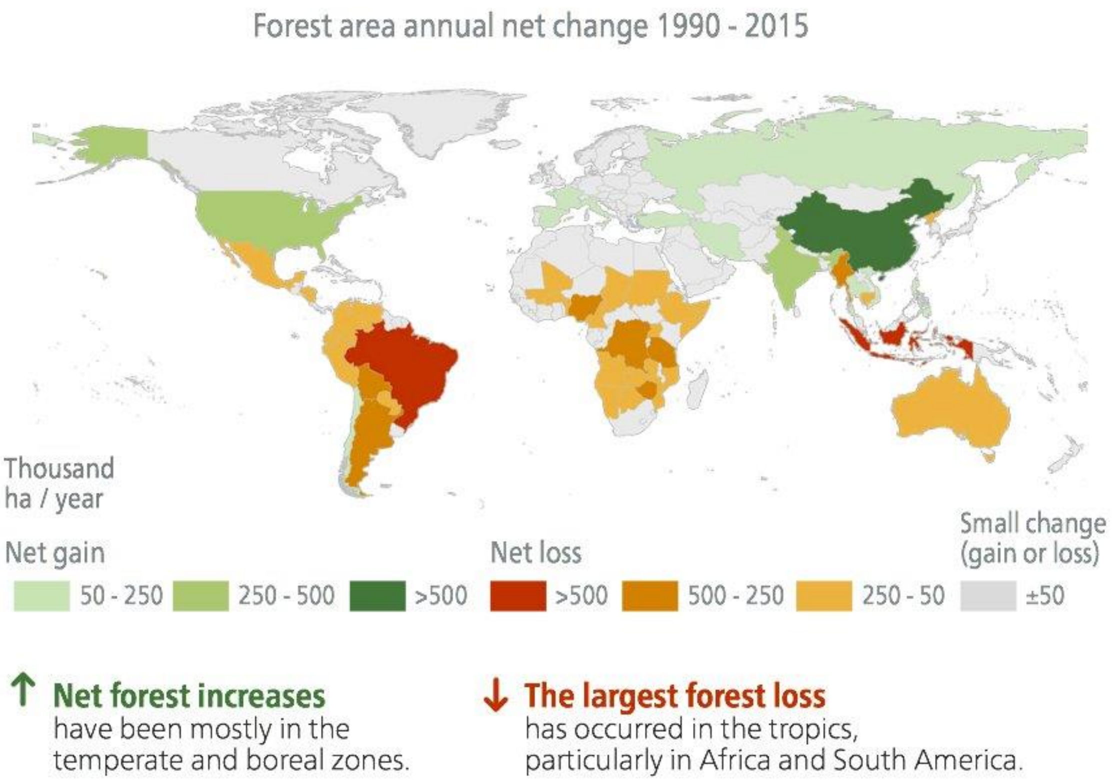

Figure 2: Change in Forest Area
Source: FAO (2016)

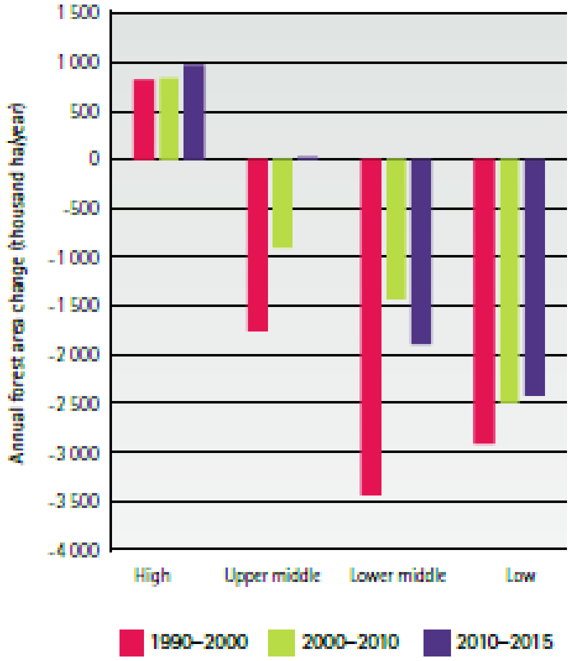

Figure 3: Annual forest area change by income category from 1990 till 2015
Source: FAO (2016)

All countries	Number of countries: 56				
	Observations	Mean	Standard Deviation	Min	Max
ln(GDP per capita)	1,428	9.301	0.891	6.878	11.127
(ln(GDP per capita))^2	1,428	87.309	16.354	47.301	123.808
(ln(GDP per capita))^3	1,428	826.631	227.273	325.311	1377.592
deforestation	1400	-0.001	0.012	-0.107	0.054

Table 1: Summary statistics for all countries
Source: Author's analysis based on data from the World Development Indicators of the World Bank

EU	Number of countries: 20				
	Observations	Mean	Standard Deviation	Min	Max
ln(GDP per capita)	518	10.001	0.535	8.411	11.127
(ln(GDP per capita))^2	518	100.306	10.451	70.738	123.808
(ln(GDP per capita))^3	518	1008.740	153.693	594.954	1377.592
deforestation	500	-0.004	0.006	-0.037	0.010

Table 2: Summary statistics for EU countries
Source: Author's analysis based on data from the World Development Indicators of the World Bank

Latin America	Number of countries: 18				
	Observations	Mean	Standard Deviation	Min	Max
ln(GDP per capita)	442	8.857	0.560	7.571	10.068
(ln(GDP per capita))^2	442	78.758	9.896	57.322	101.367
(ln(GDP per capita))^3	442	703.078	131.823	433.987	1020.579
deforestation	450	0.001	0.016	-0.107	0.027

Table 3: Summary statistics for Latin American countries
Source: Author's analysis based on data from the World Development Indicators of the World Bank

Asia	Number of countries: 18				
	Observations	Mean	Standard Deviation	Min	Max
ln(GDP per capita)	468	8.947	0.978	6.878	10.897
(ln(GDP per capita))^2	468	80.999	17.533	47.301	118.742
(ln(GDP per capita))^3	468	741.754	238.374	325.311	1293.914
deforestation	450	-0.001	0.012	-0.068	0.054

Table 4: Summary statistics for Asian countries
Source: Author's analysis based on data from the World Development Indicators of the World Bank

Wooldridge test for autocorrelation in panel data	Model						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
F	2.525	2.524	2.625	2.584	2.595	2.201	2.205
Prob > F	0.118	0.118	0.111	0.114	0.113	0.144	0.144

Table 5: Results of a test for autocorrelation in the data from all countries
Model 1 includes deforestation, ln(GDP per capita) and (ln(GDP per capita))^2, model 2 adds total population to this, model 3 adds population density, model 4 adds "openness", model 5 adds fossil fuel energy consumption, model 6 adds value of agriculture, and model 7 adds (ln(GDP per capita))^3
Source: Author's analysis based on data from the World Development Indicators of the World Bank

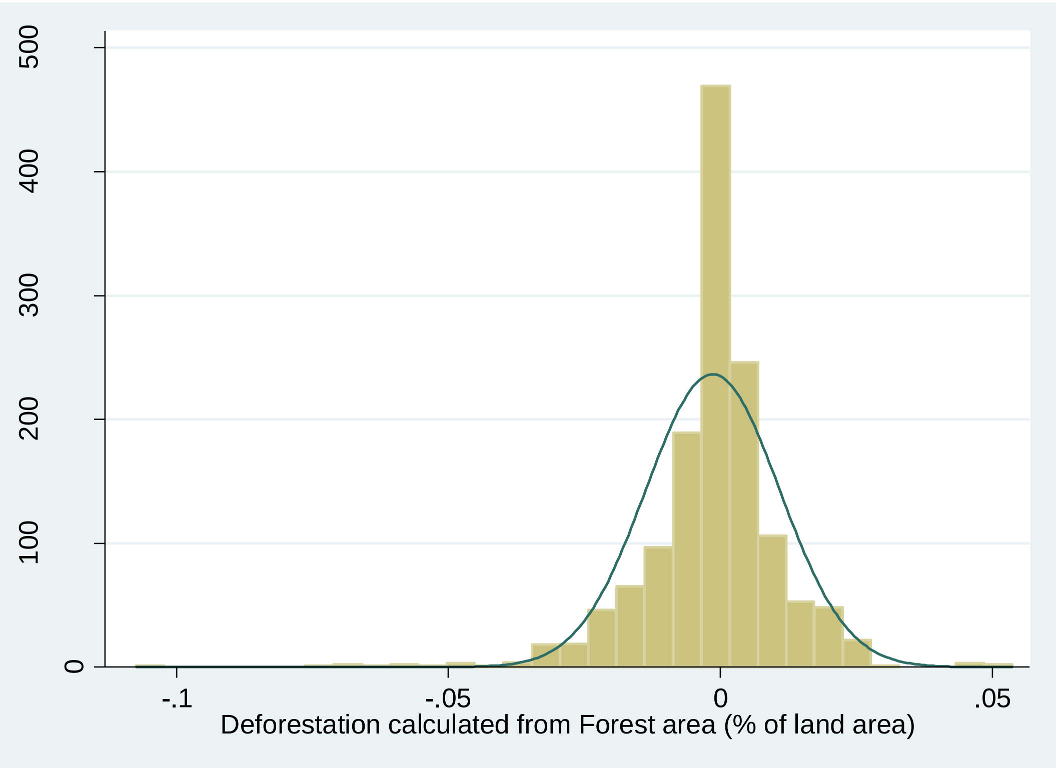

Figure 4: Histogram of deforestation calculated from the percentage forest area of total land area
Source: Author's analysis based on data from the World Development Indicators of the World Bank

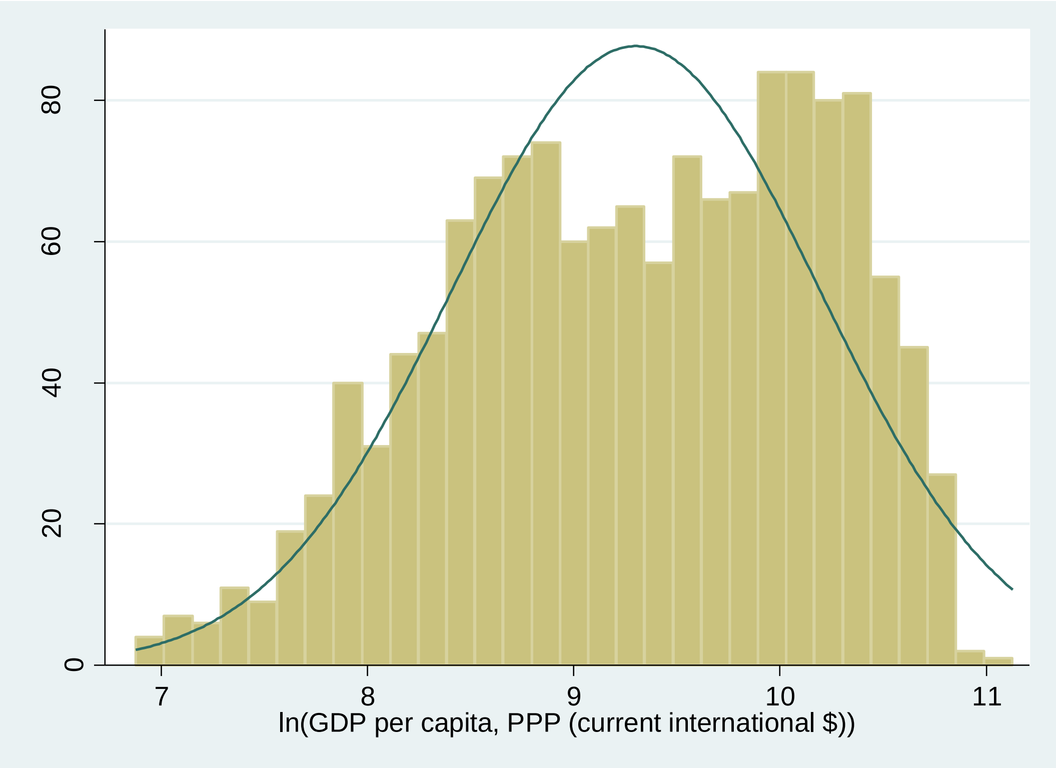

Figure 5: Histogram of ln(GDP per capita) based on Purchasing Power Parity in current international $
Source: Author's analysis based on data from the World Development Indicators of the World Bank

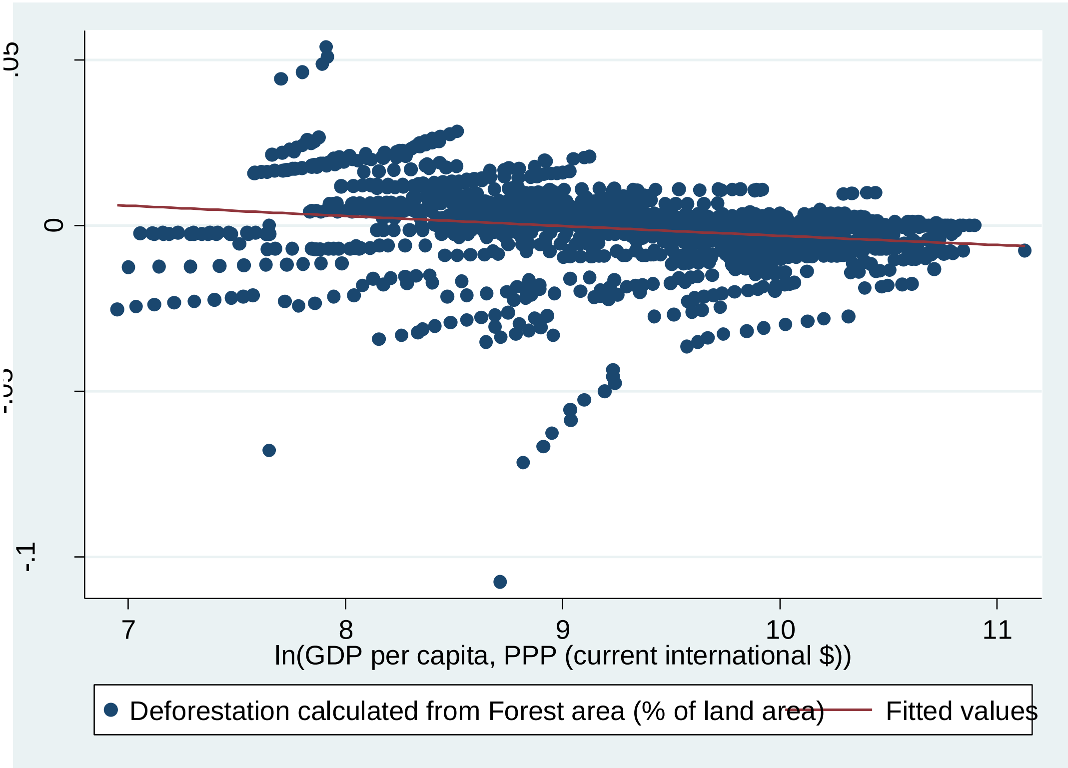

Figure 6: Scatterplot of deforestation (as percentage of total land area) and ln(GDP per capita) (based on Purchasing Power Parity in current international $)
Source: Author's analysis based on data from the World Development Indicators of the World Bank