The effects of international trade on the environment

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MASTER’S THESIS

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ABSTRACT

In this thesis, the effects of international trade on the environment are examined. This thesis consists of a replications study and an extension part. The replication study focuses on a replication of the study by Antweiler, Copeland and Taylor (2001) “Is free trade good for the environment”. When considering the scale, composition and technique effects in the replication study, international trade turns out to have a negative effect on the environment. In the extension part, a country’s three most important trading partners are added to the study. When considering a country’s three most important trading partners, international trade also has a negative effect on the environment of the domestic country.

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# 1. INTRODUCTION

The environment was to receive great importance with the establishment of, among others, the United Nations Environment Programme (UNEP) in 1972[[1]](#footnote-1). The problem of climate change has been given much attention since and is acknowledged as a serious threat to the future environment. It is often heard that climate change is the result of economic development in the last century. Environmental quality has therefore been receiving greater attention as economies grow. More specifically, the changes in a country’s environmental quality at different income levels has been researched several times (Shafik and Bandyopadhyay, 1992). Since the 90’s, the role of international trade and its effect on the environment has been added to the study. The severity of pollution is an important topic of debate, and also to what extent a country’s environmental policy affects international trade (Barret, 1994). Especially since international trade is considered to have a large and positive effect on economic growth, it is interesting to examine how this in turn affects environmental quality.

An example of the relationship between international trade and the environment, is the cleaning of the tanker Probo Koala in 2006.[[2]](#footnote-2) Originally, the international company Trafigura rented the tanker to deposit waste in the port of Amsterdam. During the deposit, it became clear that the waste was severely toxic and the cleaning process would become too expensive to be carried out in the Netherlands because of environmental regulation. Therefore, the Probo Koala navigated to the Ivory Coast in Africa, where the chemical waste was ought to be dumped at a garbage dump and where environmental regulations are less strict. The population of Abidjan, the city located near the garbage dump, protested against the deposit of the chemical waste and made the truck drivers stop.[[3]](#footnote-3) As a consequence, the truck drivers felt compelled to dump the waste illegally at several places around the city. Due to the chemicals, consisting of the highly dangerous hydrogen sulfide, at least seven people lost their lives and another 40.000 became ill with problems such as nausea, breathing problems, eye irritation and nosebleeds. Trafigura was fined for the illegal export of chemical waste to the Ivory Coast and for concealing the risks that were involved.[[4]](#footnote-4) This is an example of the relationship between international trade and the environment. It shows that due to trade openness, rich countries with strict environmental regulations have a tendency to relocate certain parts of a production process to poorer countries with less strict environmental regulations. In this case, the relocation of the cleaning of the Probo Koala had major consequences for the health and environment of the population in Abidjan.

A recent article of the Dutch newspaper NRC shed light on the effects of economic growth on the environment. The article discussed the top 10 causes of death worldwide, with most remarkably air pollution as one of the most important causes.[[5]](#footnote-5) According to NRC, 3.2 million people died as a consequence of air pollution in 2010, with the largest number of victims among the Asian population. Notably is that the countries with most deaths caused by air pollution are the ones with the largest expected economic growth in the near future. As a result of the fast growing economy, air pollution is expected to become worse and more deaths will follow. As the article explained, air pollution is expected to decline at a certain moment, but before this point is reached, it is necessary for economies to grow and, as a by-product, the environment deteriorates initially. Ones countries reach a certain amount of wealth and its population recognizes the importance of a healthy environment, money will be invested in cleaner production processes and air pollution will improve.

Motivated by these example, this thesis examines the relationship between international trade and the environment. After replicating the study “Is Free Trade Good for the Environment?” by Antweiler, Copeland and Taylor (2001), this thesis extends the study including the trade flows and trading partners of a country. Goal is to examine to what extent trade liberalization has an effect on the environment and whether a country’s trading partners play a role in this matter. Since this thesis consists of a replication study and an extension to it, I test for two hypotheses.

The replication study tests for the hypothesis: *International trade is good for the environment.*

The extension part of this thesis tests for the hypothesis: *International trade is good for the environment when you take a country’s three most important trading partners into account.*

To start with, this thesis discusses existing literature on the subject of trade liberalization and the environment. After that follows a section that summarizes the paper by Antweiler, Copeland and Taylor (2001). Chapter 4 focuses on replicating the study by Antweiler, Copeland and Taylor by constructing a new dataset and running several regressions. In chapter 5, the study is extended by including a country’s most important trading partners. This is followed by a section on limitations and additional research, and finally the conclusion.

The study by Antweiler, Copeland and Taylor showed that free trade decreases pollution concentrations and is therefore good for the environment. They focused on a combination of the scale, composition and technique effects, and concluded that the negative technique effect (on pollution) offsets the positive scale and composition effect. The replication study of this thesis however does not find the same results, and rejects the first hypothesis that international trade is good for the environment. When considering a country’s three most important trading partners in the extension part of this thesis, the second hypothesis is also rejected.

# 2. LITERATURE REVIEW

## 2.1 Scale, composition, and technique effects

The process of international trade and its effect on economic growth is a subject many researchers have intrigued (Barker, 1977). Meanwhile, a growing interest in the environment adds a nice feature to the existing literature. The relationship between international trade and the environment is main topic of this thesis.

Grossman and Krueger (1991) examined the environmental impact of the North-American free trade agreement. They elaborated on the existence of scale, composition and technique effects. I discuss these effects in more detail hereafter.

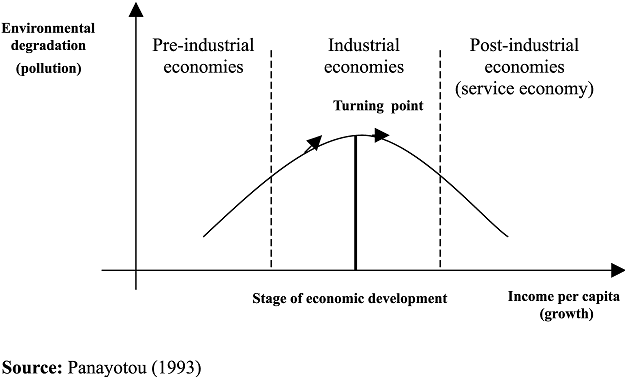
The *scale effect* arises when the scale of economic activity increases, holding production techniques and the mix of goods produced constant. When the economy is scaled up as the result of trade liberalization, Grossman and Krueger found that pollution increases. For example, a larger economy will demand a larger amount of energy, which leads to a larger amount of emissions that could harm the environment. The *composition effect* depends on the composition of an economy’s output when the scale and emission intensities are kept constant. When a country specializes in producing a polluting good as a result of trade liberalization, the composition effect leads to an increase in pollution. A country’s comparative advantage, which is “the presence of cross-country differences in the effectiveness with which primary resources can perform different activities” (Grossman and Helpman, 1991, p. 3), is important in determining the effect of trade liberalization on the environment.

The *technique effect* is the change in production techniques when trade liberalizes, and the result this change has on the country’s pollution emissions (Grossman and Krueger, 1991). Main opinion is that the technique effect leads to a decrease in pollution emissions, thus to a decrease in pollution. Not only does an increasing economy demand a cleaner environment (considering the Environmental Kuznets Curve in next paragraph), modern technologies are also considered to be cleaner than older ones. Summarizing, both scale and composition effects lead to an increase in pollution. The technique effect however results in a decrease in pollution and therefore a cleaner environment. Considering the three effects simultaneously, the magnitude of each effect, either positive or negative, plays an important role in whether trade liberalization is good or bad for the environment.

## 2.2 Environmental Kuznets Curve

In their study, Grossman and Krueger (1991) were the first to identify a bell-shaped relationship between environmental quality and income per capita. Years before, Simon Kuznets already developed the inverted U-shaped curve to explain the relationship between GDP per capita and income inequality (Kuznets, 1955). Instead of income inequality, Grossman and Krueger focused on environmental quality and discovered the same shape in the relationship between environmental quality and income per capita. They focused on three air pollutants and found that “for two pollutants (sulfur dioxide and “smoke”) that concentrations increase with per capita GDP at low levels of national income, but decrease with GDP growth at higher levels of income” (Grossman and Krueger, 1991, abstract). More specifically, they estimated that a country’s environment starts improving once income per capita reaches $4,000 to $5,000. They named the bell-shaped relationship the Environmental Kuznets Curve (hereafter EKC). The EKC describes that an increase in per capita income would lead to environmental deterioration initially, but after a turning point of income, leads to environmental improvement (Panayotou, 1993). Selden and Song (1994) expanded the research by examining two extra air pollutants and by focusing on data from rural and urban areas. They also found support for the EKC, but estimated higher turning points of income per capita at which emissions start declining. Even though the environment will improve in the long run, they expressed their concern that much time goes by before progress occurs.

The Environmental Kuznets Curve:



Panayotou (1993) has pointed out several arguments that explain the shape of the EKC. To start with, the shift in sectors of a growing economy (from agriculture to industrialization, from industrialization to services & technological progress, or as in the graph defined, pre-industrial, industrial, and post-industrial economies), has an effect on the environment. Environmental decay starts increasing in the first stages, but once the economy shifts from heavy-pollutive industries to cleaner services and technologies, environmental quality starts increasing and degradation declines. Furthermore, at low levels of income per capita the public only cares about their basic needs. At low living standards, environmental quality is not of anyone’s concern, and degradation appears. However, when living standards rise, the environment becomes more important and the public will demand a higher quality of it. Under public pressure, the government is compelled to introduce policies and regulations to protect the environment.

Despite of the positive theories on the EKC that the environment will improve in the long run, several economists recognize the downside effects of globalization on the environment. Tisdell (2001) summarized the counterarguments against the EKC, emphasizing that there are some serious doubts on the positive working of the curve. For example, the EKC does not apply for certain measurements of pollutions, such as CO2. Furthermore, the U-shaped form might not be completely correct, since it is unlikely that all emissions will reduce to zero while the economy keeps growing. It is not plausible that there will be no more production processes with (a small amount of) pollution as a by-product in the future. Another argument against the EKC, is the possibility of a certain threshold of pollution. “Pollution intensities or levels may not decline as economic growth proceeds until a critical pollution threshold is exceeded globally, or even nationally. Once this critical threshold is exceeded, the environmental change (such as might occur with rising greenhouse gas emissions) depresses incomes sharply and stymies economic growth.”(Tisdell, 2001, p.187-188)

## 2.3 Trade liberalization, economic growth and the environment

Many researchers have shown that trade liberalization is an important contributor to economic growth. As a result of free trade, resources are allocated more efficiently within countries and countries benefit from their comparative advantage by specializing in the production of certain goods (Thirlwall, 2000). Trade liberalization and foreign direct investments have contributed to the process of globalization (Christmann and Taylor, 2001). Not only via economic integration does this process of globalization occur, also channels of political interaction, information and technology, and culture contribute to a more globalized world.

Additional to the scale, composition and technique effects, Panayotou (2000) identified three other channels between globalization and the environment. Trade liberalization induces globalization, and in turn, globalization has an income, product and regulatory effect on the environment. The three effects are discussed below.

Trade-liberalization stimulates economic growth, which results in increasing income. This *income effect* has an impact on the environment through several ways. Due to a larger income, consumption expenditures increase and externalities harmful to the environment occur. Furthermore, a larger income stimulates consumers to demand a higher environmental quality, and more resources become available for abatement. Since the environment becomes more important on the agenda, the government may alter environmental policies in a beneficial way to the environment.

The *product effect* is closely associated to the technique effect described in paragraph 2.1. When the trade in goods that are produced in an environmental-friendly way increases, the product effect has a positive influence on environmental quality. However, it is also possible that goods are produced harmfully to the environment. In that situation, an increase in production has a negative impact on environmental quality.

The *regulatory effect* arises from environmental policies and standards maintained by the government. As a result of trade liberalization, environmental policies can become more strict in order to improve the environment. These policies can also be incorporated in the trading agreements between countries. However, the downside to this effect is that environmental policies can also become more eased, in order to increase the amount of trade.

Cole and Elliot (2003) explained that trade openness has an effect on the environment through the channel of environmental regulation and comparative advantage. They combined these channels in the environmental regulation effect (hereafter ERE). “The ERE implies that a country with a lower than average level of environmental regulations will have a comparative advantage in pollution-intensive production.” (Cole and Elliot, 2003, p. 364). The cleaning of the Probo Koala mentioned in the introduction is an example of this. Low environmental regulations in the Ivory Coast resulted in the relocation of the cleaning process to this country, whereas the cleaning process would have been too expensive in European countries with a more strict environmental policy. As a result of the ERE, developing countries will specialize in dirty-goods industries and suffer from an environmental downfall. On the other hand, developed countries will concentrate on producing clean goods and benefit from a cleaner environment.

Several researchers have examined the working of environmental regulation. According to Ederington and Minier (2003), environmental policy is either lacking to protect the environment or works in such a way that it forms a barrier to international trade. Ederington and Minier examined whether environmental policy should be included in the trading negotiations. They believed that caution is needed, since environmental policy could possibly start working as a trade barrier, which has a negative effect on trade liberalization. They elaborated on two arguments why countries should adopt international environmental policy. First, the ‘level-playing-field’ argument argues that the Environmental Regulation Effect mentioned earlier is unfair. They think it is improper when countries have a comparative advantage in dirty-goods because of their low environmental and labor regulations. Second, governments will have an incentive to distort national policies in such a way that they behave as a secondary trade barriers, which leads to a global loss of trade.

According to Ederington and Minier, it is important to realize whether countries have the intention to use environmental policy as a trade barrier to protect their national industries or not. When environmental regulation is treated as an endogenous variable (instead of exogenous, like earlier researchers have done), the effect of environmental regulations on flows of trade can be significantly higher than earlier assumed.

Furthermore, Cole and Elliot (2003) focused on the factor endowments of a country and referred to this as the capital-labor effect (hereafter KLE). The capital-labor effect means that the compositional changes in pollution are the result of differences in capital-labor endowments. Capital abundant countries will become pollution intensive, and labor abundant countries become relatively clean.

Taylor and Copeland (2004) stressed out two hypothesis concerning trade liberalization and the environment. The *pollution haven hypothesis* asserts that environmental policy an important contributor is to the patterns of international trade (Taylor and Copeland, 2004). High income countries are assumed to be more concerned about the environment and therefore adopt strict environmental regulations. The hypothesis asserts that, as a result of trade openness, pollution intensive production relocates from high income countries to low income countries with less strict environmental regulations. Low income countries become the ideal location for pollution-intensive industries to settle and their environments will suffer from deterioration (Taylor, 2005). However, little evidence has been found to support the hypothesis (Taylor and Copeland, 2004). Taylor and Copeland however did find strong theoretical support for there to exist at least an effect called the *pollution haven effect,* which states that “the stringency of pollution regulations does affect plant location and trade flows” (Taylor and Copeland, 2004, p. 4). They explained that, in addition to environmental regulation, other factors have an effect on patterns in trade too, and therefore the hypothesis might not exist but the effect does.

*The factor endowment hypothesis* has a different explanation for the relationship between free trade and the environment (Taylor and Copeland, 2004). The commodity that is produced with capital is considered to be a dirty good, and the commodity that is produced with labor is considered to be clean. The country with capital abundance produces and exports the dirty good, which leads to an increase in pollution in this country. The country with labor abundance produces and exports the clean good, resulting in a fall in pollution in that country (Temurshoev, 2006).

This literature study shows that different researchers have proven that international trade not only leads to economic growth, but also to degradation of the environment. A higher demand for production, combined with more use of energy, results in more pollution. As economies grow, the Environmental Kuznets Curve shows that pollution can decline after reaching a certain turning point of income. At this point, cleaner production processes and stricter environmental regulations improve the environment. Also a country’s comparative advantage, either capital-abundant or labor-abundant, plays a role in the relationship between international trade and the environment.

# 3. ANTWEILER, COPELAND AND TAILOR

## 3.1 Main question and data

In their paper “Is free trade good for the environment?”, Antweiler, Copeland and Taylor (2001), from now on referred to as ACT, examined the impact of trade openness on the environment. To estimate the effect of trade on pollution concentrations, ACT distinguished between the scale, composition and technique effects of globalization. The main variable of interest is sulfur dioxide concentrations, measured at 290 different sites at 108 cities, over 43 developed and developing countries from 1971-1996. Other data reflect economic indicators, such as city economic intensity, capital abundance, per capita income and trade intensity. For a complete list of all the used variables, see the appendix.

## 3.2 Econometric methods

ACT used the following model[[6]](#footnote-6): A small open economy, with a population of N agents, produces two final goods, X and Y. The country uses two types of production factors, labor L and capital K. The industry that produces good Y is labor intensive and does not generate pollution. The industry that produces good X is capital intensive and does pollute. There are constant returns to scale. Thus, the unit cost functions are described as cx(w,r) and cy(w,r). Domestic prices are denoted as p = βpw, where β is the importance of trade frictions and pw is the common world relative price of X. Domestic and world prices are not the same since countries differ in location, proximity to suppliers and trade barriers. Trade frictions can be either transport costs or other barriers to trade.

The model represents a reduced form that describes the relationship between pollution emissions and economic indicators. “To isolate the role of trade, it is important to understand how these different economic factors affect the demand for, and supply of, pollution. To do so, we use the terminology of scale, composition and technique effects.” (ACT, 2001, p. 882).

Pollution emissions are written as:

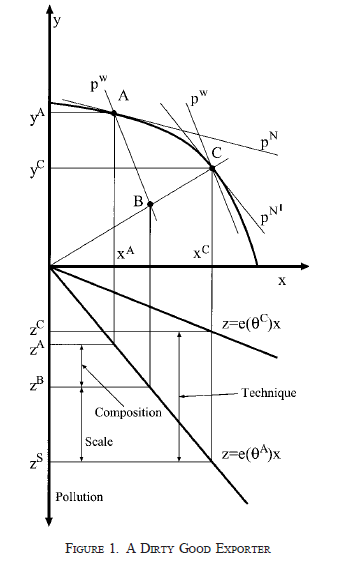
with e(θ) as emissions per unit output, θ as a measure of the intensity of abatement and φ as the share of X in total output. Sulfur dioxide emissions are used in the study to measure pollution, since it is a by-product from capital-intensive production processes. “Pollution depends on the pollution intensity of the dirty industry e(θ), the relative importance of the dirty industry in the economy φ, and the overall scale of the economy S.” (ACT, 2001, p. 882). Pollution emissions can be differentiated to:

with as the percentage change in pollution emissions, as the scale effect, as the composition effect (or the trade-induced composition effect) and as the technique effect.

The scale, composition and technique effects contribute to the understanding of to what extent economic factors have an effect on the demand for, and supply of pollution. This was already explained by Grossman and Krueger in 1991 as discusses in the literature review. The three effects have the advantage that they isolate the role of trade, and can be estimated either separately or jointly. The total impact of a change in trade frictions is found in the changes in real incomes, the scale, and composition of output. A change in β, which captures a change in trade frictions, results in a price change and production change, which alter the scale, composition and technique effect. When differentiating with respect to β and holding fixed world prices, country type and factor endowments, it leads to the full impact of a change in trade frictions:

Company profits are denoted as π, and real income per capita is denoted as I.

The following figure demonstrates the consequences of trade liberalization for a dirty good exporter. The top panel shows the changes in production, the bottom panel shows the consequential changes in pollution. Before the change in trade frictions, production is at point A, world price is p*W* and net price is p*N*, emissions intensity is e(θA), and pollution is at zA. After a change in trade frictions (and thus, a change in trade), -three different movements occur. First, the composition of output alters and moves from A to B, holding both the economy’s scale and production techniques fixed. As a consequence, pollution changes from z*A* to z*B*, also known as the trade-induced composition effect. Second, the change in the scale of the economy moves production from B to C, and pollution from z*B* to z*s*, which is the scale effect. Third, “the value of output measures at world prices rises because of trade and this real income gain (indirectly) creates the technique effect shown in the bottom panel.” (ACT, 2001, p. 886). This technique effect corresponds to the decrease in pollution from z*s* to z*C*. Summarizing, “trade liberalization for a dirty good exporter leads to less pollution if the composition and scale effects are overwhelmed by the technique effect.” (ACT, 2001, p. 886). Note that this example only applies to a dirty good exporter. “If we compare countries with similar incomes and scale, openness should be associated with higher pollution in dirty good exporters and lower pollution in dirty good importers.” (ACT, 2001, p. 888).



Source: Antweiler, W., Copeland, B.R., Taylor, M.S. (2001) “Is free trade good for the environment?” *The American Economic Review* 91(4): 877-908.

After discussing the model, ACT move from their theory to their estimating equation. ACT developed the following functional form for pollution concentrations at site *ijk,* at time *t*:

They used the following abbreviations:

*Z* Pollution emissions

*X* Total of the scale, composition, technique and trade-intensity effect

*Y* Site-specific weather variables and site-specific physical characteristics

Ψ The partial effect of an increase in trade intensity on pollution

SCALE Scale effect. City-specific economic intensity in GDP/km2

KL Composition effect. National capital-to-labor ratio (i.e. capital abundance)

INC Technique effect. One-period-lagged three year moving average of income per capita

TI Trade intensity. Export and Imports as a share of Gross Domestic Product. (X+M/GDP)

Ψ\*TI Trade-induced composition effect

REL.KL A country’s capital-to-labor ratio measured relative to the world-average

REL.INC A country’s real income measures relative to the world-average

**Linking theory and model**

The model has the advantage that the scale, composition and technique effects can be either estimated jointly or separately. It distinguishes between the negative effect on the environment of the scale and composition effect, and the positive effect on the environment of the technique effect. The scale of the economy is measured by economic activity per unit area, in other words GDP per square kilometer. It allows for differences in a city’s population size and density. Capital abundance (KL) is the measurement for the composition effect, and the technique effect is captured by income per capita (INC). Furthermore, trade frictions (β) are unobservable, and therefore trade intensity (TI) is used to represent trade openness in the model.

To isolate the role of trade, the pollution haven hypothesis and factor endowment hypothesis (chapter 2) play a considerable role in the link between theory and this model. Both hypotheses expect that trade openness effects “the composition of national output in a way that depends on a nation’s comparative advantage” (ACT, 2001, p.878). In the model, comparative advantage is captured by relative factor abundance (REL.KL) and relative factor income (REL.INC). Capital abundance and real income are main country characteristics in the model. TI represents the effect of trade on a country’s economy, and then its impact on country characteristics needs to be conditioned. “To condition the impact of openness on country characteristics we interact the trade intensity measure with our model’s predicted determinants of comparative advantage. (…) This procedure allows us to condition the predicted environmental impact of further openness on our theoretical determinants of comparative advantage.” (ACT, 2001, p. 879). In the model, this is represented by Ψ\*TI, which is the trade-induced composition effect. “The sign of the trade-induced composition effect should reflect a country’s comparative advantage in clean versus dirty goods” (ACT, 2001, p. 895).

Model A is linear in the response to scale, composition and technique effects. This model is stretched to Model B, which also includes the squares of composition and technique effects (KL2 and INC2), and to model C, that adds the squares of the scale effect (SCALE2) for a diminishing effect at the margin. ACT used random and fixed effects in their estimations of model A, B and C, and presented the elasticities of scale, composition, technique and trade intensity in their results.

## 3.3 Results

Antweiler, Copeland and Taylor (2001) have estimated the scale, composition and technique effects jointly for a new dataset. They find that “income gains brought about by further trade or neutral technological progress tend to lower pollution, whereas income gains brought about by capital accumulation raise pollution.” (Antweiler, Copeland and Taylor, 2001, p. 878). They combined the three effects mentioned above and examine the effect of trade liberalization on sulfur dioxide concentrations. They find that “freer trade appears to be good for the environment”. When measuring the magnitude of all effects and adding them up, the reduction in pollution from the technique effect offsets the increase in pollution of the scale and composition effect.

The table with the results is presented in the appendix. For all models, the scale effect has a significant and positive effect on emission concentrations and its elasticity increases as model A extends to model B and C. The composition effect is also positive and significant, including its elasticity. The technique effect has a negative and significant effect on emission concentrations, as is the technique elasticity. The magnitudes of these three effects are different for all columns, but increase when moving from model A to B and C. In the estimates, the negative technique effect is always larger than the positive scale effect, and the positive composition effect is relatively small. Thus, the three effects combined together have a negative effect on emission concentrations, and therefore lead to an improvement of environmental quality.

The trade intensity coefficient, reflecting the trade-induced composition effect, is only significant for the fixed effects, and has a negative relationship with emission concentrations. However, the trade intensity elasticity is significant and negative for both random and fixed effects.

For all columns, ACT “reject the hypothesis that the terms reflecting the trade-induced composition effect are jointly zero” (ACT, 2001, p. 894). Furthermore, “it is clear that country characteristics describing both relative income and abundance are important, but it is difficult to evaluate the relative strength of pollution haven and factor abundance motives” (ACT, 2001, p. 894). According to the pollution haven hypothesis, low-income countries become pollution havens for producing the dirty good. According to the factor abundance hypothesis, high-income countries have a comparative advantage in producing the dirty good (as explained in paragraph 2.3 of this thesis). ACT found that the pollution haven hypothesis and factor abundance hypothesis seem to reduce the magnitude of the composition effect. “Because these two partial theories work against each other, the net result of the potentially very large composition effects predicted by either theory turn out the be rather small in practice.” (ACT, 2001, p. 896). Thus, the composition effect only has a relatively small negative impact on the environment.

The overall conclusion is that sulfur dioxide concentrations decrease with trade openness. “If trade liberalization raises GDP per person by 1 percent, then pollution concentrations fall by about 1 percent. Free trade is good for the environment.” (ACT, 2001, p. 878).

# 4. REPLICATION STUDY

## 4.1 Main question and data

An important part of this thesis is a replication of the study by ACT. For this replication, a new panel dataset is constructed with new data of 139 countries from 1970-2008. These years are chosen due to data availability. Most data on the variables of this study are available from 1970 onwards to 2008. Especially one of the dependent variables, LOG of CO2, is available until 2008. Furthermore, this data was available for 139 countries. Using this number of countries has the advantage that a mix of countries is being examined, meaning that both developing and developed countries are included in the study. As in the paper by ACT, the relationship between free trade and the environment is examined.

The dataset in this study is new and different from the dataset used in the paper by ACT, since it uses data on a larger number of countries (139 as opposed to 41) and a different number of years (1970-2008 as opposed to 1971-1996). Furthermore, it is important to note that ACT focused on site-specific emission concentrations, and this study on country-wide emission levels. The reason that emissions levels are being used instead of emissions concentrations, is because this replication study focuses on country level. At country level, pollution is only measured in the form of emissions on national level. Since data for sulfur dioxide was only available for 38 countries, this study also focuses on a second dependent variable, namely carbon dioxide, for which data was available for the 139 countries used in this study.

The new dataset uses measures of environmental quality and economic indicators. It is important to note that the variables in this replication study are all on a country-level basis, as opposed to the variables in ACT which are on a city-level basis. Since this thesis focuses on a country-level basis, not all the variables from ACT are relevant. For example the suburban and rural dummy is only relevant when a study is on a site-specific basis. I have therefore excluded several variables pertaining site-specific measures.

In addition, it was not possible to include the variables with respect to the average temperature and precipitation variation. The database that provides on these variables is the Global Historical Climatology Network (GHCN). They provide the data on a daily basis for each city, over several years. It turned out to be very time-consuming to retrieve the average temperature and precipitation variation of just one country in one year, let alone of all 139 countries. Therefore, these variables are not included in the study.

The following variables are used in this replication study:

**Dependent variables:**

* *LOG of CO2*

Carbon dioxide (CO2), measured in total emissions per year by the World Bank for each country. Taken as logs.

* *LOG of SO2*

Sulfur dioxide (SO2), measured in total emissions per year by the United Nations Environment Programme (UNEP). The database only provides data on sulfur dioxide for 38 countries. Taken as logs.

**Independent variables:**

* *Economic intensity (GDP/km2)*

Constructed by multiplying a country’s GDP per capita (in constant $/person) by its population density (people/km2). These separate variables are retrieved from the World Bank.

* *Capital abundance (K/L)*

Good data on capital abundance is lacking, and therefore an alternative measure is used. The World Bank provides Gross Capital Formation (in % of GDP, constant US$), which is used in this study as an alternative measure for capital abundance. According to The World Bank, Gross Capital Formation “consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories”.

* *Relative capital abundance*

A country’s capital abundance in relation to the ‘world’s average capital abundance’ of all countries in the dataset. Estimated using the data on Gross Capital Formation from the World Bank

* *GDP per capita*

Gross domestic product per capita, measured in constant 2000 US$ by the World Bank.

* *Relative GDP per capita*

A country’s relative GDP per capita in relation to the ‘world’s average GDP per capita’ of all countries in the dataset. Estimated using the data on GDP per capita from the World Bank.

* *Trade intensity*

Measured as exports and imports as a share of GDP (X+M/GDP). Estimated by the World Bank.

* *Communist country dummy*

A dummy for countries that are either communist or have a communist past. Retrieved from [http://geography.about.com/od/lists/tp/communistcountries.htm on 18-06-2013](http://geography.about.com/od/lists/tp/communistcountries.htm%20on%2018-06-2013).

* *Helsinki Protocol dummy*

A dummy for countries that have signed the Helsinki Protocol. Retrieved from <http://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-1-b&chapter=27&lang=en> on 18-06-2013. The Helsinki Protocol is a “protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on the Reduction of Sulfur Emissions or their Transboundary Fluxes by at least 30 per cent. Helsinki, 8 July 1985.”[[7]](#footnote-7)

## 4.2 Methodology

To replicate the study by ACT, several regressions are constructed using ordinary least squares (OLS), adding each control variable step by step. In this replication study, 20 regressions are constructed for each dependent variable, using time-fixed effects (table 1 and 2, column 1-20). The tables with time-fixed effects and country-fixed effects (table 5 and 6) can be found in appendix E.

For the first 17 regressions of table 1 and 2, the control variables are added step by step until all variables are included. Regressions 18 to 20 represent the regressions from the study by ACT. Column 18 represents the model from paragraph 3.2. Column 19 adds the variables of the squared composition and technique effect, and the interaction between the Communist country dummy and the technique effect. Column 20 adds also the squared scale effect. In other words, the regressions encompass the following:

Column 18:

*Z = Constant + α1\*EcoInt + α3\*K/L + α5\*GDPpc + α8\*TI + α9\*TI\*REL.K/L + α10\*TI\*(REL.K/L)2 + α11\*TI\*REL.GDPpc + α12\*TI\*(REL.GDPpc)2 + α13TI\*(REL.K/L)\*(REL.GDPpc) + α14\*CCdummy + α16\*CCdummy\*(GDPpc)2 + α17\*Helsinki*

Column 19:

*Z = Constant + α1\*EcoInt + α3\*K/L + α4\*(K/L)2 + α5\*GDPpc + α6\*GDPpc2 + α7\*K/L\*GDPpc + α8\*TI + α9\*TI\*REL.K/L + α10\*TI\*(REL.K/L)2 + α11\*TI\*REL.GDPpc + α12\*TI\*(REL.GDPpc)2 + α13TI\*(REL.K/L)\*(REL.GDPpc) + α14\*CCdummy + α15\*CCdummy\*GDPpc + α16\*CCdummy\*(GDPpc)2 + α17\*Helsinki*

Column 20:

*Z = Constant + α1\*EcoInt + α2\*(EcoInt2)/1000 + α3\*K/L + α4\*(K/L)2 + α5\*GDPpc + α6\*GDPpc2 + α7\*K/L\*GDPpc + α8\*TI + α9\*TI\*REL.K/L + α10\*TI\*(REL.K/L)2 + α11\*TI\*REL.GDPpc + α12\*TI\*(REL.GDPpc)2 + α13TI\*(REL.K/L)\*(REL.GDPpc) + α14\*CCdummy + α15\*CCdummy\*GDPpc + α16\*CCdummy\*(GDPpc)2 + α17\*Helsinki*

The regressions use the following abbreviations:

Z Emission level, in Log CO2 or Log SO2. Dependent variable

EcoInt Economic Intensity

K/L Capital Abundance

GDPpc Gross Domestic Product per capita

TI Trade Intensity

REL.K/L Relative Capital Abundance (i.e. relative to the world’s capital abundance)

REL.GDPpc Relative Gross Domestic Product per capita (i.e. relative to the world’s Gross Domestic Product per capita)

CCdummy Communist dummy

Helsinki Helsinki Protocol dummy

Furthermore, the elasticities for the scale, composition, and technique effect, and the trade intensity are calculated for each regression. For this, the following calculations are made for each regression:

*Scale effect elasticity = Coefficient of EcoInt \* Average EcoInt (for all years, all countries)*

*Composition effect elasticity = Coefficient of K/L \* Average K/L (for all years, all countries)*

*Technique effect elasticity = Coefficient of GDPpc \* Average GDPpc (for all years, all countries)*

*Trade Intensity elasticity = Coefficient of TI \* Average TI (for all years, all countries)*

The scale elasticity indicates how much percent the dependent variable changes with a one-percentage change in economic intensity. The same holds for the composition, technique and trade intensity elasticity, with a one-percentage change in respectively capital abundance, GDPpc or trade intensity. The elasticity is a good indicator of the importance of the independent variable. I test for the hypothesis: *International trade is good for the environment.*

## 

## 4.3 Results

In discussing the results, I focus on columns 18, 19 and 20, since these represent the study by ACT. Since this replication study uses a larger dataset and focuses on a country-level basis instead of city-level basis, it is not unlikely that the results will be not be the same as in the study by ACT. However, it is expected that the signs of all effects would at least be the same (either positive or negative), but as it turns out, this is not always the case.

When comparing the results of this replicated study with the results of ACT, it shows that the scale effect in both studies has a positive and significant effect on emissions. The scale elasticities are also positive, however, the magnitudes are rather different and the elasticity of 2.2805 in column 20, table 1, is remarkably high. This could be explained by the smaller number of countries (38) with Log of SO2 as the dependent variable. When using Log of SO2 as the dependent variable, the scale elasticity increases when moving from column 18 to 20, just as in ACT. When using Log of CO2 as the dependent variable, the scale elasticity remains more steady.

The coefficients for capital abundance (meaning the composition effect) in the replicated study are somewhat different then the study by ACT. ACT found a positive and significant effect on emissions, whereas the replicated study finds a negative effect that is rarely significant for Log of CO2. This could mean that capital abundance has no or a negative effect on pollution emissions, which sounds contra-intuitive since more capital usually means more pollution. The composition elasticity starts negative for Log of SO2, but becomes positive as moving on to regression 20. However, the magnitude of the elasticity is a lot smaller than in the study by ACT, which reduces the importance of the effect. For Log of CO2, the composition elasticity has a negative effect on emissions, meaning that more capital means a reduction in pollutions and thus, an increase of environmental quality, which is not as expected.

The technique elasticity has a negative effect on Log of SO2, but positive on Log of CO2. This is in contrast to the study by ACT, in which the technique elasticity is always negative. Also the coefficients of GDPpc show very little resemblance with ACT. Furthermore in ACT, the negative technique effect is always larger than the positive scale effect, but that is not the case for this replicated study.

The trade intensity elasticity is negative in the study by ACT. In this replication study however, it has a positive effect on Log of SO2 and a negative effect for Log of CO2. This means that an increase in international trade leads to more emissions of SO2 and less of CO2. The coefficient for trade intensity is negative and significant for both the study by ACT as in this replication study (in table 2 with Log of CO2 as the dependent variable). This means that an increase in trade intensity leads to a decrease in the emission of CO2. With Log of SO2 as the dependent variable, the trade intensity coefficient is positive but not significant.

The elasticities of the scale, composition, technique and trade intensity effects describe the relationship between international trade and pollution emissions, and thus the environment.

In this replication study, the scale effect, describing an increase in the scale of economic activity while keeping production techniques and the mix of goods produced fixed, has a positive effect on the emissions of CO2 and SO2.  In other words, an increase in economic activity leads to an increase in pollution emissions and thus, a deterioration of the environment. For example, more economic activity demands more use of energy, and therefore pollution emissions increase.

The composition effect, dependent on a country’s comparative advantage, has a positive effect on the emissions of SO2 (with the exception of column 17) and a negative effect on the emissions of CO2. A country that focuses on producing the polluting good is expected to increase pollution emissions. However, these results show that the emissions of SO2 indeed increase, but the emissions of CO2 decline.

The technique effect represents the change in production techniques when international trade increases, and the result this change has on the country’s pollution emissions. Literature shows that, because of cleaner production techniques and the demand for a cleaner environment, the technique effect has a negative effect on emissions and therefore is good for the environment. The replication study shows a negative effect for SO2 emissions (except for column 17) and a positive effect for CO2 emissions. Therefore it is good ánd bad for the environment.

The trade intensity elasticity has a positive effect on emissions of SO2 and a negative effect on emissions of CO2. Thus, an increase in trade intensity leads to an increase in SO2 emissions and a decrease in CO2 emissions, which means that trade is bad ánd good for the environment.

As in the study by ACT, the scale, composition and technique effects are considered together to examine the joint effect of international trade on the environment. There are quite a few differences when comparing the results of this thesis with the result of the study by ACT. Considering the results for Log of SO2, the results for the scale, composition and technique effect altogether are positive for emissions, meaning that the positive effects are much larger than the negative effect. (This is different from the study by ACT since in their study, the negative technique effect offsets the positive scale and composition effect.) For Log of CO2 emissions, the effects altogether are also positive for emissions, but the magnitude is lot smaller. It shows that international trade is bad for the environment. Thus, the hypothesis that “international trade is good for the environment” is rejected.

The result that international trade is bad for the environment, is a different one than the results from the study by ACT. Overall, there are quite a few differences between the results of the two studies. The next paragraph explains why such differences can occur.

## 

## 4.4 Explanation of differences

In constructing these regressions, a few problems arise. To start with, it is the lack of data availability. The number of observations in the Log of SO2-regressions is in most cases only 454, and therefore, the results have to be interpreted with caution. The number of observations in the regressions with Log of CO2 as the dependent variable is much larger, namely around 3400. Unfortunately, these results also have to be interpreted with caution, since CO2 is not the best measurement for environmental quality, which is proved by Cole and Elliot (2003).

Cole and Elliot (2003) considered four types of pollution measurements: sulfur dioxide (SO2), nitrogen oxides (NOx), biochemical oxygen demand (BOD) and carbon dioxide (CO2). They argued that using different types of pollution could possible lead to different results. They also pointed out several characteristics which a type of pollution should have, to be a good indicator of pollution. Of the four types of pollution, Cole and Elliot showed that CO2 did not have all characteristics of a good indicator for pollution, but SO2, NOx and BOD do. When performing their study using SO2, they find the similar results as in the study by ACT. For the other three types of pollution, this did not hold. This could explain why the results of this replication study are different for using either Log of SO2 or Log of CO2  as the dependent variable. When interpreting the results, it is very likely that different measurements give different type of results.

Another difference in this replication study, is the use of *pollution emissions* instead of *pollution concentrations*. Cole and Elliot (2003) emphasized the importance of the difference between pollution emissions and pollution concentrations. The relationship between the economy and pollution in the Environmental Kuznets Curve can differ based on a measurement of either pollution emissions or concentrations. Pollution concentrations are generally measured on a city-level basis and therefore provide information on the effect of the city’s pollution concentrations on the population’s health. Pollution emissions are generally measured on a national level and therefore provide information on wider environmental concerns. Pollution concentrations on the other hand, are considered to be measured with more noise than emissions. Furthermore, several dummy variables on site-specific information have to be included to perform a correct study. Cole and Elliot conclude that there is no preference of using either pollution emissions or pollution concentrations, since both have benefits and pitfalls. “The two forms of data provide different information and hence we cannot necessarily expect estimation results using concentrations data to be identical to those using emissions data” (Cole and Elliot, 2003, p. 369).

**Table 1: Dependent variable: Log of SO2. Time-fixed effects**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Constant | 2.4068\*\*\*  0.0366 | 2.4163\*\*\*  0.0363 | 2.5344\*\*\*  0.0794 | 2.4621\*\*\*  0.1082 | 2.4621\*\*\*  0.1126 | 2.4240\*\*\*  0.1152 | 2.4271\*\*\*  0.1129 | 4.0468\*\*\*  0.1167 | 2.7697\*\*\*  0.1478 |
| Economic intensity | -0.0027\*\*\*  0.0001 | -0.0050\*\*\*  0.0008 | 0.0503  0.0034 | 0.0366  0.0370 | 0.0366  0.0370 | 0.0248  0,0377 | 0.0657\*  0.0382 | 0.1450\*\*\*  0.0281 | 0.1980\*\*\*  0.0248 |
| (Eco. int)2/1000 |  | 0.0017\*\*\*  0.0001 | -1.370  2.870 | -0.1250  3.050 | -0.1250  3.0600 | 0.7250  3.1000 | -1.0600  3.0700 | -5.8800\*\*\*  2.2500 | -12.6000\*\*\*  2.0300 |
| K/L |  |  | -0.055\*\*\*  0.0176 | -0.0068  0.0520 | -0.0069  0.0969 | -0.2000  0.1620 | 0.2930  0.1960 | 0.4850  0.1430 | 0.5470\*\*\*  0.1240 |
| (K/L)2 |  |  |  | -0.0049  0.0050 | -0.0049  0.0058 | 0.0103  0.0115 | 0.1300\*\*\*  0.0030 | 0.1220\*\*\*  0.0218 | 0.0736\*\*\*  0.0194 |
| GDPpc |  |  |  |  | 0.0187  12.300 | 53.600  37.100 | -68.9000  46.1000 | -0.0145\*\*\*  33.7000 | -69.9000\*\*  30.0000 |
| GDPpc2 |  |  |  |  |  | -0.0010  0.0007 | 0.0094\*\*\*  0.0025 | 0.0113\*\*\*  0.0002 | 0.0070\*\*\*  0.0016 |
| (K/L) x GDPpc |  |  |  |  |  |  | -0.0732\*\*\*  0.0169 | -0.0779\*\*\*  0.0123 | -0.0507\*\*\*  0.0109 |
| Trade intensity |  |  |  |  |  |  |  | -0.019\*\*\*  0.0010 | -0.0038\*\*  0.0015 |
| TI x Rel.K/L |  |  |  |  |  |  |  |  | -0.0064\*\*\*  0.0005 |
|  |  |  |  |  |  |  |  |  |  |
| N | 475 | 475 | 454 | 454 | 454 | 454 | 454 | 454 | 454 |
| Adjusted R2 | 0.437 | 0.448 | 0.009 | 0.008 | 0.006 | 0.009 | 0.049 | 0.496 | 0.621 |
| Log Likelihood | -545.614 | -540.585 | -519.656 | -519.146 | -519.146 | -517.904 | -508.196 | -363.348 | -298.515 |
|  |  |  |  |  |  |  |  |  |  |
| Scale elasticity | -0.0340 | -0.6393 | 0.6444 | 0.4689 | 0.4689 | 0.3177 | 0.8417 | 1.8577 | 2.5367 |
| Composition elasticity |  |  | -0.0819 | -0.0101 | -0.0103 | -0.3066 | 0.4361 | 0.7218 | 0.8141 |
| Technique elasticity |  |  |  |  | 0.0001 | 0.3795 | -0.4879 | -1.0267 | -0.4950 |
| Trade int. elasticity |  |  |  |  |  |  |  | -1.5038 | -0.3101 |

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1% \*\*Significant at 5% \* Significant at 10%

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | 10 | 11 | 12 | 13 | 14 | 15 |
| Constant | 2.8669\*\*\*  0.1600 | 2.8999\*\*\*  0.1546 | 2.9375\*\*\*  0.1537 | 2.9172\*\*\*  0.1532 | 2.9294\*\*\*  0.1525 | 2.6680\*\*\*  0.1882 |
| Economic intensity | 0.2090\*\*\*  0.0257 | 0.1900\*\*\*  0.0250 | 0.1930\*\*\*  0.0248 | 0.1900\*\*\*  0.0247 | 0.1940\*\*\*  0.0247 | 0.1930\*\*\*  0.0245 |
| (Eco. int)2/1000 | -13.8000\*\*\*  2.1600 | -12.2000\*\*\*  2.1100 | -13.2000\*\*\*  2.1100 | -12.8000\*\*\*  2.1100 | -13.2000\*\*\*  2.1000 | -13.1000\*\*\*  2.0900 |
| K/L | 0.5000\*\*\*  0.1240 | -0.0865  0.1630 | 0.2910  0.2050 | 0.3300  0.2050 | 0.0004\*  0.0002 | 0.2600  0.2070 |
| (K/L)2 | 0.0789\*\*\*  0.0196 | 0.0803\*\*\*  0.0190 | 0.0787\*\*\*  0.0188 | 0.1270\*\*\*  0.0280 | 0.131\*\*\*  0.0279 | 0.1300\*\*\*  0.0278 |
| GDPpc | -84.3000\*\*\*  31.3000 | 40.7000  37.5000 | -62.8000  50.8000 | -69.1000  50.6000 | -82.7000  50.7000 | -45.0000  52.9000 |
| GDPpc2 | 0.0073\*\*\*  0.0016 | 0.0052\*\*\*  0.0016 | 0.0085\*\*\*  0.1807 | 0.0112\*\*\*  0.0023 | 0.0118\*\*\*  0.0023 | 0.0109\*\*\*  0.0278 |
| (K/L) x GDPpc | -0.0515\*\*\*  0.0109 | -0.0404\*\*\*  0.0107 | -0.0517\*\*\*  0.0113 | -0.0751\*\*\*  0.0151 | -0.0777\*\*\*  0.0151 | -0.0748\*\*\*  0.0150 |
| Trade intensity | -0.0055\*\*\*  0.0018 | -0.0074\*\*\*  0.0018 | -0.0018\*\*\*  0.0043 | -0.0077\*\*\*  0.0018 | -0.0038  0.0025 | 0.0005  0.0031 |
| TI x Rel.K/L | -0.0044\*\*\*  0.0014 | 0.0089\*\*\*  0.0027 | -0.0012  0.0043 | -0.0028  0.0044 | -0.0034  0.0044 | 0.0002  0.0046 |
| TI x (REL.K/L)2 | -0.0004  0.0002 | -0.0010\*\*\*  0.0003 | 0.0002  0.0005 | -0.0032\*\*  0.0015 | -0.0031\*\*  0.0015 | -0.0032\*\*  0.0015 |
| TI x Rel.GDPpc |  | -0.0112\*\*\*  0.0020 | 0.0026  0.0050 | 0.0040  0.0050 | 0.0029  0.0050 | -0.0028  0.0056 |
| TI x (Rel.GDPpc)2 |  |  | -0.0021\*\*\*  0.0007 | -0.0064\*\*\*  0.0020 | -0.0062\*\*\*  0.0020 | -0.0054\*\*\*  0.0020 |
| TI x (Rel.K/L) x (Rel.GDPpc) |  |  |  | 0.0077\*\*  0.0033 | 0.0077\*\*  0.0033 | 0.0072\*\*  0.0033 |
| Communist dummy |  |  |  |  | -0.3391\*\*  0.1480 | -0.0619  0.1888 |
| CC dummy x GDPpc |  |  |  |  |  | -0.0001\*\* |
| CC dummy x (GDPpc)2 |  |  |  |  |  |  |
| Helsinki dummy |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| N | 454 | 454 | 454 | 454 | 454 | 454 |
| Adjusted R2 | 0.622 | 0.647 | 0.654 | 0.6575 | 0.6609 | 0.6645 |
| Log Likelihood | -297.205 | -280.729 | -275.9981 | -273.1102 | -270.2979 | -267.3401 |
|  |  |  |  |  |  |  |
| Scale elasticity | 2.6777 | 2.4342 | 2.4727 | 2.4342 | 2.4854 | 2.4727 |
| Composition elasticity | 0.7962 | -0.1287 | 0.4331 | 0.4911 | 0.5313 | 0.3870 |
| Technique elasticity | -0.5969 | 0.2882 | -0.4447 | -0.4893 | -0.5856 | -0.3186 |
| Trade int. elasticity | -0.4478 | -0.6024 | -0.6555 | -0.6237 | -0.3037 | -0.3037 |

**Table 1: Dependent variable: Log of SO2. Time-fixed effects**

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

**Table 1: Dependent variable: Log of SO2. Time-fixed effects**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 16 | 17 | 18 | 19 | 20 |
| Constant | 2.6410\*\*\*  0.1882 | 2.7172\*\*\*  0.1894 | 2.6851\*\*\*  0.1560 | 2.7199\*\*\*  0.1956 | 2.7172\*\*\*  0.1894 |
| Economic intensity | 0.1940\*\*\*  0.0245 | 0.1780\*\*\*  0.0252 | 0.0396\*\*\*  0.0088 | 0.0504\*\*\*  0.0089 | 0.1780\*\*\*  0.0252 |
| (Eco. int)2/1000 | -13.2000\*\*\*  2.0900 | -11.7000\*\*\*  2.1600 |  |  | -11.7000\*\*\*  2.1600 |
| K/L | 0.2400  0.207 | 0.3240  0.2070 | -0.3320\*\*\*  0.0.061 | 0.1540  0.2120 | 0.3240  0.2070 |
| (K/L)2 | 0.1270\*\*\*  0.0277 | 0.1350\*\*\*  0.0278 |  | 0.1370\*\*\*  0.0287 | 0.1350\*\*\*  0.0278 |
| GDPpc | -41.2000  52.8000 | -64.4000  53.2000 | 116.000\*\*\*  14.9000 | -0.1190  53.6000 | -64.4000  53.2000 |
| GDPpc2 | 0.0107\*\*\*  0.0150 | 0.0118\*\*\*  0.0023 |  | 0.0107\*\*\*  0.0024 | 0.0118\*\*\*  0.0002 |
| (K/L) x GDPpc | -0.0730\*\*\*  0.0150 | -0.0796\*\*\*  0.0151 |  | -0.0784\*\*\*  0.0156 | -0.0796\*\*\*  0.0151 |
| Trade intensity | 0.0010  0.0031 | 0.0013  0.0031 | 0.0006  0.0030 | 0.0015  0.0032 | 0.0013  0.0031 |
| TI x Rel.K/L | 0.0007  0.0046 | 0.001  0.0046 | 0.0100\*\*\*  0.0033 | 0.0038  0.0047 | 0.0010  0.0046 |
| TI x (REL.K/L)2 | -0.0031\*\*  0.0015 | -0.0026\*  0.0056 | 0.0018\*  0.0010 | -0.0028\*  0.0016 | -0.0026\*  0.0015 |
| TI x Rel.GDPpc | -0.0036  0.0056 | -0.0046  0.0055 | -0.0159\*\*\*  0.0040 | -0.0099\*  0.0056 | -0.0046  0.0055 |
| TI x (Rel.GDPpc)2 | -0.0051\*\*  0.0020 | -0.0044\*\*  0.0020 | 0.0025  0.0016 | -0.0041\*  0.0021 | -0.0044\*\*  0.0055 |
| TI x (Rel.K/L) x (Rel.GDPpc) | 0.0068\*\*  0.0033 | 0.0057\*  0.0033 | -0.0050\*\*  0.0024 | 0.0061\*  0.0034 | 0.0057\*  0.0033 |
| Communist dummy | 0.3923  0.3071 | 0.4681  0.3066 | 0.0349  0.1884 | 0.5397\*  0.3164 | 0.4681  0.3066 |
| CC dummy x GDPpc | -0.0004\*\*  0.0001 | -0.0005\*\*\*  0.0001 | -0.0002\*\*\*  0.000 | -0.0005\*\*\*  0.0002 | -0.0005\*\*\*  0.0001 |
| CC dummy x (GDPpc)2 | 0.0298\*  0.01590 | 0.0360\*\*  0.0160 |  | 0.0373\*\*  0.0165 | 0.0360\*\*  0.0160 |
| Helsinki dummy |  | 0.1761\*\*  0.0693 | 0.2065\*\*\*  0.0668 | 0.2835\*\*\*  0.0686 | 0.1761\*\*  0.0693 |
|  |  |  |  |  |  |
| N | 454 | 454 | 454 | 454 | 454 |
| Adjusted R2 | 0.6665 | 0.6708 | 0.6256 | 0.6487 | 0.6707 |
| Log Likelihood | -265.4507 | -261.9731 | -293.8531 | -277.2244 | -261.9731 |
|  |  |  |  |  |  |
| Scale elasticity | 2.4854 | 2.2805 | 0.5073 | 0.6457 | 2.2805 |
| Composition elasticity | 0.3691 | 0.4822 | -0.4941 | 0.2292 | 0.4822 |
| Technique elasticity | -0.2917 | -0.4560 | 0.8214 | -0.0008 | -0.456 |
| Trade int. elasticity | 0.0818 | 0.1030 | 0.0505 | 0.1223 | 0.1030 |

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

**Table 2: Dependent variable: Log of CO2. Time-fixed effects**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Constant | 0.95901\*\*\*  0.0164 | 0.9460\*\*\*  0,0167 | 0.9235\*\*\*  0.0195 | 0.7653\*\*\*  0.0213 | 0.7752\*\*\*  0,0213 | 0.7489\*\*\*  0.0217 | 0.7464\*\*\*  0.0217 | 1.4466\*\*\*  0.0326 | 1.3124\*\*\*  0.0364 |
| Economic intensity | 0.0024\*  0.0014 | 0.0161\*\*\*  0.0036 | -0.0055  0.0045 | -0.0088\*\*  0.0044 | -0.0028  0.0043 | -0.0039  0.0045 | -0.0028  0.0045 | 0.0466\*\*\*  0.0045 | 0.0706\*\*\*  0.0053 |
| (Eco. int)2/1000 |  | -0.1050\*\*\*  0.0255 | 0.0000  0.0283 | 0.0276  0.0273 | -0.0030  0.0277 | 0.0011  0.0276 | -0.00481  0.0277 | -0.1600\*\*\*  0.0258 | -0.2240\*\*\*  0.0268 |
| K/L |  |  | 0.2250\*\*\*  0.0088 | 0.5170\*\*\*  0.0205 | 0.2890\*\*\*  0.043 | -0.00241  0.0657 | -0.0202  0.0661 | 0.3860\*\*\*  0.0630 | 0.5740\*\*\*  0.0667 |
| (K/L)2 |  |  |  | -0.0440\*\*\*  0.0028 | -0.0377\*\*\*  0.0030 | -0.0055  0.0062 | -0.0473\*\*  0.0193 | -0.0375\*\*  0.0176 | -0.0182  0.0176 |
| GDPpc |  |  |  |  | 42.0000\*\*\*  7.0700 | 121.000\*\*\*  15.1000 | 127.0000\*\*\*  15.4000 | 47.1000\*\*\*  14.5000 | 27.5000\*  14.6000 |
| GDPpc2 |  |  |  |  |  | -0.0022\*\*\*  0.0004 | -0.0047\*\*\*  0.0012 | -0.0012  0.0011 | 0.0006  0.0011 |
| (K/L) x GDPpc |  |  |  |  |  |  | 0.0206\*\*  0.0090 | -0.0003  0.0008 | -0.0135  0.0084 |
| Trade intensity |  |  |  |  |  |  |  | -0.0113\*\*\*  0.0004 | -0.0093\*\*\*  0.0005 |
| TI x Rel.K/L |  |  |  |  |  |  |  |  | -0.0022\*\*\*  0.0003 |
|  |  |  |  |  |  |  |  |  |  |
| N | 4596 | 4596 | 3412 | 3412 | 3412 | 3412 | 3412 | 3402 | 3402 |
| Adjusted R2 | 0.0037 | 0.0072 | 0.1793 | 0.2346 | 0.2423 | 0.2498 | 0.2508 | 0.3838 | 0.3953 |
| Log Likelihood | -6918.066 | -6909.464 | -4496.600 | -4377.031 | -4359.232 | -4341.777 | -4339.135 | -3998.276 | -3965.827 |
|  |  |  |  |  |  |  |  |  |  |
| Scale elasticity | 0.0310 | 0.2063 | -0.0354 | -0.1133 | -0.0357 | -0.0501 | -0.0354 | 0.5970 | 0.9045 |
| Composition elasticity |  |  | 0.3349 | 0.7694 | 0.4301 | -0.0036 | -0.0301 | 0.57448 | 0.8543 |
| Technique elasticity |  |  |  |  | 0.2974 | 0.8568 | 0.8993 | 0.3335 | 0.1947 |
| Trade int. elasticity |  |  |  |  |  |  |  | -0.9176 | -0.7494 |

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1% \*\*Significant at 5% \* Significant at 10%

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | 10 | 11 | 12 | 13 | 14 | 15 |
| Constant | 1.3297\*\*\*  0.0400 | 1.2722\*\*\*  0.0393 | 1.2644\*\*\*  0.0340 | 1.2675\*\*\*  0.0400 | 1.2038\*\*\*  0.0405 | 1.2088\*\*\*  0.0409 |
| Economic intensity | 0.0702\*\*\*  0.0054 | 0.0474\*\*\*  0.0055 | 0.0495\*\*\*  0.0058 | 0.0493\*\*\*  0.0059 | 0.0489\*\*\*  0.0058 | 0.0487\*\*\*  0.0058 |
| (Eco. int)2/1000 | -0.2230\*\*\*  0.0268 | -0.0224  0.0304 | -0.3300  0.0319 | -0.0341  0.0319 | -0.0310  0.0317 | -0.0300  0.0317 |
| K/L | 0.5520\*\*\*  0.0701 | 1570.000  80.6000 | -0.0428  0.0903 | -0.0529  0.0907 | -0.110  0.0902 | -0.1230  0.0913 |
| (K/L)2 | -0.0149  0.0179 | -0.0616\*\*\*  0.0178 | -0.0576\*\*\*  0.0182 | -0.0406\*  0.0228 | -0.0435\*  0.0226 | -0.0439\*  0.0226 |
| GDPpc | 28.1000\*  14.6000 | 172.0000\*\*\*  18.1000 | 187.0000\*\*\*  22.6000 | 187.0000\*\*\*  22.60000 | 205.0000\*\*\*  22.5000 | 207.0000\*\*\*  0.0226 |
| GDPpc2 | 0.0006  0.0011 | -0.0045\*\*\*  0.0011 | -0.0049\*\*\*  0.0012 | -0.0038\*\*  0.0015 | -0.0044\*\*\*  0.0015 | -0.0046\*\*\*  0.0015 |
| (K/L) x GDPpc | -0.0137  0.0084 | 0.0210\*\*  0.0086 | 0.0211\*\*  0.0086 | 0.0126  0.0110 | 0.0158  0.0109 | 0.0163  0.0109 |
| Trade intensity | -0.0096\*\*\*  0.0006 | -0.0090\*\*\*  0.0006 | -0.0089\*\*\*  0.0006 | -0.0089\*\*\*  0.0006 | -0.0087\*\*\*  0.0006 | -0.0087\*\*\*  0.0006 |
| TI x Rel.K/L | -0.0016\*\*\*  0.0006 | 0.0070\*\*\*  0.0009 | 0.0081\*\*\*  0.0014 | 0.0083\*\*\*  0.0014 | 0.0085\*\*\*  0.0014 | 0.0086\*\*\*  0.0014 |
| TI x (REL.K/L)2 | -0.0001  0.0001 | -0.0006\*\*\*  0.0001 | -0.0008\*\*\*  0.0002 | -0.0013\*\*\*  0.0005 | -0.0012\*\*\*  0.0004 | -0.0012\*\*\*  0.0004 |
| TI x Rel.GDPpc |  | -0.0101\*\*\*  0.0008 | -0.0121\*\*\*  0.0020 | -0.0121\*\*\*  0.0020 | -0.0126\*\*\*  0.0020 | -0.0127\*\*\*  00020 |
| TI x (Rel.GDPpc)2 |  |  | 0.0004  0.0004 | -0.0004  0.0008 | -0.0002  0.0008 | -0.0002  0.0008 |
| TI x (Rel.K/L) x (Rel.GDPpc) |  |  |  | 0.0013  0.0010 | 0.0011  0.0010 | 0.0010  00010 |
| Communist dummy |  |  |  |  | 0.3421\*\*\*  0.0443 | 0.3071\*\*\*  0.0570 |
| CC dummy x GDPpc |  |  |  |  |  | 0.0000  0.0000 |
| CC dummy x (GDPpc)2 |  |  |  |  |  |  |
| Helsinki dummy |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| N | 3402 | 3402 | 3402 | 3402 | 3402 | 3402 |
| Adjusted R2 | 0.3953 | 0.4238 | 0.4238 | 0.4239 | 0.4338 | 0.4338 |
| Log Likelihood | -3965.282 | -3882.657 | -3882.056 | -3881.272 | -3851.214 | -3850.730 |
|  |  |  |  |  |  |  |
| Scale elasticity | 0.8994 | 0.6073 | 0.6342 | 0.6316 | 0.6265 | 0.6239 |
| Composition elasticity | 0.8215 | 0.0023 | -0.0637 | -0.0787 | -0.1637 | -0.1830 |
| Technique elasticity | 0.1990 | 1.2179 | 1.3241 | 1.3241 | 1.4516 | 1.4658 |
| Trade int. elasticity | -0.7760 | -0.7318 | -0.7179 | -0.7230 | -0.7022 | -0.70443 |

**Table 2: Dependent variable: Log of CO2. Time-fixed effects**

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 16 | 17 | 18 | 19 | 20 |
| Constant | 1.2436\*\*\*  0.0407 | 1.2815\*\*\*  0.0405 | 1.4325\*\*\*  0.0366 | 1.2807\*\*\*  0.0405 | 1.2815\*\*\*  0.0405 |
| Economic intensity | 0.0537\*\*\*  0.0056 | 0.0565\*\*\*  0.0057 | 0.0474\*\*\*  0.0025 | 0.0505\*\*\*  0.0025 | 0.0565\*\*\*  0.0057 |
| (Eco. int)2/1000 | -0.0559\*  0.0315 | -0.0366  0.0313 |  |  | -0.03.66  0.0313 |
| K/L | -0.0991  0.0905 | -0.0632  0.0896 | -0.0002\*\*\*  0.0400 | -0.0744  0.0891 | -0.0632  0.0896 |
| (K/L)2 | -0.0414\*  0.0224 | -0.0040  0.0226 |  | -0.0068  0.0224 | -0.0040  0.0226 |
| GDPpc | 200.0000\*\*\*  0.0224 | 171.0000\*\*\*  22.4000 | 129.0000\*\*\*  9.6600 | 173.0000\*\*\*  22.4000 | 171.0000\*\*\*  22.40000 |
| GDPpc2 | -0.0044\*\*\*  0.0015 | -0.0015  0.0015 |  | -0.0016  0.0015 | -0.0015  0.0015 |
| (K/L) x GDPpc | 0.0148  0.011 | -0.0040  0.0109 |  | -0.0025  0.0109 | -0.0040  0.0109 |
| Trade intensity | -0.0091\*\*\*  0.0006 | -0.0094\*\*\*  0.0005 | -0.0113\*\*\*  0.0005 | -0.0094\*\*\*  0.0006 | -0.0094\*\*\*  0.0006 |
| TI x Rel.K/L | 0.0085\*\*\*  0.0014 | 0.0080\*\*\*  0.0013 | 0.0070\*\*\*  0.0010 | 0.0081\*\*\*  0.0013 | 0.0080\*\*\*  0.0013 |
| TI x (REL.K/L)2 | -0.0012\*\*\*  0.0004 | -0.0013\*\*\*  0.0004 | -0.0013\*\*\*  0.0003 | -0.0012\*\*\*  0.0004 | -0.0013\*\*\*  0.0004 |
| TI x Rel.GDPpc | -0.0129\*\*\*  0.0019 | -0.0115\*\*\*  0.0019 | -0.00361\*\*\*  0.0013 | -0.0112\*\*\*  0.0019 | -0.0115\*\*\*  0.0019 |
| TI x (Rel.GDPpc)2 | 0.0000  0.0008 | -0.0009  0.0007 | -0.0031\*\*\*  0.0006 | -0.0010  0.0008 | -0.0009  0.0008 |
| TI x (Rel.K/L) x (Rel.GDPpc) | 0.0009  0.0010 | 0.0014  0.0010 | 0.0018\*\*  0.0008 | 0.0014  0.0010 | 0.0014  0.0010 |
| Communist dummy | 0.0290  0.0657 | 0.0375  0.0650 | 0.1859\*\*\*  0.0568 | 0.0407  0.0650 | 0.0375  0.0650 |
| CC dummy x GDPpc | 0.0003\*\*\*  0.0000 | 0.0002\*\*\*  0.0000 | 0.0000  0.0000 | 0.0002\*\*\*  0.0000 | 0.0002\*\*\*  0.0000 |
| CC dummy x (GDPpc)2 | -0.0249\*\*\*  0.0030 | -0.0197\*\*\*  0.0031 |  | -0.0193\*\*\*  0.0030 | -0.0197\*\*\*  0.0031 |
| Helsinki dummy |  | 0.4546\*\*\*  0.0537 | 0.6289\*\*\*  0.0511 | 0.4592\*\*\*  0.0536 | 0.4546\*\*\*  0.0537 |
|  |  |  |  |  |  |
| N | 3402 | 3402 | 3402 | 3402 | 3402 |
| Adjusted R2 | 0.4450 | 0.4564 | 0.4352 | 0.4564 | 0.4564 |
| Log Likelihood | -3816.391 | -3780.389 | -3848.132 | -3781.084 | -3780.389 |
|  |  |  |  |  |  |
| Scale elasticity | 0.6880 | 0.7239 | 0.7239 | 0.6470 | 0.7239 |
| Composition elasticity | -0.1475 | -0.0941 | -0.3125 | -0.1107 | -0.0941 |
| Technique elasticity | 1.4162 | 1.2108 | 0.9134 | 1.2250 | 1.2108 |
| Trade int. elasticity | -0.7410 | -0.7606 | -0.9118 | -0.7626 | -0.7606 |

**Table 2: Dependent variable: Log of CO2. Time-fixed effects**

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

# 5. EXTENSION

The extension part of this thesis focuses on additional research on the relationship between international trade and the environment. To gain a better understanding of the trade flows between countries and to what extent these have an influence on the environment, a country’s most important trading partners are added to the study. The hypothesis “international trade is good for the environment” was rejected in the replication study. This chapter focuses on a country’s most important trading partners to see whether it depends on a country’s trading partners for international trade to have a positive effect on the environment. I test for the hypothesis: *International trade is good for the environment when you take a country’s three most important trading partners into account.*

## 5.1 Data

The United Nations Comtrade database provides data on a country’s most important trading partners. [[8]](#footnote-8) The data was only available for the years 1995, 2000, 2005 and 2010. Moreover, the number of countries in this study was reduced from 139 to 64, due to limited data availability. The appendix provides a list of the countries used in this part of the study.

The UN Comtrade database provides information on both import and export trade flows of a country. Not only are the trading partners being displayed, also the value of the trade flows with each country are available (in US dollars). Since export is most likely to have a larger effect on the environment than import (due to the fact that export requires domestic production, which causes CO2 and SO2 emissions), the export trade flows of the three most important trading partners are being examined in this study.

## 5.2 Methodology

The trading partners of a country do not change over time, or only very little, between 1995 and 2010. Therefore, the year 1995 is used as a base year to determine the weighting factors of the three most important trading partners. This is calculated by dividing the export trade flows of each of the three most important trading partners over the total export trade flows of all the three most important trading partners. The weighting factors of each country’s most important trading partners are kept the same for all years between 1970 and 2008. The weighting factor of country i’s trading partner j is multiplied with the GDPpc of country j for each year. When this number of all three trading partners is added, it leads to the trade weighted average GDPpc of the trading partners. An example:

The most important trading partners of The Netherlands are: 1) Germany; 2) Belgium; and 3) the United Kingdom. These partners have a weighting factor of respectively 0.5593, 0.2566, and 0.1841. Then, the GDPpc of Germany, Belgium, and the United Kingdom separately from 1970-2008 is multiplied with the weighting factor of that specific trading partner. (For 1970, the GDPpc of Germany is 11895.37, for Belgium 11360.20 and for the United Kingdom 13042.15) This leads to following calculation to construct the *trade weighted average GDPpc of the trading partners for the Netherlands in 1970*:

(0.5593\*11895.37) + (0.2566\*11360.20) + (0.1841\*13042.15) = 11969.16

The trade weighted average GDPpc of the trading partners are calculated for all countries, for all years. Then, to examine the influence of the trading partners, the ratio of the trade weighted average GDPpc of the trading partners for the Netherlands over the domestic GDPpc of the Netherlands is constructed, again for all years. For simplification, this is called *Ratio Trading Partners, or Ratio TP.*

*Ratio TP for Netherlands in 1970:* 11969.16/12759.18 = 0.9381

After the Ratio Trading Partners of a country is constructed for all years (1970-2008), it replaces the relative factor abundance (REL. KL) interacting with trade intensity in the regressions. The regressions are constructed again, with time-fixed effects and again with the two different dependent variables, but now with this new variable Ratio TP inserted. Furthermore, the elasticities of the scale, composition, technique and trade intensity are calculated. Columns 6, 7 and 8 reflect the study by ACT, but then with REL.KL replaced by Ratio TP.

When the Ratio Trading Partners decreases, it means that the domestic country (in this example the Netherlands) becomes richer relative to its trading partners. In that situation, trade is less harmful. The hypothesis “international trade is good for the environment when you only take the three most important trading partners into account” can be checked by calculating the marginal effect of Ratio TP on pollution emissions. Since country characteristics are captured by the variable relative GDP per capita, the following calculations are performed for the columns with significant results for the variable Ratio TP:

*Coefficient for TI\*Ratio TP + [Coefficient for TI\*Ratio TP\*Rel.GDPpc X Mean of Rel.GDPpc]*

However, the mean of relative GDPpc is 1, and therefore leads to the calculation for each column:

*Coefficient for TI\*Ratio TP + Coefficient for TI\*Ratio TP\*Rel.GDPpc*

If the domestic country becomes richer, trade openness decreases pollution emissions. The hypothesis is confirmed when this marginal effect is negative for all columns.

## 5.3 Results

It is important to keep in mind that the there is a small number of observations when using Log of SO2 as the dependent variable. Columns 6 to 8 of both tables are the ones that represent that study by ACT, but now with Ratio TP added to the study.

The economic intensity in table 3 and 4 has, just like in the study by ACT, a positive and significant effect on emissions. Furthermore, the coefficient increases when moving from column 6 to 8. Also the scale elasticity is positive and shows a remarkably high number in column 8. A positive scale effect means that trade openness leads to an increase in the emissions of SO2 and CO2, which is harmful to the environment.

The coefficient for capital abundance is negative in column 6, table 3 and 4, but becomes positive and significant for columns 7 and 8. (In the study by ACT it also shows a positive and significant effect.) The composition elasticity in table 3 however looks quite different from ACT since it is negative, whereas it is expected to be positive. A negative composition effect means a decrease in the emissions of SO2 and CO2, and is therefore good for the environment. Even though this negative was not expected and is not according to theory (see paragraph 2.1), it is a positive outcome for environmental quality.

The signs for GDPpc change from column 6 to 8 for table 3 and 4, and since both negative and positive coefficients are significant, it is difficult to base any conclusion on this. The technique elasticity is mostly negative, which means that, when trade becomes more open, the change in production techniques reduces the emissions of SO2 and CO2, and is therefore good for the environment. This result is as expected.

The trade intensity has a negative effect, and is significant in table 4, which resembles the findings of the study by ACT. Its elasticity is also negative, meaning that an increase in trade openness reduces SO2- and CO2-emissions, which is good for the environment. This is also as expected.

The interaction terms TI\*Ratio TP and TI\*(Ratio TP)\*(REL.GDPpc) only shows significant results for table 4. TI\*Ratio TP is negative and significant in column 7 and 8, and TI\*(Ratio TP)\*(REL.GDPpc) is positive and significant in column 6 to 8. I now consider the newly constructed variable Ratio TP, by examining its marginal effects on pollution emissions and to test for the hypothesis “international trade is good for the environment when you take a country’s three most important trading partners into account.”

The results for the marginal effect of Ratio TP on pollution emissions are the following:

|  |  |  |
| --- | --- | --- |
| Table | Column | Marginal effect |
| 4 | 1 | 0.0042 |
| 4 | 2 | 0.0039 |
| 4 | 3 | 0.0039 |
| 4 | 4 | 0.0039 |
| 4 | 5 | 0.0044 |
| 4 | 6 | 0.0042 |
| 4 | 7 | 0.0043 |
| 4 | 8 | 0.0044 |

These marginal effects are always positive. This implies that an increase in international trade leads to an increase in the emissions of SO2 and CO2 of the domestic country, if the domestic country becomes relatively more rich than the trading partners. In that case, international trade is bad for the environment of the domestic country. Thus, the hypothesis is rejected.

It sounds somewhat contra-intuitive that international trade is bad for the environment when you take a country’s three most important trading partners into account. For example, the Netherlands, with the top three trading partners consisting of Germany, Belgium, and the United Kingdom, is a high-income country. Considering the Environmental Kuznets Curve, it is expected that international trade would lead to an improvement of the environment in the Netherlands. On the other hand, the factor abundance hypothesis could play a role here. The factor abundance hypothesis asserts that high-income countries have a comparative advantage in producing the dirty good. The three most important trading partners of the Netherlands are also high-income countries, but of course, the Netherlands trades also with low-income countries.

**Table 3: Dependent variable: Log of SO2. Time-fixed effects**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 |
| Constant | 3.0732\*\*\*  0.2020 | 2.8072\*\*\*  0.2275 | 2.8730\*\*\*  0.2422 | 2.8237\*\*\*  0.2523 |
| Economic intensity | 0.1550\*\*\*  0.0225 | 0.1570\*\*\*  0.0223 | 0.1580\*\*\*  0.0224 | 0.1590\*\*\*  0.0224 |
| (Eco. int)2/1000 | -9.8600\*\*\*  1.8200 | -10.3000\*\*\*  1.8100 | -10.4000\*\*\*  1.8200 | -10.4000\*\*\*  1.8200 |
| K/L | 0.6580\*\*\*  0.1210 | 0.6480\*\*\*  0.1200 | 0.6540\*\*\*  0.1210 | 0.6570\*\*\*  0.1210 |
| (K/L)2 | 0.0864\*\*\*  0.0161 | 0.0828\*\*\*  0.0160 | 0.0836\*\*\*  0.0161 | 0.0835\*\*\*  0.0161 |
| GDPpc | -129.0000\*\*\*  35.2000 | -116.0000\*\*\*  35.3000 | -122.0000\*\*\*  36.1000 | -120.0000\*\*\*  36.3000 |
| GDPpc2 | 0.0107\*\*\*  0.0016 | 0.0104\*\*\*  0.0016 | 0.0106\*\*\*  0.0016 | 0.0106\*\*\*  0.0016 |
| (K/L) x GDPpc | -0.0660\*\*\*  0.0096 | -0.0640\*\*\*  0.0095 | -0.0646\*\*\*  0.0096 | -0.0646\*\*\*  0.0096 |
| Trade intensity | -0.0308\*  0.0173 | -0.0263  0.0172 | -0.0141  0.0231 | -0.0151  0.0233 |
| TI x Ratio TP | 0.0050  0.0081 | 0.0046  0.0080 | -0.0036  0.0130 | -0.0026  0.0131 |
| TI x (Ratio TP)2 | 0.0000  0.0009 | 0.0002  0.0009 | 0.0011  0.0015 | 0.0010  0.0015 |
| TI x Rel.GDPpc | 0.0129  0.0084 | 0.0109  0.0084 | 0.0058  0.0106 | 0.0062  0.0106 |
| TI x (Rel.GDPpc)2 | -0.0032\*\*\*  0.0010 | -0.0030\*\*\*  0.0010 | -0.0026\*\*  0.0011 | -0.0026\*\*  0.0011 |
| TI x (Ratio TP) x (Rel.GDPpc) | -0.0021  0.0026 | -0.0017  0.0026 | 0.0003  0.0036 | 0.0001  0.0036 |
| Communist dummy |  | -0.5467\*\*  0.2210 | -1.3566  1.0449 | 2.0698  4.9770 |
| CC dummy x GDPpc |  |  | 0.0002  0.003 | -0.0021  0.0021 |
| CC dummy x (GDPpc)2 |  |  |  | 0.0000  0.0000 |
| Helsinki dummy |  |  |  |  |
|  |  |  |  |  |
| N | 361 | 361 | 361 | 361 |
| Adjusted R2 | 0.7620 | 0.7656 | 0.7654 | 0.7650 |
| Log Likelihood | -137.9426 | -134.6068 | -134.2600 | -133.9856 |
|  |  |  |  |  |
| Scale elasticity | 1.9858 | 2.0115 | 2.0243 | 2.0371 |
| Composition elasticity | 0.9793 | 0.9644 | 0.9733 | 0.9778 |
| Technique elasticity | -0.9135 | -0.8214 | -0.8639 | -0.8497 |
| Trade int. elasticity | -2.4942 | -2.1295 | -1.1388 | -1.2223 |

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

**Table 3: Dependent variable: Log of SO2. Time-fixed effects**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 5 | 6 | 7 | 8 |
| Constant | 2.7434\*\*\*  0.2485 | 2.9197\*\*\*  0.2156 | |  | | --- | | 2.8423\*\*\* | | 0.2638 | | 2.4338\*\*\*  0.2485 |
| Economic intensity | 0.1760\*\*\*  0.0225 | 0.0145\*  0.0078 | 0.0366\*\*\*  0.0082 | 0.1760\*\*\*  0.0225 |
| (Eco. int)2/1000 | -12.2000\*\*\*  1.8400 |  |  | -12.2000\*\*\*  1.8400 |
| K/L | 0.5700\*\*\*  0.1210 | -0.1430\*\*\*  0.0279 | 0.5160\*\*\*  0.1280 | 0.5700\*\*\*  0.1210 |
| (K/L)2 | 0.0623\*\*\*  0.0168 |  | 0.0687\*\*\*  0.0178 | 0.0623\*\*\*  0.0168 |
| GDPpc | -87.0000\*\*  36.7000 | 73.7000\*\*\*  10.4000 | -52.4000  38.6000 | -87.0000\*\*  36.7000 |
| GDPpc2 | 0.0084\*\*\*  0.0017 |  | 0.0078\*\*\*  0.0018 | 0.0084\*\*\*  0.0017 |
| (K/L) x GDPpc | -0.0517\*\*\*  0.0100 |  | -0.0538\*\*\*  0.0106 | -0.0517\*\*\*  0.0100 |
| Trade intensity | -0.0112  0.0228 | -0.0073  0.0250 | -0.0288  0.0241 | -0.0112  0.0228 |
| TI x Ratio TP | -0.0056  0.0129 | -0.0057  0.0142 | 0.0044  0.0136 | -0.0056  0.0129 |
| TI x (Ratio TP)2 | 0.0015  0.0015 | 0.0013  0.0016 | 0.0003  0.0016 | 0.0015  0.0015 |
| TI x Rel.GDPpc | 0.0067  0.0104 | 0.0051  0.0114 | 0.0138  0.0110 | 0.0067  0.0104 |
| TI x (Rel.GDPpc)2 | -0.0026\*\*  0.0011 | -0.0026\*\*  0.0012 | -0.0032\*\*\*  0.0012 | -0.0026\*\*  0.0011 |
| TI x (Ratio TP) x (Rel.GDPpc) | -0.0002  0.0036 | 0.0001  0.0039 | -0.0032  0.0038 | -0.0002  0.0036 |
| Communist dummy | 1.5208  4.8859 | -1.1962  1.1283 | 1.4527  5.1947 | 1.5208  4.8859 |
| CC dummy x GDPpc | -0.0010  0.0021 | 0.0003  0.0003 | -0.0008  0.0022 | -0.0010  0.0021 |
| CC dummy x (GDPpc)2 | 0.0000  0.0000 |  | 0.0993  0.2190 | 0.1300  0.2060 |
| Helsinki dummy | -0.2327\*\*\*  0.0631 | -0.1984\*\*\*  0.0629 | -0.1273\*  0.0649 | -0.2327  0.0631 |
|  |  |  |  |  |
| N | 361 | 361 | 361 | 361 |
| Adjusted R2 | 0.7738 | 0.7143 | 0.7443 | 0.7738 |
| Log Likelihood | -126.5931 | -171.4554 | -149.2702 | -126.5931 |
|  |  |  |  |  |
| Scale elasticity | 2.2549 | 0.1858 | 0.4689 | 2.2548 |
| Composition elasticity | 0.8483 | -0.2128 | -0.7680 | 0.8483 |
| Technique elasticity | -0.6161 | 0.5219 | -0.3710 | -0.6161 |
| Trade int. elasticity | -0.9042 | -0.5882 | -2.3327 | -0.9042 |

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

**Table 4: Dependent variable: Log of CO2. Time-fixed effects**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 |
| Constant | 1.7525\*\*\* | 1.6084\*\*\* | 1.5418\*\*\* | 1.5155\*\*\* |
|  | 0.0590 | 0.0572 | 0.0541 | 0.0544 |
| Economic intensity | 0.0387\*\*\*  0.0053 | 0.0383\*\*\*  0.0051 | 0.0418\*\*\*  0.0048 | 0.0412\*\*\*  0.0048 |
| (Eco. int)2/1000 | -0.0119  0.0283 | -0.0151  0.0270 | -0.0226  0.0254 | -0.0184  0.0254 |
| K/L | 0.4740\*\*\*  0.0694 | 0.3330\*\*\*  0.0669 | 0.5140\*\*\*  0.0641 | 0.5070\*\*\*  0.0639 |
| (K/L)2 | 0.0608\*\*\*  0.0193 | 0.0528\*\*\*  0.0184 | 0.0627\*\*\*  0.0173 | 0.0617\*\*\*  0.0173 |
| GDPpc | -26.1000  17.1000 | 13.8000  16.6000 | -4.7300  15.7000 | -0.5980  15.7000 |
| GDPpc2 | 0.0075\*\*\*  0.0013 | 0.0059\*\*\*  0.0012 | 0.0071\*\*\*  0.0011 | 0.0069\*\*\*  0.0011 |
| (K/L) x GDPpc | -0.0508\*\*\*  0.0095 | -0.0423\*\*\*  0.0091 | -0.0523\*\*\*  0.0086 | -0.0516\*\*\*  0.0085 |
| Trade intensity | -0.0234\*\*\*  0.0013 | -0.0225\*\*\*  0.0013 | -0.0218\*\*\*  0.0012 | -0.0210\*\*\*  0.0012 |
| TI x Ratio TP | -0.0001  0.0001 | 0.0001  0.0001 | 0.0000  0.0001 | 0.0000  0.0001 |
| TI x (Ratio TP)2 | 0.0000  0.0000 | 0.0000\*  0.0000 | 0.0000  0.0000 | 0.0000  0.0000 |
| TI x Rel.GDPpc | 0.0053\*\*\*  0.0014 | 0.0057\*\*\*  0.0013 | 0.0040\*\*\*  0.0013 | 0.0035\*\*\*  0.0013 |
| TI x (Rel.GDPpc)2 | -0.0024\*\*\*  0.0003 | -0.0025\*\*\*  0.0003 | -0.0022\*\*\*  0.0003 | -0.0021\*\*\*  0.0003 |
| TI x (Ratio TP) x (Rel.GDPpc) | 0.0043\*\*\*  0.0003 | 0.0038\*\*\*  0.0003 | 0.0039\*\*\*  0.0003 | 0.0039\*\*\*  0.0003 |
| Communist dummy |  | 0.8779\*\*\*  0.0628 | 1.8385\*\*\*  0.0850 | 2.1004\*\*\*  0.1125 |
| CC dummy x GDPpc |  |  | -0.0002\*\*\*  0.0000 | -0.0004\*\*\*  0.0000  0.0000\*\*\* |
| CC dummy x (GDPpc)2 |  |  |  | 0.0000 |
| Helsinki dummy |  |  |  |  |
|  |  |  |  |  |
| N | 1995 | 1995 | 1995 | 1995 |
| Adjusted R2 | 0.4656 | 0.5143 | 0.5690 | 0.5715 |
| Log Likelihood | -1986.798 | -1891.084 | -1771.433 | -1765.010 |
|  |  |  |  |  |
| Scale elasticity | 0.4958 | 0.4907 | 0.5355 | 0.5278 |
| Composition elasticity | 0.7055 | 0.4956 | 0.7650 | 0.7546 |
| Technique elasticity | -0.1848 | 0.0977 | -0.0335 | -0.0042 |
| Trade int. elasticity | -1.8945 | -1.8207 | -1.7633 | -1.6971 |
|  |  |  |  |  |

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

**Table 4: Dependent variable: Log of CO2. Time-fixed effects**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 5 | 6 | 7 | 8 |
| Constant | 1.6477\*\*\*  0.0535 | |  | | --- | | 1.6249\*\*\* | | 0.0438 | | |  | | --- | | 1.6458\*\*\* | | 0.0535 | | |  | | --- | | 1.6477\*\*\* | | 0.0535 | |
| Economic intensity | 0.0526\*\*\*  0.0047 | 0.0414\*\*\*  0.0022 | 0.0496\*\*\*  0.0022 | 0.0526\*\*\*  0.0047 |
| (Eco. int)2/1000 | -0.0177  0.0245 |  |  | -0.0177  0.0245 |
| K/L | 0.6400\*\*\*  0.0625 | -0.0052  0.0251 | 0.6440\*\*\*  0.0622 | 0.6400\*\*\*  0.0625 |
| (K/L)2 | 0.1240\*\*\*  0.0174 |  | -0.1250\*\*\*  -0.0173 | -0.1240\*\*\*  -0.0174 |
| GDPpc | -61.6000\*\*\*  15.9000 | 65.5000\*\*\*  6.5300 | -63.5000\*\*\*  15.7000 | -61.6000\*\*\*  15.9000 |
| GDPpc2 | 0.0119\*\*\*  0.0012 |  | 0.0121\*\*\*  0.0012 | 0.0119\*\*\*  0.0012 |
| (K/L) x GDPpc | -0.0848\*\*\*  0.0087 |  | 0.0855\*\*\*  -0.0086 | 0.0848\*\*\*  -0.0087 |
| Trade intensity | -0.0219\*\*\*  0.0012 | -0.0232\*\*\*  0.0011 | -0.0219\*\*\*  0.0012 | -0.0219\*\*\*  0.0012 |
| TI x Ratio TP | -0.0001\*\*  0.0001 | 0.0000  0.0001 | -0.0001\*\*  0.0001 | -0.0001\*\*  0.0001 |
| TI x (Ratio TP)2 | 0.0000  0.0000 | 0.0000  0.0000 | 0.0000  0.0000 | 0.0000  0.0000 |
| TI x Rel.GDPpc | 0.0024\*\*  0.0012 | 0.0074\*\*\*  0.0009 | 0.0028\*\*\*  0.0011 | 0.0024\*\*  0.0012 |
| TI x (Rel.GDPpc)2 | -0.0023\*\*\*  0.0003 | -0.0033\*\*\*  0.0002 | -0.0024\*\*\*  0.0002 | -0.0023\*\*\*  0.0003 |
| TI x (Ratio TP) x (Rel.GDPpc) | 0.0045\*\*\*  0.0003 | 0.0042\*\*\*  0.0003 | 0.0044\*\*\*  0.0003 | 0.0045\*\*\*  0.0003 |
| Communist dummy | 2.0645\*\*\*  0.1085 | 1.6317\*\*\*  0.0863 | 2.0658\*\*\*  0.1084 | 2.0645\*\*\*  0.1085 |
| CC dummy x GDPpc | -0.0005\*\*\*  0.0000 | -0.0002\*\*\*  0.0000 | -0.0005\*\*\*  0.0000 | -0.0005\*\*\*  0.0000 |
| CC dummy x (GDPpc)2 | 0.0000\*\*\*  0.0000 |  | 0.0211\*\*\*  0.0033 | 0.0210\*\*\*  0.0033 |
| Helsinki dummy | 0.6124\*\*\*  0.0500 | 0.4195\*\*\*  0.0467 | 0.6125\*\*\*  0.0500 | 0.6124\*\*\*  0.0500 |
|  |  |  |  |  |
| N | 1995 | 1995 | 1995 | 1995 |
| Adjusted R2 | 0.6021 | 0.5609 | 0.6022 | 0.6021 |
| Log Likelihood | -1690.574 | -1791.522 | -1690.843 | -1690.574 |
|  |  |  |  |  |
| Scale elasticity | 0.6739 | 0.5304 | 0.6355 | 0.6739 |
| Composition elasticity | 0.9525 | -0.0077 | 0.9585 | 0.9525 |
| Technique elasticity | -0.4362 | 0.4638 | -0.4496 | -0.4362 |
| Trade int. elasticity | -1.7709 | -1.8799 | -1.7763 | -1.7709 |

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

# 6. CONCLUSION AND LIMITATIONS

This thesis examines the relationship between international trade and environmental quality. More specifically, a study by Antweiler, Copeland, and Taylor (2001) is replicated and the results are compared. The scale, composition and technique effect, and trade intensity, are given great attention, and are compared to the results from the study by ACT. Then the study extends by including a country’s most important trading partners and their GDPpc to the study.

The replication study tests for the hypothesis: *International trade is good for the environment.*

The extension part of this thesis tests for the hypothesis: *International trade is good for the environment when you take a country’s three most important trading partners into account.*

In the replication study, the scale effect is positive, meaning that an increase in the scale of the economy as a consequence of trade leads to more pollution emissions, and thus a deterioration of the environment. This is as expected. The composition effect shows to be negative, which is not as expected (in the study by ACT the composition effect is positive), but is a good result for the environment. A negative composition effect means that apparently, a change in the composition of an economy’s output when the scale and emission intensities are kept constant is beneficial to the environment. In other words, a country does not necessarily focuses on producing the polluting good. The technique effect is expected to be negative, moreover it is expected that the negative technique effect offsets the positive scale and composition effect, and therefore trade is good for the environment. In the replication study, the technique effect is either positive or negative, so strong conclusions are difficult to make. This also counts for trade intensity, which is expected to have a negative effect on pollution emissions. However, the replication study shows either a positive or negative effect for trade intensity. The scale, composition and technique effects combined together lead to a positive effect on pollution emissions. In this replication study, it turns out that international trade leads to an increase in pollution emissions, and is therefore bad for the environment. The hypothesis that international trade is good for the environment is rejected.

Considering the extension part of this thesis, a new variable is introduced. This is the ratio of the trade weighted average GDPpc of the trading partners for a domestic country over its domestic GDPpc. This is called Ratio TP, and replaces the variable for relative factor abundance. The regressions from the replication study are run again. The results show that the scale effect is positive, meaning a deterioration of the environment. The composition effect is negative, thus leads to a decrease in pollution emissions and is therefore good for the environment. The technique and trade intensity effects are both negative, which also leads to an improvement of the environment. The scale, composition and technique effects combined together lead to a positive effect on pollution emissions. This means that an increase in trade leads to an increase in pollution emissions and thus, a deterioration of the environment.

The marginal effects of the new variable Ratio TP are constructed and show to be positive. As it turns out, the positive marginal effects imply that an increase in trade openness leads to an increase in the emissions of SO2 and CO2 of the domestic country, if the domestic country becomes relatively more rich than the trading partners. In that case, trade openness is bad for the environment of the domestic country. Therefore, the hypothesis that “international trade is good for the environment when you take a country’s three most important trading partners into account” is rejected.

There are a few reasons to explain the differences in the results between this thesis and the results from the study by ACT. Data unavailability is an important one to consider. To start with, due to the lack of data availability, this thesis only uses a small number of observations. Moreover, this study is based on pollution emissions, which is a different measurement than pollution concentrations. According to Cole and Elliot (2003), this is not necessarily a very large problem, but it should be kept in mind that both measurements provide different information. Therefore it is quite likely that the different studies (ACT using pollution concentrations, and this thesis using pollution emissions) do not provide the exact same results. An important feature of this difference between emissions and concentrations, is that several site-specific variables that are used in the study by ACT (which are required when using concentrations as the dependent variable), could not be used in the study on pollution emissions.

When recommending for additional research, it would be a good idea to perform this study with a more complete dataset. Then the small number of observations and the now missing data would give less of a problem when interpreting the results. Also, it would be interesting to study more in depth the effect and differences between pollution emissions and pollution concentrations. Finally, a case study for the environmental effects of trade on one country could show interesting findings in how an individual country improves or deteriorates its environment as a result of trade.

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# APPENDIX

## APPENDIX A: List of variables ACT

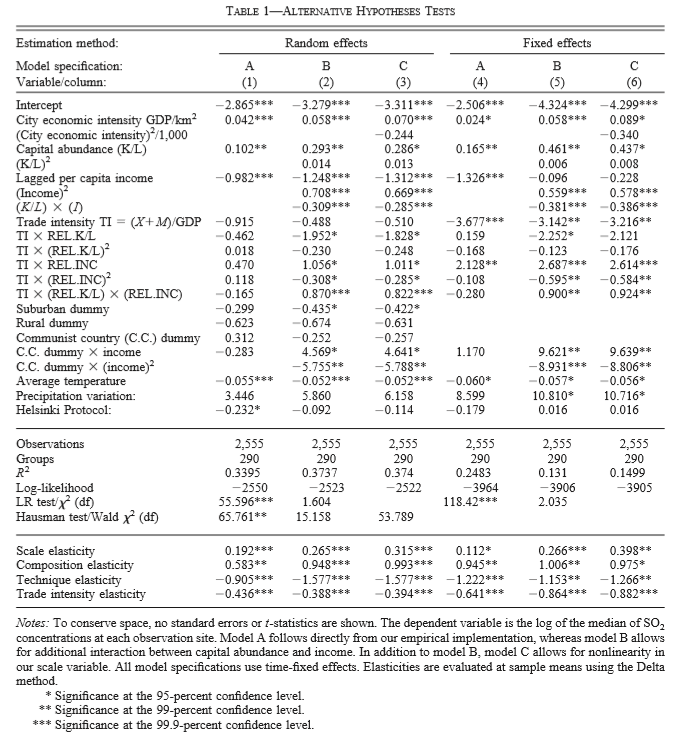
**Dependent variable:**

* Median of SO2 concentrations

**Independent variables:**

* City economic intensity GDP/km2
* (City economic intensity)/1,000
* Capital abundance (K/L)
* (K/L)2
* Lagged per capita income
* Income2
* (K/L) X (I)
* Trade intensity TI = (X+M)/GDP
* TI X REL.K/L
* TI X (REL.K/L)2
* TI X REL.INC
* TI X (REL.INC)2
* TI X (REL.K/L) X (REL.INC)
* Suburban dummy
* Rural dummy
* Communist country (C.C.) dummy
* C.C. dummy X income
* C.C. dummy X (income)2
* Average temperature
* Precipitation variation
* Helsinki protocol

## APPENDIX B: Results ACT



Source: Antweiler, W., Copeland, B.R., Taylor, M.S. (2001) “Is free trade good for the environment?” *The American Economic Review* 91(4): 877-908.

## APPENDIX C: Lists of countries

## List of countries (replication study)

|  |  |  |  |
| --- | --- | --- | --- |
| Algeria | France | Mongolia | Syrian Arab Republic |
| Andorra | French Polynesia | Morocco | Thailand |
| Argentina | Gabon | Mozambique | Togo |
| Australia | Gambia, The | Namibia | Tonga |
| Austria | Germany | Nepal | Trinidad and Tobago |
| Bahamas, The | Ghana | Netherlands | Tunisia |
| Bahrain | Greece | New Caledonia | Turkey |
| Bangladesh | Greenland | New Zealand | Uganda |
| Barbados | Grenada | Nicaragua | United Arab Emirates |
| Belize | Guatemala | Niger | United Kingdom |
| Benin | Guinea-Bissau | Nigeria | United States |
| Bermuda | Guyana | Norway | Uruguay |
| Bhutan | Honduras | Oman | Vanuatu |
| Bolivia | Hong Kong SAR, China | Pakistan | Venezuela, RB |
| Brazil | Hungary | Panama | Zambia |
| Brunei Darussalam | Iceland | Papua New Guinea | Zimbabwe |
| Burkina Faso | India | Paraguay |  |
| Burundi | Indonesia | Peru |  |
| Cameroon | Iran, Islamic Rep. | Philippines |  |
| Canada | Israel | Portugal |  |
| Cape Verde | Italy | Puerto Rico |  |
| Chad | Jamaica | Romania |  |
| Chile | Japan | Rwanda |  |
| China | Jordan | Samoa |  |
| Colombia | Kenya | San Marino |  |
| Comoros | Korea, Rep. | Saudi Arabia |  |
| Congo, Dem. Rep. | Latvia | Senegal |  |
| Congo, Rep. | Lesotho | Seychelles |  |
| Costa Rica | Liberia | Sierra Leone |  |
| Cote d'Ivoire | Liechtenstein | Singapore |  |
| Cuba | Macao SAR, China | Slovak Republic |  |
| Cyprus | Madagascar | South Africa |  |
| Denmark | Malawi | Spain |  |
| Dominica | Malaysia | Sri Lanka |  |
| Dominican Republic | Mali | St. Kitts and Nevis |  |
| Ecuador | Malta | St. Vincent and the Grenadines |  |
| Egypt, Arab Rep. | Mauritania | Sudan |  |
| El Salvador | Mauritius | Suriname |  |
| Ethiopia | Mexico | Swaziland |  |
| Fiji | Moldova | Sweden |  |
| Finland | Monaco | Switzerland |  |

## List of countries (extension part)

## 

|  |  |
| --- | --- |
| Algeria | Israel |
| Argentina | Italy |
| Australia | Japan |
| Austria | Kenya |
| Bangladesh | Luxembourg |
| Barbados | Madagascar |
| Belgium | Malaysia |
| Bolivia | Malta |
| Botswana | Mexico |
| Cameroon | Morocco |
| Canada | Netherlands |
| Central African Republic | Nicaragua |
| Chile | Norway |
| China | Oman |
| Colombia | Paraguay |
| Cote d'Ivoire | Philippines |
| Denmark | Portugal |
| Ecuador | Korea, Rep. |
| El Salvador | Saudi Arabia |
| Fiji | Senegal |
| Finland | Singapore |
| France | South Africa |
| Germany | Spain |
| Greece | Sri Lanka |
| Guatemala | Sweden |
| Guyana | Thailand |
| Hong Kong SAR, China | Trinidad and Tobago |
| Hungary | Tunisia |
| Iceland | Turkey |
| India | United Kingdom |
| Indonesia | Uruguay |
| Ireland | United States |

## APPENDIX D: Descriptive statistics

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Observations | Mean | Median | Standard Deviation | Minimum | Maximum |
| (Economic intensity^2)/1000 | 5428 | 10200000000000 | 9242839 | 129000000000000 | 226,8444 | 365 |
| (Relative GDP per capita)^2 | 6974 | 3,4098 | 0,0808 | 10,9482 | 0,0001 | 154,6012 |
| (Relative capital abundance)^2 | 4675 | 2,8233 | 0,1188 | 6,5923 | 0 | 63,0790 |
| Communist country | 9202 | 0,2056 | 0 | 0,4042 | 0 | 1 |
| Economic intensity | 5428 | 12811820 | 96139,5900 | 100000000 | 476,2819 | 1910000000 |
| GDP per capita | 6974 | 7080,9810 | 2015,8750 | 11202,9600 | 54,5052 | 108111,2000 |
| (GDP per capita)^2 | 6974 | 176000000 | 4063751 | 593000000 | 2970,8160 | 11700000000 |
| Helsinki protocol | 9245 | 0,1163 | 0 | 0,3206 | 0 | 1 |
| Capital abundance | 4675 | 1488,2890 | 509,3676 | 2057,9850 | -104,7202 | 14756,7100 |
| (Capital abundance)^2 | 4675 | 6449402 | 259455,4000 | 16081684 | 2,8337 | 218000000 |
| LOG of CO2 | 6708 | 0,9443 | 0,9791 | 1,1074 | -1,9589 | 3,8573 |
| LOG of SO2 | 709 | 2,2549 | 2,3541 | 1,0280 | -1,4935 | 4,3209 |
| Ratio trading partners GDP per capita | 2608 | 13,6372 | 4,1548 | 21,7530 | 0,4368 | 116,2255 |
| (Ratio trading partners GDP per capita)^2 | 2608 | 658,9851 | 17,2624 | 19,1705 | 0,1908 | 13508,3600 |
| Relative GDP per capita | 6974 | 1 | 0,2842 | 1,5525 | 0,0081 | 12,4339 |
| Relative capital abundance | 4675 | 1 | 0,3446 | 1,3505 | -0,0753 | 7,9422 |
| Trade intensity | 6495 | 80,9965 | 70,8924 | 50,0457 | 0,3088 | 460,4711 |

## APPENDIX E: Results

Appendix E shows the results from the replication study and from the extension. Table 5 and 6 show the results from the replication study with time-fixed effects and country-fixed effects. It is important to note that due to country-fixed effects, table 5 and 6 cannot include the Communist and Helsinki dummy, and therefore some regressions are missing (14-17) or are incomplete (18-20).

Table 7 and 8 show the results from the extension.

**Table 5: Dependent variable: Log of SO2. Time-fixed effects, country-fixed effects**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Constant | 2.2564\*\*\*  0.0140 | 2.2052\*\*\*  0.0688 | 3.2451\*\*\*  0.1240 | 3.2923\*\*\*  0.1505 | 3.1804\*\*\*  0.1852 | 3.6652\*\*\*  0.2894 | 3.7936\*\*\*  0.2968 | 3.7389\*\*\*  0.3010 | 3.2417\*\*\*  0.3054 |
| Economic intensity | 0.0001  0.0002 | 0.0018  0.0022 | -0.6040\*\*\*  0.0655 | -0.5990\*\*\*  0.0661 | -0.6100\*\*\*  0.0670 | -0.5760\*\*\*  0.0684 | -0.5600\*\*\*  0.0687 | -0.5620\*\*\*  0.6870 | -0.6130\*\*\*  0.0670 |
| (Eco. int)2/1000 |  | -0.0006  0.0008 | 25.6000\*\*\*  3.1000 | 25.4000\*\*\*  3.1300 | 25.4000\*\*\*  3.1300 | 24.1000\*\*\*  3.1800 | 23.4000\*\*\*  3.1900 | 23.5000\*\*\*  3.1900 | 26.3000\*\*\*  3.1300 |
| K/L |  |  | 0.0536\*\*\*  0.0121 | 0.0326  0.0399 | 0.0186  0.0421 | 0.109\*  0.0589 | 0.1840\*\*  0.0716 | 0.1960\*\*\*  0.0725 | 0.2660\*\*\*  0.0713 |
| (K/L)2 |  |  |  | 0.0014  0.0026 | 0.0014  0.0026 | -0.0038  0.0035 | 0.0101  0.0083 | 0.0100  0.0083 | 0.0099  0.0080 |
| GDPpc |  |  |  |  | 10.0000  9.6900 | -51.9000\*  30.1000 | -83.2000\*\*  34.5000 | -87.3000\*\*  34.7000 | -47.5000  34.3000 |
| GDPpc2 |  |  |  |  |  | 0.0008\*\*  0.0004 | 0.00241\*\*  0.0001 | 0.0025\*\*\*  0.0009 | 0.00201\*\*  0.0009 |
| (K/L) x GDPpc |  |  |  |  |  |  | -0.0091\*  0.0050 | -0.0094\*  0.0050 | -0.0092\*  0.0048 |
| Trade intensity |  |  |  |  |  |  |  | 0.0010  0.0010 | 0.0042\*\*\*  0.0011 |
| TI x Rel.K/L |  |  |  |  |  |  |  |  | -0.0028\*\*\*  0.0005 |
|  |  |  |  |  |  |  |  |  |  |
| N | 475 | 475 | 454 | 454 | 454 | 454 | 454 | 454 | 454 |
| Adjusted R2 | 0.9678 | 0.9678 | 0.9530 | 0.9529 | 0.9529 | 0.9533 | 0.9536 | 0.9536 | 0.9566 |
| Log Likelihood | 146.9905 | 147.3089 | 184.7790 | 184.9495 | 185.5475 | 188.1747 | 190.0694 | 190.7339 | 206.4705 |
|  |  |  |  |  |  |  |  |  |  |
| Scale elasticity | 0.0010 | 0.0225 | -7.7383 | -7.6743 | -7.8152 | -7.3796 | -7.1746 | -7.2002 | -7.8537 |
| Composition elasticity |  |  | 0.0798 | 0.0485 | 0.0277 | 0.1622 | 0.2738 | 0.2917 | 0.2917 |
| Technique elasticity |  |  |  |  | 0.0708 | -0.3675 | -0.5891 | -0.6182 | -0.3364 |
| Trade int. elasticity |  |  |  |  |  |  |  | 0.0796 | 0.3407 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 10 | 11 | 12 | 13 |
| Constant | 3.2471\*\*\*  0.3048 | 3.2945\*\*\*  0.3450 | 3.2535\*\*\*  0.3441 | 3.1758\*\*\*  0.3463 |
| Economic intensity | -0.5990\*\*\*  0.0670 | -0.5980\*\*\*  0.0677 | -0.5650\*\*\*  0.0692 | -0.5570\*\*\*  0.0692 |
| (Eco. int)2/1000 | 25.8000\*\*\*  3.1400 | 25.8000\*\*\*  3.1500 | 24.5000  3.2000 | 23.9000\*\*\*  3.2100 |
| K/L | 0.2900\*\*\*  0.0727 | 0.3080\*\*\*  0.0963 | 0.2100\*  0.1070 | 0.1810\*  0.1080 |
| (K/L)2 | 0.0089  0.0080 | 0.0087  0.0081 | 0.0108  0.0081 | -0.0031  0.0116 |
| GDPpc | -53.1000  34.4000 | -61.2000  44.2000 | -37.9000  45.4000 | -25.7000  45.9000 |
| GDPpc2 | 0.0023\*\*  0.0009 | 0.00236\*\*  0.0010 | 0.0017\*  0.0010 | 0.0008  0.0012 |
| (K/L) x GDPpc | -0.0101\*\*  0.0048 | -0.0104\*\*  0.0049 | -0.0083\*  0.0051 | -0.0012  0.0066 |
| Trade intensity | 0.0052\*\*\*  0.0012 | 0.0050\*\*\*  0.0013 | 0.0061\*\*\*  0.0014 | 0.0062\*\*\*  0.0014 |
| TI x Rel.K/L | -0.0040\*\*\*  0.0009 | -0.0043\*\*\*  0.0014 | -0.0020  0.0018 | -0.0013  0.0018 |
| TI x (REL.K/L)2 | 0.0002  0.0001 | 0.0002  0.0001 | -0.0001  0.0002 | 0.0009  0.0006 |
| TI x Rel.GDPpc |  | 0.0004  0.0013 | -0.0045\*  0.0027 | -0.0055\*\*  0.0027 |
| TI x (Rel.GDPpc)2 |  |  | 0.0009\*\*  0.0004 | 0.0022\*\*  0.0009 |
| TI x (Rel.K/L) x (Rel.GDPpc) |  |  |  | -0.0022\*  0.0013 |
| Communist dummy |  |  |  |  |
| CC dummy x GDPpc |  |  |  |  |
| CC dummy x (GDPpc)2 |  |  |  |  |
| Helsinki dummy |  |  |  |  |
|  |  |  |  |  |
| N | 454 | 454 | 454 | 454 |
| Adjusted R2 | 0.9568 | 0.9567 | 0.9571 | 0.9573 |
| Log Likelihood | 207.9408 | 207.9899 | 210.4653 | 212.0621 |
|  |  |  |  |  |
| Scale elasticity | -7.6742 | -7.6615 | -7.2387 | -7.1362 |
| Composition elasticity | 0.4316 | 0.4584 | 0.3125 | 0.3125 |
| Technique elasticity | -0.3760 | -0.4334 | -0.2684 | -0.1820 |
| Trade int. elasticity | 0.3407 | 0.3407 | 0.4903 | 0.5047 |

**Table 5: Dependent variable: Log of SO2. Time-fixed effects, country-fixed effects**

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

**Table 5: Dependent variable: Log of SO2. Time-fixed effects, country-fixed effects**

|  |  |  |  |
| --- | --- | --- | --- |
|  | 18 | 19 | 20 |
| Constant | 2.1886\*\*\*  0.1886 | 3.0914\*\*\*  0.3690 | 3.1758\*\*\*  0.3464 |
| Economic intensity | -0.0782\*\*\*  0.0251 | -0.0727\*\*\*  0.0251 | -0.5570\*\*\*  0.0692 |
| (Eco. int)2/1000 |  |  | 23.9000\*\*\*  3.2100 |
| K/L | 0.0449  0.0330 | 0.1450  0.1150 | 0.1810\*  0.108 |
| (K/L)2 |  | -0.0040  0.0123 | -0.0031  0.0116 |
| GDPpc | 27.2000\*  15.0000 | -71.3000  48.5000 | -25.7000  45.9000 |
| GDPpc2 |  | 0.0013  0.0013 | 0.0008  0.0012 |
| (K/L) x GDPpc |  | -0.0007  0.0070 | -0.0012  0.0069 |
| Trade intensity | 0.0073\*\*\*  0.0014 | 0.0065\*\*\*  0.0014 | 0.0062\*\*\*  0.0014 |
| TI x Rel.K/L | 0.0009  0.0014 | 0.0006  0.0019 | -0.0013  0.0018 |
| TI x (REL.K/L)2 | 0.0009\*\*  0.0004 | 0.0012\*  0.0006 | 0.0009  0.0006 |
| TI x Rel.GDPpc | -0.0105\*\*\*  0.0022 | -0.0092\*\*\*  0.0028 | -0.0055\*\*  0.0027 |
| TI x (Rel.GDPpc)2 | 0.0033\*\*\*  0.0007 | 0.0035\*\*\*  0.0009 | 0.0022\*\*  0.0009 |
| TI x (Rel.K/L) x (Rel.GDPpc) | -0.0028\*\*\*  0.0010 | -0.0033\*\*  0.0014 | -0.0022\*  0.0013 |
| Communist dummy |  |  |  |
| CC dummy x GDPpc |  |  |  |
| CC dummy x (GDPpc)2 |  |  |  |
| Helsinki dummy |  |  |  |
|  |  |  |  |
| N | 454 | 454 | 454 |
| Adjusted R2 | 0.9507 | 0.9515 | 0.9573 |
| Log Likelihood | 177.3753 | 182.5517 | 212.0621 |
|  |  |  |  |
| Scale elasticity | -1.0019 | -1.0019 | -7.1362 |
| Composition elasticity | 0.0668 | 0.2158 | 0.2694 |
| Technique elasticity | 0.1926 | -0.5049 | -0.1820 |
| Trade int. elasticity | 0.5904 | 0.5283 | 0.5047 |

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Constant | 0.9640\*\*\*  0.0026 | 0.9672\*\*\*  0.0033 | 1.3242\*\*\*  0.0062 | 1.3004\*\*\*  0.0094 | 1.4097\*\*\*  0.0104 | 1.4182\*\*\*  0.0147 | 1.4146\*\*\*  0.0149 | 1.3373\*\*\*  0.0176 | 1.3214\*\*\*  0.0179 |
| Economic intensity | 0.0000  0.0004 | -0.0024  0.0016 | 0.0033\*  0.0017 | 0.0029\*  0.0017 | 0.0098\*\*\*  0.0016 | 0.0102\*\*\*  0.0017 | 0.0099\*\*\*  0.0017 | 0.0106\*\*\*  0.0017 | 0.0142\*\*\*  0.0019 |
| (Eco. int)2/1000 |  | 0.0122  0.0077 | -0.0062  0.0017 | -0.0041  0.0077 | -0.0237\*\*\*  0.0073 | -0.0252\*\*\*  0.0075 | -0.0245\*\*\*  0.0075 | -0.0310\*\*\*  0.0074 | -0.0418\*\*\*  0.00783 |
| K/L |  |  | -0.0608\*\*\*  0.0041 | -0.0328\*\*\*  0.0092 | 0.0406\*\*\*  0.0095 | 0.4740\*\*\*  0.0126 | 0.0434\*\*\*  0.0128 | 0.0134  0.0128 | 0.0428\*\*\*  0.0145 |
| (K/L)2 |  |  |  | -0.0028\*\*  0.0008 | -0.0009  0.0008 | -0.0015  0.0011 | -0.0066\*\*  0.0033 | -0.0070\*\*  0.0033 | -0.0046  0.0033 |
| GDPpc |  |  |  |  | -35.9000\*\*\*  1.8300 | -39.6000\*\*\*  4.8400 | -37.5000\*\*\*  5.0100 | -33.4000\*\*\*  4.9200 | -35.7000\*\*\*  4.9400 |
| GDPpc2 |  |  |  |  |  | 0.0001  0.0001 | -0.0003  0.0002 | -0.0005\*\*  0.0002 | -0.0003  0.0002 |
| (K/L) x GDPpc |  |  |  |  |  |  | 0.0027  0.0017 | 0.0040\*\*  0.0016 | 0.0025  0.0017 |
| Trade intensity |  |  |  |  |  |  |  | 0.0013\*\*\*  0.0002 | 0.0016\*\*\*  0.0002 |
| TI x Rel.K/L |  |  |  |  |  |  |  |  | -0.0004\*\*\*  0.0000 |
|  |  |  |  |  |  |  |  |  |  |
| N | 4596 | 4596 | 3412 | 3412 | 3412 | 3412 | 3412 | 3402 | 3402 |
| Adjusted R2 | 0.9774 | 0.9774 | 0.9820 | 0.9821 | 0.9840 | 0.9840 | 0.9840 | 0.9847 | 0.9848 |
| Log Likelihood | 1842.720 | 1844.040 | 2081.660 | 2087.683 | 2278.730 | 2279.085 | 2280.440 | 2350.063 | 2359.667 |
|  |  |  |  |  |  |  |  |  |  |
| Scale elasticity | 0.0006 | -0.0305 | 0.0423 | 0.0377 | 0.1253 | 0.1307 | 0.1270 | 0.1358 | 0.1819 |
| Composition elasticity |  |  | -0.0905 | -0.0488 | 0.0604 | 0.0705 | 0.0646 | 0.0199 | 0.0637 |
| Technique elasticity |  |  |  |  | -0.2542 | -0.2804 | -0.2655 | -0.2365 | -0.2528 |
| Trade int. elasticity |  |  |  |  |  |  |  | 0.1057 | 0.1269 |

**Table 6: Dependent variable: Log of CO2. Time-fixed effects, country-fixed effects**

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1% \*\* Significant at 5% \* Significant at 10%

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 10 | 11 | 12 | 13 |
| Constant | 1.2986\*\*\*  0.0189 | 1.2951\*\*\*  0.0193 | 1.2940\*\*\*  0.0193 | 1.2921\*\*\*  0.0194 |
| Economic intensity | 0.0123\*\*\*  0.0020 | 0.0133\*\*\*  0.0220 | 0.0137\*\*\*  0.0023 | 0.0148\*\*\*  0.0024 |
| (Eco. int)2/1000 | -0.0323\*\*\*  0.0082 | -0.0328\*\*\*  0.0082 | -0.0349\*\*\*  0.0091 | -0.0392\*\*\*  0.0093 |
| K/L | 0.0687\*\*\*  0.0161 | 0.0599\*\*\*  0.0183 | 0.0556\*\*\*  0.0200 | 0.0551\*\*\*  0.0199 |
| (K/L)2 | -0.0077\*\*  0.0034 | -0.0074\*\*  0.0034 | -0.0072\*\*  0.0035 | -0.0125\*\*\*  0.0044 |
| GDPpc | -35.1000\*\*\*  4.9300 | -32.1000\*\*\*  5.7500 | -30.7000\*\*\*  6.3400 | -29.7000\*\*\*  6.3500 |
| GDPpc2 | -0.0003  0.0002 | -0.0004  0.0002 | -0.0004  0.0003 | -0.0008\*\*  0.0003 |
| (K/L) x GDPpc | 0.0028\*  0.0017 | 0.0028\*  0.0017 | 0.0029\*  0.0017 | 0.0058\*\*\*  0.0022 |
| Trade intensity | 0.0019\*\*\*  0.0002 | 0.0020\*\*\*  0.0002 | 0.0020\*\*\*  0.0002 | 0.0020\*\*\*  0.0002 |
| TI x Rel.K/L | -0.0011\*\*\*  0.0002 | -0.0009\*\*\*  0.0003 | -0.0008\*\*  0.0004 | -0.0007\*\*  0.0004 |
| TI x (REL.K/L)2 | 0.0001\*\*\*  0.0000 | 0.0000\*\*\*  0.0000 | 0.0001  0.0000 | 0.0002\*\*\*  0.0000 |
| TI x Rel.GDPpc |  | -0.0002  0.0002 | -0.0005  0.0005 | -0.0006  0.0005 |
| TI x (Rel.GDPpc)2 |  |  | 0.0001  0.0001 | 0.0003\*\*  0.0002 |
| TI x (Rel.K/L) x (Rel.GDPpc) |  |  |  | -0.0004\*\*  0.0002 |
| Communist dummy |  |  |  |  |
| CC dummy x GDPpc |  |  |  |  |
| CC dummy x (GDPpc)2 |  |  |  |  |
| Helsinki dummy |  |  |  |  |
|  |  |  |  |  |
| N | 3402 | 3402 | 3402 | 3402 |
| Adjusted R2 | 0.9849 | 0.9849 | 0.9849 | 0.9849 |
| Log Likelihood | 2366.792 | 2367.319 | 2367.477 | 2369.628 |
|  |  |  |  |  |
| Scale elasticity | 0.1576 | 0.17040 | 0.1755 | 0.1896 |
| Composition elasticity | 0.1022 | 0.0891 | 0.0827 | 0.0820 |
| Technique elasticity | -0.2485 | -0.2273 | -0.2174 | -0.2103 |
| Trade int. elasticity | 0.1565 | 0.1586 | 0.1607 | 0.1622 |

**Table 6: Dependent variable: Log of CO2. Time-fixed effects, country-fixed effects**

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

**Table 6: Dependent variable: Log of CO2. Time-fixed effects, country-fixed effects**

|  |  |  |  |
| --- | --- | --- | --- |
|  | 18 | 19 | 20 |
| Constant | 1.3141\*\*\*  0.0146 | 1.2884\*\*\*  0.0194 | 1.2921\*\*\*  0.0194 |
| Economic intensity | 0.0059\*\*\*  0.0010 | 0.0057\*\*\*  0.0010 | 0.0148\*\*\*  0.0024 |
| (Eco. int)2/1000 |  |  | -0.0392\*\*\*  0.0093 |
| K/L | 0.0354\*\*  0.0094 | 0.0676\*\*\*  0.0198 | 0.0551\*\*\*  0.0199 |
| (K/L)2 |  | -0.0127\*\*\*  0.0044 | -0.0125\*\*\*  0.0044 |
| GDPpc | -31.1000\*\*\*  2.7800 | -30.1000\*\*\*  6.3700 | -29.7000\*\*\*  6.3500 |
| GDPpc2 |  | -0.0007\*\*  0.0000 | -0.0001\*\*  0.000 |
| (K/L) x GDPpc |  | 0.0050\*\*  0.0022 | 0.0058\*\*\*  0.0022 |
| Trade intensity | 0.0017\*\*\*  0.0002 | 0.0019\*\*\*  0.0002 | 0.0020\*\*\*  0.0002 |
| TI x Rel.K/L | -0.0009\*\*\*  0.0003 | -0.0013\*\*\*  0.0003 | -0.0007\*\*  0.0004 |
| TI x (REL.K/L)2 | 0.0001  0.0001 | 0.0002\*\*\*  0.0001 | 0.0002\*\*\*  0.0000 |
| TI x Rel.GDPpc | 0.0003  0.0004 | 0.0003  0.0005 | -0.0006  0.0005 |
| TI x (Rel.GDPpc)2 | -0.0002  0.0001 | 0.0000  0.0002 | 0.0003\*\*  0.0002 |
| TI x (Rel.K/L) x (Rel.GDPpc) | 0.0001  0.0001 | -0.0002  0.0002 | -0.0004\*\*  0.0002 |
| Communist dummy |  |  |  |
| CC dummy x GDPpc |  |  |  |
| CC dummy x (GDPpc)2 |  |  |  |
| Helsinki dummy |  |  |  |
|  |  |  |  |
| N | 3402 | 3402 | 3402 |
| Adjusted R2 | 0.9847 | 0.9848 | 0.9849 |
| Log Likelihood | 2353.135 | 2360.377 | 2369.628 |
|  |  |  |  |
| Scale elasticity | 0.0766 | 0.0726 | 0.1896 |
| Composition elasticity | 0.0527 | 0.1006 | 0.0820 |
| Technique elasticity | -0.2202 | -0.2131 | -0.2103 |
| Trade int. elasticity | 0.1407 | 0.1522 | 0.1622 |

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

**Table 7: Dependent variable: Log of SO2. Time-fixed effects, country-fixed effects**

|  |  |  |  |
| --- | --- | --- | --- |
|  | 10 | 12 | 13 |
| Constant | 3.5179\*\*\*  0.3304 | 3.6347\*\*\*  0.3562 | 4.0529\*\*\*  0.3948 |
| Economic intensity | -0.7830\*\*\*  0.0566 | -0.7810\*\*\*  0.0580 | -0.7620\*\*\*  0.0581 |
| (Eco. int)2/1000 | 32.2000\*\*\*  2.5800 | 32.2000\*\*\*  2.6200 | 30.8000\*\*\*  2.6700 |
| K/L | 0.1480\*\*  0.0691 | 0.1490\*\*  0.0694 | 0.1690\*\*  0.0694 |
| (K/L)2 | 0.0006  0.0064 | 0.0004  0.0065 | 0.0031  0.0065 |
| GDPpc | 31.8000  36.1000 | 22.3000  37.5000 | -9.5300  39.5000 |
| GDPpc2 | -0.0001  0.0009 | 0.0000  0.0009 | 0.0006  0.0009 |
| (K/L) x GDPpc | -0.0036  0.0041 | -0.0036  0.0041 | -0.0056  0.0042 |
| Trade intensity | -0.0043\*  0.0024 | 0.0062  0.0123 | -0.0065  0.0133 |
| TI x Ratio TP | -0.0031\*\*  0.0012 | -0.0062  0.0038 | 0.0016  0.0050 |
| TI x (Ratio TP)2 | 0.0010\*\*\*  0.0002 | 0.0013\*\*\*  0.0004 | 0.0006  0.0005 |
| TI x Rel.GDPpc |  | -0.0043  0.0045 | 0.0061  0.0063 |
| TI x (Rel.GDPpc)2 |  | 0.0006  0.0006 | -0.0004  0.0007 |
| TI x (Ratio TP) x (Rel.GDPpc) |  |  | -0.0055\*\*  0.0023 |
| Communist dummy |  |  |  |
| CC dummy x GDPpc |  |  |  |
| CC dummy x (GDPpc)2 |  |  |  |
| Helsinki dummy |  |  |  |
|  |  |  |  |
| N | 361 | 361 | 361 |
| Adjusted R2 | 0.9731 | 0.9730 | 0.9734 |
| Log Likelihood | 264.0650 | 264.6912 | 267.9495 |
|  |  |  |  |
| Scale elasticity | -10.0317 | -10.006 | -9.7626 |
| Composition elasticity | 0.2203 | 0.2218 | 0.2515 |
| Technique elasticity | 0.2252 | 0.1579 | -0.0675 |
| Trade int. elasticity | -0.3511 | 0.4991 | -0.5303 |

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

|  |  |  |  |
| --- | --- | --- | --- |
|  | 18 | 19 | 20 |
| Constant | |  |  | | --- | --- | | 3.7399\*\*\* | | | 0.2549 | | |  | | --- | | 4.5743\*\*\* | | 0.4679 | | 4.0529\*\*\*  0.3948 |
| Economic intensity | -0.1290\*\*\*  0.0229 | -0.1280\*\*\*  0.0226 | -0.7620\*\*\*  0.0581 |
| (Eco. int)2/1000 |  |  | 30.8000\*\*\*  2.6700 |
| K/L | 0.0182  0.0177 | 0.2250\*\*\*  0.0826 | 0.1690\*\*  0.0694 |
| (K/L)2 |  | 0.0160\*\*  0.0076 | 0.0031  0.0065 |
| GDPpc | -27.1000\*\*  13.7000 | |  | | --- | | -140.0000\*\*\* | | 45.2000 | | -9.5300  39.5000 |
| GDPpc2 |  | 0.0032\*\*\*  0.0011 | 0.0006  0.0009 |
| (K/L) x GDPpc |  | -0.0140\*\*\*  0.0049 | -0.0056  0.0042 |
| Trade intensity | -0.0360\*\*  0.0151 | -0.0296\*  0.0157 | -0.0065  0.0133 |
| TI x Ratio TP | 0.0138\*\*  0.0058 | 0.0130\*\*  0.0058 | 0.0016  0.0050 |
| TI x (Ratio TP)2 | -0.0004  0.0005 | -0.0004  0.0005 | |  | | --- | | 0.0006 | | 0.0005 | |
| TI x Rel.GDPpc | 0.0186\*\*  0.0073 | 0.0196\*\*\*  0.0073 | 0.0061  0.0063 |
| TI x (Rel.GDPpc)2 | -0.0013  0.0008 | -0.0014  0.0008 | -0.0004  0.0007 |
| TI x (Ratio TP) x (Rel.GDPpc) | -0.0095\*\*\*  0.0026 | -0.0114\*\*\*  0.0027 | -0.0055\*\*  0.0023 |
| Communist dummy |  |  |  |
| CC dummy x GDPpc |  |  |  |
| CC dummy x (GDPpc)2 |  |  |  |
| Helsinki dummy |  |  |  |
|  |  |  |  |
| N | 361 | 361 | 361 |
| Adjusted R2 | 0.9614 | 0.9622 | 0.9734 |
| Log Likelihood | 198.1580 | 203.6248 | 267.9495 |
|  |  |  |  |
| Scale elasticity | -1.6527 | -1.6399 | -9.7626 |
| Composition elasticity | 0.0271 | 0.3349 | 0.2515 |
| Technique elasticity | -0.1919 | -0.9913 | -0.0675 |
| Trade int. elasticity | -2.9174 | -2.3964 | -0.5303 |

**Table 7: Dependent variable: Log of SO2. Time-fixed effects, country-fixed effects**

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

**Table 8: Dependent variable: Log of CO2. Time-fixed effects, country-fixed effects**

|  |  |  |  |
| --- | --- | --- | --- |
|  | 10 | 12 | 13 |
| Constant | 1.9103\*\*\*  0.0276 | 1.8525\*\*\*  0.0278 | 1.9284\*\*\*  0.0276 |
| Economic intensity | 0.0148\*\*\*  0.0016 | 0.0242\*\*\*  0.0020 | 0.0197\*\*\*  0.0019 |
| (Eco. int)2/1000 | -0.0449\*\*\*  0.0069 | -0.0676\*\*\*  0.0072 | -0.0489\*\*\*  0.0071 |
| K/L | 0.0495\*\*\*  0.0158 | 0.0645\*\*\*  0.0156 | 0.0537\*\*\*  0.0151 |
| (K/L)2 | -0.0056  0.0039 | -0.0077\*\*  0.0038 | -0.0086\*\*  0.0037 |
| GDPpc | -68.2000\*\*\*  6.2900 | -55.5000\*\*\*  6.3100 | -55.9000\*\*\*  6.0900 |
| GDPpc2 | 0.0003  0.0003 | -0.0001  0.0003 | -0.0002  0.0003 |
| (K/L) x GDPpc | 0.0023  0.0020 | 0.0030  0.0020 | 0.0038\*\*  0.0019 |
| Trade intensity | 0.0017\*\*\*  0.0002 | 0.0041\*\*\*  0.0003 | 0.0007  0.0004 |
| TI x Ratio TP | 0.0000  0.0000 | -0.0001\*\*\*  0.0000 | -0.0001\*\*\*  0.0000 |
| TI x (Ratio TP)2 | 0.0000\*\*\*  0.0000 | 0.0000  0.0000 | 0.0000\*\*\*  0.0000 |
| TI x Rel.GDPpc |  | -0.0033\*\*\*  0.0004 | -0.0038\*\*\*  0.0004 |
| TI x (Rel.GDPpc)2 |  | 0.0005\*\*\*  0.0001 | 0.0006\*\*\*  0.0001 |
| TI x (Ratio TP) x (Rel.GDPpc) |  |  | 0.0012\*\*\*  0.0001 |
| Communist dummy |  |  |  |
| CC dummy x GDPpc |  |  |  |
| CC dummy x (GDPpc)2 |  |  |  |
| Helsinki dummy |  |  |  |
|  |  |  |  |
| N | 1995 | 1995 | 1995 |
| Adjusted R2 | 0.9855 | 0.9861 | 0.9870 |
| Log Likelihood | 1639.821 | 1685.248 | 1755.454 |
|  |  |  |  |
| Scale elasticity | 0.1896 | 0.3100 | 0.2524 |
| Composition elasticity | 0.0737 | 0.0960 | 0.0799 |
| Technique elasticity | -0.4829 | -0.3930 | -0.3958 |
| Trade int. elasticity | 0.1380 | 0.3315 | 0.0565 |

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

|  |  |  |  |
| --- | --- | --- | --- |
|  | 18 | 19 | 20 |
| Constant | 1.8754\*\*\*  0.0202 | 1.9229\*\*\*  0.0280 | |  |  | | --- | --- | | 1.9284\*\*\* | | | 0.0276 | |
| Economic intensity | 0.0082\*\*\*  0.0009 | 0.0079\*\*\*  0.0009 | 0.0197\*\*\*  0.0019 |
| (Eco. int)2/1000 |  |  | -0.0489\*\*\*  0.0071 |
| K/L | 0.0432\*\*\*  0.0065 | 0.0352\*\*  0.0150 | 0.0537\*\*\*  0.0151 |
| (K/L)2 |  | -0.0092\*\*  0.0037 | -0.0086\*\*  0.0037 |
| GDPpc | -38.3000\*\*\*  2.4100 | -45.7000\*\*\*   |  | | --- | | 5.9800 | | -55.9000\*\*\*  6.0900 |
| GDPpc2 |  | -0.0004  0.0003 | -0.0002  0.0003 |
| (K/L) x GDPpc |  | 0.0047\*\*  0.0020 | 0.0038\*\*  0.0019 |
| Trade intensity | -0.0005  0.0004 | -0.0007\*  0.0004 | 0.0007  0.0004 |
| TI x Ratio TP | -0.0001\*\*\*  0.0000 | -0.0001\*\*\*  0.0000 | -0.0001\*\*\*  0.0000 |
| TI x (Ratio TP)2 | 0.0000\*\*\*  0.0000 | 0.0000\*\*\*  0.0000 | 0.0000\*\*\*  0.0000 |
| TI x Rel.GDPpc | -0.0034\*\*\*  0.0003 | -0.0030\*\*\*  0.0003 | -0.0038\*\*\*  0.0004 |
| TI x (Rel.GDPpc)2 | 0.0005\*\*\*  0.0001 | 0.0004\*\*\*  0.0001 | 0.0006\*\*\*  0.0001 |
| TI x (Ratio TP) x (Rel.GDPpc) | 0.0014\*\*\*  0.0001 | 0.0014\*\*\*  0.0001 | 0.0012\*\*\*  0.0001 |
| Communist dummy |  |  |  |
| CC dummy x GDPpc |  |  |  |
| CC dummy x (GDPpc)2 |  |  |  |
| Helsinki dummy |  |  |  |
|  |  |  |  |
| N | 1995 | 1995 | 1995 |
| Adjusted R2 | 0.9867 | 0.9868 | 0.9871 |
| Log Likelihood | 1723.227 | 1730.548 | 1755.454 |
|  |  |  |  |
| Scale elasticity | 0.1056 | 0.1015 | 0.2524 |
| Composition elasticity | 0.0643 | 0.052388 | 0.0799 |
| Technique elasticity | -0.2712 | -0.3236 | -0.3958 |
| Trade int. elasticity | -0.0373 | -0.05411 | 0.0565 |

**Table 8: Dependent variable: Log of CO2. Time-fixed effects, country-fixed effects**

*Notes:* Economic intensity in millionth; (Economic intensity)2/1000 in trillionth; K/L in thousandth; (K/L)2 in millionth; GDPpc in millionth; GDPpc2 in millionth; (K/L) x GDPpc in millionth; CC dummy x (GDPpc) in millionth.

\*\*\* Significant at 1%

\*\*Significant at 5%

\* Significant at 10%

1. United Nations Environment Programme website. “Milestones.” [↑](#footnote-ref-1)
2. NOS Nieuws (2010). “Probo Koala: de feiten.” [↑](#footnote-ref-2)
3. Lenntech (2006). “Gifschepen.” [↑](#footnote-ref-3)
4. NRC (2012). “Justitie schikt met Trafigura in Probo Koala-zaak.” [↑](#footnote-ref-4)
5. [NRC (2012). “Met stip binnen in top-10 mondiale doodsoorzaken: luchtvervuiling.”](http://www.nrc.nl/nieuws/2012/12/23/met-stip-binnen-in-top-10-mondiale-doodsoorzaken-luchtvervuiling/) [↑](#footnote-ref-5)
6. A complete version of the model can be found in the article by ACT. In this thesis, only the most relevant formulas are included. [↑](#footnote-ref-6)
7. <http://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-1-b&chapter=27&lang=en> [↑](#footnote-ref-7)
8. <http://comtrade.un.org/db/> All data were retrieved between 22-02-2013 and 25-02-2013 [↑](#footnote-ref-8)