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TRADE AND ENVIRONMENT: A EUROPEAN ANALYSIS

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INTRODUCTION

"*The only thing that we CAN do is control what we can do next. How we live our lives. What we consume. How we get involved. And how we use our vote to tell our leaders that we know the truth about climate change.*"

These are words of Leonardo DiCaprio in his documentary "*Before the Flood*", one of the most famous voices warning about the Climatic Changes, but not the last one. Scientists and experts in the entire globe are studying the Climate Change from the past decades. Despite different results and theories, there is a starting point over which the vast majority of them agree: the Earth temperature is rising, the world climate is changing and this is due to human activity.

Climate Change is a definition that encompasses a variety of trends and phenomena concerning the climate and lasting for extended periods of time. The most important phenomenon is the well-known Global Warming. Global Warming defines a strong-stated trend of the Earth's temperature, which shows a substantial increase of about one Celsius degree over the past century. This may appear trivial but it's very alarming indeed, considering the amount of the increase (the average Earth's temperature is about 14 C°) and the relatively short period of time in which it occurred. Scientists have investigated the causes of such phenomenon, using a record of Earth's climate, dating back hundreds of thousands of years (and, in some cases, millions or hundreds of millions of years). Data were obtained by analyzing a number of indirect measures of climate such as ice cores, tree rings, glacier lengths, pollen remains and ocean sediments, and by studying changes in Earth's orbit around the Sun.

It comes that the models involving only natural factors are adequate in explaining the climate changes prior to the Industrial Revolution in the 1700s. Such factors are for example changes in solar energy, volcanic eruptions, and natural changes in greenhouse gas (GHG) concentrations. However, natural factors are insufficient for recent changes. Especially the rapid escalation of the temperature since the mid-20th century can be acknowledged only taking into account the human activities.

The human negative contribution to the climate is mainly constituted by the emission of Greenhouse Gases in the atmosphere. Gases such as water vapor (H_2O), carbon dioxide (CO_2), and methane (CH_4) are released from energy production, industrial activities, transport of people and goods, heating systems and other activities such as change in land use (deforestation) and so on. These gases absorb energy in the atmosphere, impeding the release of the sunlight energy and slowing the loss of heat from the Earth's surface; in other words, greenhouse gases act like a blanket, making Earth warmer than it would otherwise be. This process is commonly known as the **"Greenhouse Effect".**

As said, the first consequence is the increment of the Globe's hotness, but this is just the opening; a warmer Earth has more and more critical effects. First there is the melting of glaciers; the reduction of the ice caps (as well as the other glaciers) is a well-known phenomenon ongoing for many years already, and it has never been as urgent as today. Despite of, it's perceived by the public opinion to be far and poorly important. The fact that most of the people maybe neglect is the following: the direct consequence of the ice melting is the rising of the sea levels. Has been observed that in the past century, the level of the sea has risen up to 20 centimeters, and if the heating of the globe will continue, the sea could raise between 0.8 and 2 meters[1]. Consequences would be tragic: cities like Venice, New York, or Amsterdam could be seriously affected. Furthermore, water phenomena such as floods and droughts would be exacerbated, putting in extreme conditions hundreds of thousands of people. Other effects to mention are the loss of habitats and life spaces for animals and plants, with the consequent alteration of environmental equilibria. Climate changes could also lead to diminishing crop production, seriously impairing the capacity of producing foods by humans.

All these are extreme scenarios regarding the future of the planet, but some are already in progress. However, the most critical characteristic of Climate Change is that

[1] http://climate.nasa.gov/

is not stopping. If the humankind will not modify its behaviors, consequences are potentially catastrophic. To solve this problem, scientists and Heads of State launched in 1992 the United Nations Framework Convention on Climate Change, a document that states the will of Nations to cooperate and commit for the environment's sake[2]. The substantial part of the Convention is the organization of the yearly UN Climate Change Conferences, with the objectives of monitoring the global climatic changes, establishing common environmental policies and Binding Nations with mechanisms aimed to reduce greenhouse emissions, for example the Kyoto Protocol (1991). The results of these Conferences are the International Agreements on Climate; unfortunately, these agreements have produced poor results to these days, despite the efforts of few virtuous Nations. Governs are very reluctant to take strong, unpopular and extremely expensive decisions. Developed countries do not want to commit themselves in not-competitive energetic policies; on the other hand, developing countries don't want to forsake their "right to pollute" as developed countries did for many years.

Nevertheless, the point remains: if emissions will not be strongly reduced, the Climate Changes could become irreversible. In particular, scientists have identified the Carbon Dioxide (CO_2) as the most dangerous Greenhouse Gas, for its characteristics. It is produced and released in large quantities by human activities and, more important, it lasts for long periods in the atmosphere; between 65% and 80% of CO2 released into the air dissolves into the ocean over a period of 20–200 years[3]. The rest is removed by slower processes that take up to several hundreds of thousands of years, including chemical weathering and rock formation. This means that once in the atmosphere, carbon dioxide can continue to affect climate for thousands of years.

Of course, humans produce not all the carbon dioxide in the atmosphere. The normal carbon cycle involves quantities of gas much larger than what is coming from industrialized civilization. The tricky point is that the surplus levels from economic activities are not absorbed by the natural carbon silks (oceans, forests etc.). This quantity

[2] http://unfccc.int
[3] https://www.theguardian.com/environment/2012/jan/16/greenhouse-gases-remain-air

just clumps in the atmosphere reaching critical levels, as can be noticed in present days, up to compromising the planet's equilibrium.

Scientists believe that climatic changes would be manageable if the global warming will stop **below** an increase of 2 Celsius degrees. The new temperature will cause issues and changes in any case, but the common opinion is that they would not be permanent and could regress if humanity stops emissions within the year 2100. The scientific community has suggested the possible working solution: a drastic cut off of the CO_2 emissions to satisfy the so called "*2° threshold*". The amount to cut off is calculated about the 50-80% of the 1990 baseline emissions, and corresponds roughly to a decrease of carbon dioxide emissions for 750 Gt (gigatonnes) to be achieved within 2050[4]. As can be easily seen, it's a very ambitious and difficult-to-reach objective. Economic growth is strongly dependent on energy, and energy is mostly produced using fossil fuels (the most polluting activity). Governments find themselves in an ambiguous position: on one side they have committed to decrease emissions, on the other they still promote economic growth and welfare through their primary driver: trade**.**

International trade is the exchange of goods or services along international borders. This type of trade allows for a greater competition and more competitive pricing in the market. In 2014, the value of the global exports of merchandise (manufactured goods) was about 18.93 trillion of US dollars, while the dollar value of commercial services exports was 4.85 trillion, followed by fuels and mining products and agricultural goods.

The last 20 years have confirmed that world gross domestic product (GDP) and world merchandise exports move in tandem, even if export growth is much more volatile than GDP growth. Following the strong correlation between GDP levels and trade volumes, economists have hypothesized a relation between polluting emissions of a Nation and its trade volumes; in other words, there are economic theories that consider International Trade partially responsible for the increase or the reduction of greenhouse gases emissions. It's important to notice that in these theories trade is considered as a proxy for the economic growth of a nation; the unit of measurement taken into consideration is the

[4] Information taken from German Advisory Council on Global Change (WBGU), *Solving the Climate Dilemma: the Budget Approach*, 2009.

GDP per capita. Actually, there are two main schools: one considers trade and emissions negatively correlated; after a certain turning point, the more a Nation become richer, the more the demand for air quality and environmental goods rises. Vice versa, a segment of literature judges Trade as one of the principal causes of the atmospheric pollution; open borders and free trade lead to augmented production and transport of goods , the main drivers of energy consumption and, consequentially, of polluting emissions. Scholars have studied this relation for decades, and even if they didn't arrive to any definitive conclusion, they gave a precious contribution to policy makers and to the doctrine, codifying a number of interesting theories. New findings emerge from the recent literature concerned about Intra-Industry Trade, the simultaneous import and export of goods within the same industry, assessing a possible positive impact on environmental quality.

European Union includes most of the countries that have undertaken great efforts in reducing national emissions of GHG. Several policies both at local and communitarian level (think about the European Emissions Trading Scheme) were put in action, and this is a result of great awareness of Environmental danger. Despite of that, few attempts were made to identify the relation between in the European scenario and the evolution of emissions. The aim of this paper is to investigate the relation between trade and emissions in the European market, focusing on the European Intra-Regional market. Particular attention is given to IIT, since it is a relative new subject of analysis.

The paper is structured as follows: Chapter 1 reviews at the surrounding literature and analyzes the more significant studies. Chapter 2 conducts the graphic and descriptive analysis of data to find empirical evidence for the hypothesis formulated. In Chapter 3, multivariable linear regressions are conducted to test rigorously the insights from the data analysis.

CHAPTER 1: THEORETICAL BACKGROUND

Theories investigating the relation between Trade/Economic Growth and environmental pollution take roots from the debate about Sustainable Development. Sustainable Development is an expression introduced by the document "*Our Common Future"* (1987), a Report from the United Nations World Commission on Environment and Development:

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs." *(Our Common Future*, UN 1987)

The report was released in 1987, and called "a global agenda for change" by the UN General Assembly, seeking to "Propose long-term environmental strategies for achieving sustainable development by the year 2000 and beyond." *(*UN, *Our Common Future,* 1987)

In those years, great importance was given to environmental issues and to the need of balancing the preservation of the natural capital with the development of welfare. The issue of sustainability was posed in terms of human utility; the aim was to guarantee to the future generations the same possibilities (of the present generations) of producing welfare using the total capital left: produced, natural, human and social. (Neumayer, 2007)

In particular, the question of Sustainable Development was posed in these terms: "Is it ethic and desirable to consume the natural capital now and leave the same value of capital in other forms or natural capital needs to be preserved?"

The debate was focused on two main schools of thought: Weak Sustainability and Strong Sustainability.

Weak Sustainability

The WS paradigm was effectively founded in the 1970s (there was no such sustainability terminology at the time) by extending the neoclassical theory of economic growth to account for non-renewable natural resources as a factor of production. (Neumayer, 2007)

It assumes complete substitutability between natural capital and produced capital; to ensure an infinite and constant (or even increasing) generation of utility, the income from the use of natural capital should be totally invested in other assets (produced capital). These assets could be used in the production functions at the place of natural endowments. A good example for that may be the usage of fossil fuels to improve industrialization processes and technological progress to achieve an adequate supply of renewable energy (wind, solar, etc.). This assumption is considered true if some conditions are satisfied. First of all, the elasticity of substitution between natural and produced capital should be greater than or equal to unity. Moreover, technological progress is required to ensure a constant increase of the productivity of produced capital, which could be, in its turn, non-renewable. If it holds, a long run model in which the natural resources stock falls to zero can be considered sustainable.

Strong Sustainability

According to the proponents of SS, natural capital is not substitutable by any other forms. Even if some of its secondary functions could be replaced (raw materials for production and direct consumption), its primary characteristic of providing the basic life-support functions on which human life depends cannot be in any way find elsewhere. In addition, there are absolutely no guarantees about the substitutability between natural and produced capital; proceeding in this way could expose to the risk of irreversible losses. Furthermore, there is little information about the effects from the loss of some natural cycles and equilibria. Consequently, this side of the discipline suggests to preserve a subset of total natural capital in physical terms, in order to maintain its functions and to behave ethically towards next generations. This subset is called Critical Capital.

This brief opening it is useful in understanding the idea beneath the theories that follows. The Environmental Kuznets Curve is generally viewed as optimistic, attributable to the WS philosophy. Does not matter if the economic growth initially damages the environment; the following development will be beneficial, even if some depleted resources could not be retrieved.

1.1: THE ENVIRONMENTAL KUZNETS CURVE

The Environmental Kuznets Curve (EKC) is the fundamental theory elaborated on the relation between trade and environment. Despite it has been formulated decades ago and it's subject to many critics, it has never been invalidated and continues to be the starting point for the studies in this sector.

The curve was first used by Simon Kuznets (Nobel Prize for Economy in 1971) to correlate income's inequality distribution with income per capita. His idea was the more the welfare increase, the less disparity in wealth there is among the population. Grossman and Krueger readapted the theory in 1991 drafting the report "*Environmental Impacts of a North American Free Trade Agreement",* aimed to verify possible environmental damages for Mexico as a consequence of the ratification of NAFTA. Their conclusions were that the agreement would have been beneficial even for the Mexican environmental situation, already uncertain. In 1992, the World's Bank popularized the EKC in its Report, giving large importance to the theory:

"The view that greater economic activity inevitably hurts the environment is based on static assumptions about technology, tastes and environmental investments. As incomes rise, the demand for improvements in environmental quality will increase, as will the resources available for investment" (World's Bank, *World Development Report*, 1992).

"..there is clear evidence that, although economic growth usually leads to environmental degradation in the early stages of the process, in the end the best – and probably the only – way to attain a decent environment in most countries is to become rich". (Beckerman 1992)

As explained before, this theory considers trade as a driver of economic growth, so the analysis is focused on the welfare of a Nation measured in Gross Domestic Product per capita.

1.1.1: General Formulation

The EKC puts into relation environmental indicators related to a form of environmental degradation with a measure of welfare and other different factors. Its basic formulation is the following:

$$E_{it} = \alpha + \beta_i F_i \ + \delta Y_{it} + \phi (Y_{it})^2 + k_t + \varepsilon_{it}$$ (Neumayer, 2008)

E is the environmental indicator, which could refer to different types of pollution and different measures (ex: per capita form or by concentrations).

Y denotes per capita income.

F represents country-specific effects; *k* refers to years specific dummies.

Finally, *i* and *t* refer to country and year; ε is the error term.

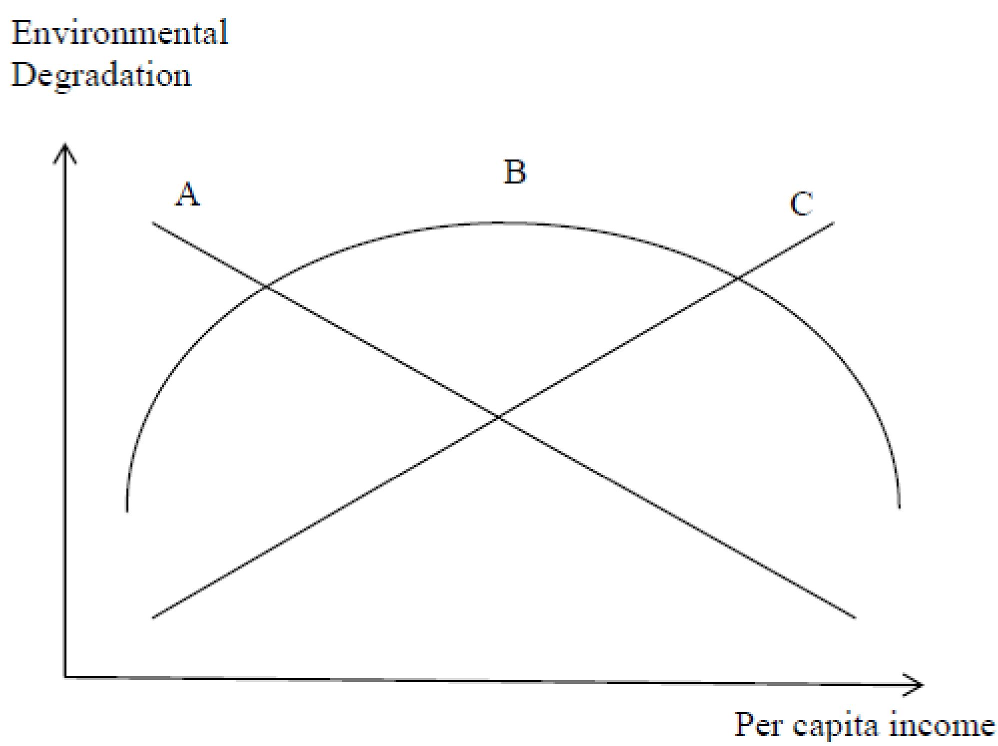


Figure 1: Environmental Kuznets Curve

The estimation of the parameters φ and δ leads typically to three different patterns:

In pattern A δ is negative and statistically significant but φ is statistically insignificant. Then we get a linear path in which environmental degradation diminishes while the income per capita rises. This could mean that economic development brings positive effects such as access to clean water and adequate sanitation.

Pattern C shows δ positive and statistically significant but φ statistically insignificant. Degradation increases unambiguously with the economic growth. For example, this pattern reflects the increase in CO_2 emissions due to economic activities.

Finally, in the third scenario (B) δ is positive and statistically significant and φ is negative and statistically significant. First emissions rise following the economic development; then after a certain point, they start to decline while income per capita is still increasing. The third pattern is the most commonly encountered in the academic studies; the main implication is that there is a "turning point", a certain level of income, at which something changes in the social and economic structure of the nation and, due to different policies or citizens' preferences, environmental pollution starts declining.

In order to understand better these findings, is useful to have a deeper look to the determinants of the EKC formula.

Dependent Variables

The dependent variable is generally named "Environmental degradation" or "pollution" or similar, and it refers to some indicators of the quality of the environment.

"Environmental quality has many dimensions. Our lives are affected by the air we breathe, the water we drink, the beauty we observe in nature, and the diversity of species with which we come into contact. The productivity of our resources in producing goods and services is influenced by climate, rainfall, and the nutrients in the soil". (Grossman, 1995)

These and more natural elements may respond to economic growth in different ways, therefore should be used in a study about environment and growth as comprehensive as possible. Unfortunately, available data are often too scarce or too difficult to compare in order to permit a wide scope for such papers.

It follows that the majority of studies focus their analysis on a limited number of indicators, mostly grouped and elaborated by International organisms monitoring environmental conditions (US EPA, World Health Organization, European Environment Agency, etc.). Typically, these are numeric indicators regarding the concentration of dangerous materials in the air or water. Here some examples.

Air Pollutants is the broader category of indicators; it comprises among all Carbon Dioxide (CO_2), Nitrogen Oxides (NO_x), Sulphur Dioxide (SO2), Carbon Monoxide (CO), Suspended particulate matter (SPM) and Volatile Compounds (VOC).

Water quality is measured using the concentration of Phosphorus and Biological Oxygen Demand (BOD): an indirect measure of the amount of organic material present in a sample of water.

Other indicators could be Deforestation rate (Copper and Griffiths, 1994), Lack of clean water, Lack of urban sanitation and Municipal waste per capita (Shafik, 1994)

Independent Variables

As said, the counterpart of environmental degradation is income per capita. Usually is presented in the equation in the first-degree form (Y) and in the quadratic form (Y^2), reflecting two different stages of the economic growth: low income and middle-high income. Two different parameters are estimated. Nevertheless, to isolate properly the effect of income on environment it is necessary to add some more variables, qualitative, quantitative or dummies, which account for other correlated relations. The mainly used are Population size, the higher is the population, the higher the emissions; Manufacturing share in the economy, since an economy strongly oriented towards manufacturing industries is likely to have a worse environmental quality. Trade intensity is also commonly used, usually with a positive correlation with GDP. Energy prices and other local socio-economical information complete the data needed for a punctual analysis.

1.1.2: The Relation

According to the theoretical formulation, environmental degradation is foreseen to increase when the income starts to rise and then to fall at medium-high level of welfare.

The theory gives an explanation: at the first steps of economic growth, people (and governments) invest in sectors and activities that could return benefits in the short period, without caring about the environmental sustainability. A nation's economy could shift from subsistence-based to industrialization in relatively few years, damaging its natural assets.

When citizens reach a sufficient level of wealth, their attention is directed towards the environment quality. Demand for less polluted air rises, as well as public awareness and responsibility of the shared ecosystem. Following this trend, policy-makers are subject to pressures for "greener" laws; consumers shift their preferences towards products respectful of the environment; technological investments are made into cleaner technologies and procedures. Looking deeper into these mechanisms, Grossman and Krueger (1995) divided the influence of the economic growth on environmental quality into three effects: scale, composition and technique

The scale effect is simply the dimension of the economy taken in exam. Can be measured as unity of output produced or value added, and it's positively correlated with Pollution: *ceteris paribus*, when the size of an economy (meant as set of productive activities) increases, the emissions and the pollution it produces increase as well.

Composition effect can be ambiguous. Literally, it indicates the shift of production activities from a high polluting mix (let's say heavy industrialized economy) to more environmental friendly composition (third sector); but the trend could also go in the opposite direction.

Technique dimension analyzes the emissions intensities of the various industries, and refers to a general decrease of pollution intensity of the inputs (pollution per unity of input). It is made possible by new technologies that allow to use less polluting outputs as productive factors and to reduce the quantity of output necessary for the production of a unity of input, as well by more stringent environmental policies which bound pollution producers.

Arik Levinson (2009) analyzed the US manufacturing in order to correlate two opposite events: the decline of air pollution from US manufacturers of 60% during the period 1970 and 2002 and the increase in real value of manufacturing output by more than 80 percent. His findings show that although the composition effect is relevant, is the technological progress the major responsible for the decline in pollution. Such result is impossible to reach without technic and economic development, which gives strength to the Environmental Kuznets Curve theory.

1.1.3: Empirical Evidence

Although the theoretical formulation of the EKC appears to work pretty well, the same cannot be said for the empirical results. A waste number of studies have been conducted to test the theory, but the empirical evidence resulted to be ambiguous and in some cases denying the existence of such growth-environment relation as described by EKC. Empirical literature is huge and so it is possible to survey only a small fraction of results; the focus is on the studies that gave internationally recognized contribution.

Grossman and Krueger (1991) produced the first EKC study; their environmental indicators were SO_2, dark matter (fine smoke), and suspended particles (SPM). Data were collected by the GEMS dataset, a panel of ambient measurements from a number of locations in cities around the world.

The estimations involved a cubic function in levels of per capita GDP and various site-related variables, a time trend, and a trade intensity variable. Of course, they find statistical evidence of EKC relation for these environmental indicators. In addition, Grossman and Krueger estimated the turning point (the income level at which emissions start declining) for SO2 and dark matter, which appear to be at around $4,000-5,000 while the concentration of suspended particles was forecasted to decline even at lower income levels.

A study that was particularly influential was the one of Shafik (1994). It contains the estimation of ten different indicators using three different functional forms (log linear, quadratic, and cubic). The results he obtained are variegate and not always in line with the EKC.

“The results indicate that access to clean water and urban sanitation are indicators that clearly improve with higher per capita incomes. The addition of the quadratic or cubic terms does not add considerable explanatory power to either the water or sanitation regressions. The time trend is significantly negative in all the regressions, implying that, at any given income level, more people have access to water and sanitation services than in the past” (Shafik, 1994).

In addition, deforestation doesn’t show any correlation with income, but these results could be biased by data gaps. Some indicators of poor environmental quality seems to be positive correlated with income. River quality tended to worsen with increasing income, and both municipal waste and carbon dioxide emissions per capita increased unambiguously with rising income. Nevertheless, the Suspended Particulate Matter (SPM) and the Sulphur Dioxide (SO_2) indicators follow a U-shaped trend. Since they are mostly the result of energy production and consumption, their concentration gets worse in the first stages as countries become more energy intensive, and then improves. This trend is attributable to technological progress.

Harbaugh and Levinson (2001) sought to reexamine the empirical evidence from the data analyzed by the World Bank in 1992 and by Grossman and Krueger in 1995. In particular, Grossman and Krueger estimated three air pollution indicators (SO_2, smoke and heavy particles) and three water pollution indicators (state of the oxygen, pathogenic contamination and heavy metals concentration); data where taken by the GEMS database for a sample of several cities from 19 countries and 287 river stations in 58 countries. The reference period is 1979-1990. Their finding display a strong U-inverse shaped relation between environmental indicators and lagged income terms (first level and quadratic) jointly with high statistical relevance. Grossman also estimated the turning points for the indicators, placing them below $10.000. In the Levinson study, the initial results of Grossman are revised and modified using a retrospective data cleaning and observations covering ten additional years. The authors focus on the air pollution indicators, for which the most complete data are available. In addition, they introduce new econometric variables describing political structure, investment, trade, population density and the location from which are taken the observations. Their conclusions are very different from the previous study:

"…the evidence for an inverted-U is much less robust than previously thought. We find that the locations of the turning points, as well as their very existence, are sensitive both to slight variations in the data and to reasonable permutations of the econometric specification. Merely cleaning up the data, or including newly available observations, makes the inverse-U shape disappearing. Furthermore, econometric specifications that extend the lag structure of GDP per capita as a dependent variable, include additional country-specific covariates, or include country-level fixed effects, generate predicted pollution-income relationships with very different shapes." (Harbaugh and Levinson, *Reexamining the Empirical Evidence for an Environmental Kuznets Curve*, 2001)

The successive studies have underlined a persistent path in the literature; an EKC exists for pollutants with semi-local and medium term impacts, but for other indicators (CO_2 emissions, waste and biodiversity loss) no turning point is confirmed. (Shafik, 1994; Arrow et al., 1995; Cole et al., 1997)

Many explanations have been given, some pointing out that economy is evolving, and with it also the mix of effluent it produces; other argue that the formulation of EKC as introduced in 1991 is, in the best cases, incomplete and modifications could either confirm or negate the theory. In general, many authors have criticized the EKC theory, but despite the successive contributions, the literature did not approach to a definitive formulation.

1.1.4: Criticism

In this section the main critics to the EKC will be briefly reviewed. It is important to take in mind that here are showed the contributions aimed to improve and to obtain more reliable results. The theories that contrast the EKC will be illustrated in the next chapter.

Econometric problems

As pointed out by Stern (2014), the equation is too simple and probably there are other omitted variables important in explaining the level of emissions. The previous mentioned study of Harbaugh and Levinson (2001), already noticed how values of the turning points for the various pollutants, as well as even their existence, were sensitive both to variations in the data sample and to reasonable changes in the econometric specification. The heavy dependence of the results on the sample choice has been noticed by other authors.

"Stern and Common (2001) pointed out that estimates of the EKC for Sulphur emissions are very sensitive to the choice of sample used in the analysis. In particular, they found that SO2 emissions per capita were a monotonic function of income per capita when they used a global sample and an inverted U-shape function of income in a sample of OECD countries only" (Halkos, 2015). Their conclusion is that no out-of-sample predictions are possible for such estimation results.

If the environmental indicator and GDP per capita are both trending over time (in technical terms: are non-stationary), then spurious regression results are possible, thus invalidating the reliability of data. (Stern, 2014; Neumayer 2008)

Some studies identify the inappropriateness of the EKC in describing the growth-environment relation with the very static nature of the model. They argued that by introducing dynamic elements, the resulting findings can fit better the data. (Halkos, 2015)

Another issue identified in some papers is the pertinence of the indicators and of the variables taken in exam. The first example is the skewed income**.** Some studies show that a number of indicators reach their turning point at the actual levels of mean income per capita; it follows that environmental degradation should have started to decline. However, income is not normally distributed but very skewed, with much larger numbers of people below mean income per capita than above it. This does not compromise the validity of the theory, but indicates that its results should be taken as indicative, the contrary of the initial interpretation.

Moreover, environmental indicators could be inappropriate often the choice of indicator such as concentration of specific elements in air or water is very limiting the reliability of results. Is it possible that those indicators, which refer to local situations and are very important to human health such as Sulphur dioxide and Particulates, are not easily externalized and tend to improve at low levels of income. Other indicators that are global public goods, quite easy to externalize such as CO_2 emissions, therefore worsen with economic growth *(*Shafik, 1994). The authors suggest drawing the attention on global indicators, in order to avoid bias related to the location of the observations and to produce results wide applicable. In particular, CO_2 emissions seem to be linked with income per capita by a positive monotonic function. (Holtz-Eakin and Selden, 1995)

Due to technological progress, new production processes are producing new forms of pollution, and this trend is parallel to economic growth. New toxics can be released, new indicators must be drawn. “The mix of effluent has shifted from sulfur and nitrogen oxides to carbon dioxide and solid waste so that aggregate waste is still high and per capita waste may not have declined.” (Stern, *The Environmental Kuznets Curve: A Primer*, 2014)

Regarding econometric technical issues, probably the main bias is the absence of a country and time fixed effect estimation; it has been noticed that not all the studies concerned about countries and time fixed effect, in particular the early ones.

“Country fixed effects are required if per capita GDP or some other explanatory variables are correlated with country-specific time-invariant factors, such as geographical factors (climate, land size and resource endowments), or institutional quality. Year-specific time effects are required if there are global changes in environmental quality, perhaps due to global advances in technology, that have a roughly equal impact on countries at any given point of time.” (Neumayer, *The Environmental Kuznets Curve*, 2008)

Even controlling for time and country effect, results are once again ambiguous; Wagner (2008), Vollebergh (2009) *et al.* find very large negative time effects for sulfur and smaller negative time effects for carbon since the mid-1970s. Other studies show positive time effect for carbon.

Many studies tried to overcome the apparent weakness of basic EKC by adding additional explanatory variables intended to model underlying or proximate factors. Examples of these variables are “Openness to International Trade” (Cole, 2004), “political freedom, democracy, income inequality and education levels” (Torras and Boyce, 1998), structure of GDP (Panayotou, 1993; Cole, 2004) and others. The related findings are very interesting, but too weak to be path-breaking. Cole found significant results that confirm the role played by GDP composition. Share of manufacturing in the GDP is positive related with emissions for a large sample of observations. Torras and Boyce found that more equitable power distribution tends to result in better environmental quality and Neumayer

(2002) showed that democracies exhibit stronger international environmental commitment than non-democracies, but there is no evidence of a direct link between democracy and environmental quality. However, testing different variables individually is subject to the problem of potential omitted variables bias and do not appear to be robust conclusions that can be drawn. In addition, the findings about political freedoms and power distribution appear to be only policy relevant, since they are related with local environmental measures.

Finally, some studies argued that emissions path can be influenced by governments themselves. Under-pricing of natural resources or subsidies to polluting industries can be destructive in terms of both economic efficiency and environmental perspectives (Halkos 2015). On the other side, governments can improve their EKC (making it flatter) reinforcing the establishment of property rights over natural assets, correcting market failures and in general "…internalize environmental externalities to the sources that generate them by enforcing stricter environmental regulations." (Panayotou, 1993)

To conclude this section, is evident that the statistical analysis on which the environmental Kuznets curve is based is not robust. There is little evidence for a common inverted U-shaped pathway that countries follow as their income rises. Such relation has been found for some pollutants and in some locations (samples) but doesn't hold in more complex contest. However, it is a fact that, at least in slow-growing economies, emissions are reducing through the efforts of technical progress and environmental regulations. Thus, it's reasonable to expect new studies employing more sophisticated econometrics analysis that could furnish strong evidence to this theory.

Future Forecasting: LCDs

One of the key issues that EKC has raised is whether the same pattern of growth versus environmental impact can be replicated by the now poor countries in the future. Most of the studies have focused their analysis on OECD countries, principally due to the greater availability of data. Since the model claims to give future predictions about levels of pollution (think about the turning points), it follows that the same models should be applied to predict the path of Least Developed Countries. Unfortunately, this transposition is not so easy.

Cole and Neumayer (2008) examined the implication of the EKC for pollution trends in LCDs. First they forecast the future levels of income per capita in Purchase Power Parity for Developing Countries. In doing so, they use the growth rates estimated by the US Energy Information Administration (EIA), which provides forecasts of economic growth up to year 2020. The authors extended those previsions to the year 2100 using the growth rates for the years 2015 to 2020. Secondly, they compare the obtained levels of GDP per capita with the table of turning points (peak points) for a number of pollutants obtained by the studies of Shafik (1994), Grossman and Krueger (1995), Cole et al. (1997) and others. The aim is to extrapolate approximately the year in which the environmental situation will start to improve for the countries in analysis.

Results show three distinct groups of categories:

Africa and India: Africa is the region for which this study provides least hope in the future. Pollution is predicted to rise for the most part of this century and frequently beyond the year 2100 India shows almost the same situation, with pollution predicted to decline only from the year 2030.

Central and South America, China, Eastern Europe and the Former Soviet Union (FSU) as well as the Middle East: Even though this group has higher initial income levels and partly higher predicted growth rates than Africa and India, often pollution is still forecast to deteriorate for many years to come.

Mexico and South Korea: As a part of OECD, these two countries have initial income levels high enough to foresee a fall in the pollution in a short period. Only emissions of a few pollutants are predicted to continue increasing beyond 2020.

To explain these results Cole and Neumayer, claim that the developing countries would follow a different path than the developed one. Even if advanced technologies are at their disposal and could facilitate the transition towards a cleaner economy, several authors believe that LCDs will be strongly influenced by some International phenomena, linked to the openness towards International Trade. Is the case of their role as exporter of “dirty products” and the supposed international competition on environmental regulations, the so called “race to the bottom”. More space to these arguments will be given in the next paragraphs.

1.2: THE ROLE OF INTERNATIONAL TRADE

As already said, International trade is one of the main drivers of the economic growth for a country; thus, when analyzing the environmental impact of economic growth it is not possible to ignore the trade effects

Most of the literature concerning the trade-environment relation focuses on the global inter-industry trade, following the well-known Heckscher-Ohlin and Ricardian models.

According to the models, two countries engage in trade if they have a comparative advantage in different industries, producing goods in a more efficient way, or if a country is well-endowed of a factor of production that is intensively used in a specific industry (ex: labor).

In both cases, each country specializes in the industry of which it can produce more or at lower costs. Thanks to trade, both countries can export their products and purchase the other goods they need.

Applying this model to reality, it follows that countries engaging in international trade tend to specialize in specific industries, exporting products they have an advantage in producing and importing the others; thus the trade flows configures as inter-industry, i.e. trade among different industries according to countries industry's composition. International trade is beneficial for all countries involved: a greater quantity of goods is produces at a reduced price, leading to surplus for consumers and producers.

The impact of this trade framework can be divided into three effects, the same for economic growth: scale, composition and technique. (Antweiler, Copeland, Taylor, *Is trade Good or Bad for the Environment?* 2001)

The scale, or size, is negatively related with environmental quality. The increased quantity inevitably leads to an increase in polluting emissions, impairing the environment together with transport pollution. This negative effect is counter balanced by technique. The increase in income and the following demand for better environmental quality foster technological progress and the adoption of greener technologies. In addition, environmental policies are formulated and set environmental standards firms shall respect (Copeland and Taylor, 2004). Some studies have also hypothesized that when multinational firms export or set Direct Investments in foreign countries, they also contribute to spread better technologies and pollution standards.

The composition effect deserves a more complex analysis, since its consequences on the environment are ambiguous. On one side, following consumers' preferences, trade can satisfy the demand for "clean" products by domestic customers when domestic firms are not able to. Reallocation of production can also lead to a diminishment of emissions; Grether and Mathys suggest that the (temporal) reallocation of production brought by has led to a small reduction (around 2–3%) rather than to an increase in SO_2 emissions at the world level (Grether and Mathys, 2009). On the other side, domestic firms can easily relocate their production in countries with less stringent regulations, or alter trade flows generating "dirty" imports.

Antweiler, Copeland and Taylor (2001) provide the first rigorous analysis of the trade-induced composition effect. Their model identifies two opposite forces determining the overall effect: the relative factor endowments (Capital and Labor Effect, KLE) and differences in pollution policies (Environmental Regulation Effect, ERE), which are determined by differences income per capita; both contribute to build the trade comparative advantage for a country. (Antweiler, Copeland, Taylor, *Is trade Good or Bad for the Environment?* The American Economic Review, Vol. 91, No. 2001)

The relative factor endowment is considered as the Capital to Labor ratio (K/L), the physical stock of capital per worker. According to the comparative advantage theory, if a country is capital abundant and engages in International Trade, will be incentivized to produce more capital abundant goods and to specialize. Given that capital abundant goods are the most polluting, an increase in trade openness for that country will increase its emissions, thus worsening its environmental quality. Vice versa, if a country is labor abundant, will specialize in "clean" products improving its situation. The second force in the field is the stringency of environmental policies. High income countries usually generate high demand for environmental quality, thus adopting stricter policies; consequently they tend to specialize in less polluting goods due to the political bounds. On the other side, low income countries (with lax regulations) find to have a comparative advantage in polluting products, based on differences in regulations. Increasing trade openness leads to specialization in polluting industries, worsening their environment.

The ambiguity of these considerations is given by simple evidence: usually, a high income country is also capital abundant, and a low income level country is typically labor abundant. Thus it originates the contrasting nature of composition effect; its impact on environmental quality is determined by country's specific characteristics.

1.2.1: Empirical evidence

Antweiler conducts an empirical analysis on SO_2 concentrations in 44 countries, willing to estimate the magnitude of trade impact. Using a log-linear methodology, the pollutant concentrations are regress to scale effect measured as GDP/km^2, technique effect represented by income per capita I and factor endowment indicated by K/L. In addition, a series of interaction terms between Trade Openness (exports plus imports on GDP) and the aforementioned effects, isolate the trade-induced impact on the environment. The regression equation is completed by a set of dummy variables on the observation-sites and countries' characteristics. Results are in line with the theoretical model they drawn: the increase in output and income induced by trade will result in a net reduction of emissions. The magnitude and the sign of separated effects will depend on country's attributes.

After this paper that posed the basis for the empirical analysis of the trade-environment topic, various authors conducted additional research, trying to better assess the impact of trade on the environment and strength the theory. Cole and Elliot (2003) enlarged the pollutants involved in the analysis, adding Nitrogen Oxides (NO_x) Biochemical Oxygen Demand (BOD) a measure of water pollution and Carbon Dioxide (CO_2). Their findings about CO_2 and SO_2 are in line with the theory, but the other two pollutants show different results. The authors' conclusion is that results are heavily influenced by the nature of pollutants (measurement techniques, regulation, local versus transboundary etc.). This is particularly true for Carbon Dioxide, which is a transboundary pollutant and reflects not only the production emissions but also relative to consumption and transport.

Other authors differentiated the approach, considering the endogeneity of regression terms (Frankel and Rose, 2003; Managi, Tsurumi, Hibiki, 2010) through the adoption of Instrumental Variables or Generalized Method of Moments. They always finding support for the theory; in some papers is highlighted a difference in response between OECD and not OECD countries, suggesting that at least in some periods and for some pollutants, the Environmental Regulation Effect has prevailed in not OECDs, shifting the polluting production in such countries and worsening their environmental quality.

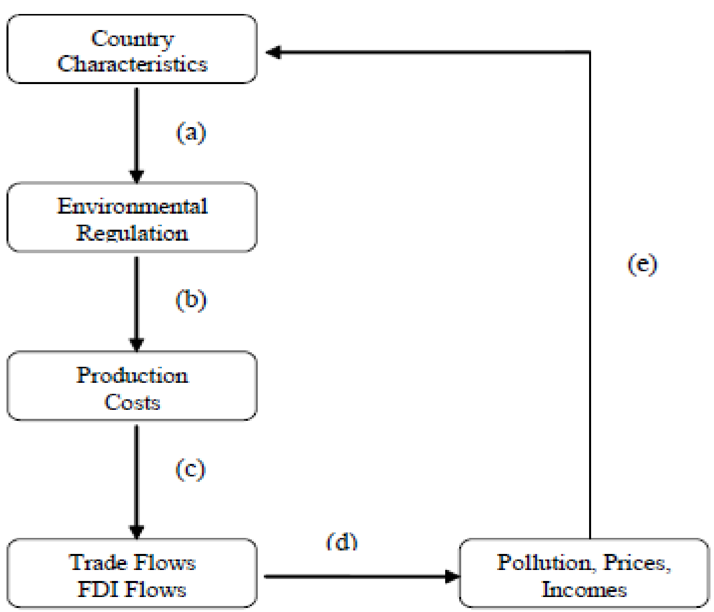
This effect of trade is called the Pollution Heaven Hypothesis, and in the literature is the main counter-argument to the optimistic theory regarding economic growth being beneficial for the Environment.

1.3: THE POLLUTION HEAVEN HYPOTHESIS

In the early 90's, the North America Free Trade Agreement posed firms in US and Canada (rich and regulated countries) and firms in Mexico (poorer and laxly regulated) in competition for the North American market. Protests against the agreement claimed that the result shift of production and firms from US to Mexico would result in an environmental disaster for Mexican citizens and in an employment disaster for America. Since then, the debate continued focusing on the Environmental consequences of the effect of trade liberalization among countries with different environmental policies.

The general idea is that differences in environmental regulations would shift the production of dirty products regulated in rich countries towards the lower income countries, which are supposed to have laxer environmental policies. Scholars denominated this concept "Pollution Heaven Hypothesis"; they attribute to it much importance because, if it holds, environmental regulations could have different effects from the desired one, and lead to potential disaster for less developed countries.

Taylor (2005) produced a simple scheme to understand the mechanisms of the PHH



Source: M. Scott Taylor, *Unbundling the Pollution Haven Hypothesis*, University of Calgary, 2005

The explanation is very clear: considering its own characteristics (income per capita, factor endowments, citizens' preferences, etc.) a nation promulgates environmental regulations that set environmental standards. Complying with those standards is costly, thus abatement costs are generated, affecting country's firms' productivity and competitiveness. It follows that with increased trade openness, domestic consumers will prefer foreign products less costly due to less abatement costs and/or domestic firms will have the incentive to relocate in different countries with laxer regulations.

Literature has produced many papers, but despite that, the debate is very far from being conclusive. The empirical evidence founded is not strong enough to sustain the theory; although recent papers have posed significant and interesting questions. Note that the literature analyzes cases in which differences in regulations arise due to differences in income, culture or strength of institutions. Studies have not found yet evidence for a sort of "strategic behavior" of governments, aimed to attract foreign polluting firms. This phenomenon is called "race to bottom" and consists in government that, in order to incentivize polluting firms in investing in their own country, lower the environmental regulations. To avoid the relocation of their firms, foreign governments respond lowering as well their policies, creating a loop effect that brings as only consequence worldwide environmental deterioration. The "race to the bottom" effect was postulated in the past decades, but fortunately has never been proven. As shown in next paragraphs, relocation decisions of firms are based on other factors than abatement costs.

First, is useful to mention the distinction between two different aspects of the PHH, the Pollution Heaven Effect and the Pollution Heaven Hypothesis.

1.3.1: The Pollution Heaven Effect

The Pollution Heaven Effect is the immediate consequence of differences in environmental regulations among countries that trade: domestic production of polluting goods decreases and imports of such products from foreign trade patterns increase. In literature is analyzed as the effect of tightened regulation in one country holding trade openness as given. Ceteris paribus, if a country adopts stringent rules, exports of polluting goods are expected to decrease, in favor of foreign imports; thus, the competitiveness of domestic firms decreases.

Mixed evidence for this effect is found by the studies, which demonstrates that in developed countries the share of “dirty” manufacturing products has diminished and has been partially replaced by imports from foreign countries; however, such shift often is not sufficient to account for the overall decrease or is influenced by other factors.

Levinson and Ederington (2004) analyzed the shift towards green sector in the US manufacturing compare to the composition of imports, to search if the polluting goods not produced domestically anymore where replaced by foreign imports. Their findings are striking: there is evidence that imports contain a considerably share of polluting products, but such share is decreasing faster than the share of dirty domestic production; furthermore, the authors find that the share of pollution in US export decreased too, but at lower rates. Their conclusion is that the polluting industries are less sensitive to tariff reductions that have interested United States in past years; thus the Pollution Heaven Effect was not exacerbated. “In fact, the opposite is more likely to be true: if anything, trade liberalization has shifted U.S. industrial composition toward dirtier industries, by increasing imports of polluting goods by less than clean goods”, proving the existence of comparative advantage of United States in polluting, capital intensive goods. (Ederington J., Levinson A., Minier J., *Trade Liberalization and Pollution Havens,* 2004)

These results are shared by Cole (2004) who analyzed the trade trends between four pairs of countries (USA-Asia, USA-Latin America, UK-Asia, Japan-Asia). Cole did not find comprehensive support for the PHH from the movements of dirty imports respect to clean exports; although net Exports as a Proportion of Consumption do behave in a PHH consistent manner throughout the period for certain sectors in certain trade-pairs (Cole A. Matthew, *Trade, the pollution haven hypothesis and the environmental Kuznets curve: examining the linkages*, 2004). From the regression analysis emerges that trade flows in polluting intensive imports and exports appear to partially explain the environmental indicators; these effects are not found for all pollutants, and their significance appears to be limited.

Finally, analyzing the impact of the adoption of U.S. Environmental Protection Agency's Toxics Release Inventory (TRI) program, Tang (2015) finds support for the Pollution Heaven Effect. He demonstrates that the more stringent US regulation is associated with a shift of involved chemicals toward trade partners with lower per capita incomes. His findings could claim that for certain industries and under certain assumptions, the Pollution Heaven Effect exists.

1.3.2: The Pollution Heaven Hypothesis

The second aspect of the PHH is whether the differences in environmental regulations are capable to determine the pattern of trade or investments, i.e. if a reduction in trade barriers will shift the polluting industries in less regulated countries. While for the PHH effect some evidence was found, the empirical support for the Pollution Heaven Hypothesis is very weak. "Trade theory suggests that other haven hypothesis is, in contrast, quite weak, because many other factors, in addition to pollution regulation, affect trade flows. If these other factors are sufficiently strong, then it is quite possible for there to exist a pollution haven effect, but have the pollution haven hypothesis fail " (Copeland and Taylor, *Trade, Growth and the Environment,* 2004).

A branch of the literature investigated if differences in regulations could influence the set-up of Foreign Direct Investments; again, no evidence was founded. Eskeland and Harrison (1997) analyzed the pattern of foreign investments in developing countries, not finding proofs that investors were concentrating in dirty sectors, In addition, they demonstrated that using energy consumption as a proxy for pollution, foreign firms pollute less than their peers in developing countries do.

Their conclusions are that the pattern of trade and investments are not driven by differences in regulations; abatement costs represent only a small fraction of the total costs of a firm. Following the profit maximizing philosophy, firms decide to locate where they can have access to infrastructures, subsidies and where production costs are lower.

Difficulties

Before moving to the next argument, it’s important to note that studies willing to uncover the existence of pollution heavens must face many obstacles. First, differences in environmental regulations are difficult to measures, since governments could use a wide variety of instruments and they could not be comparable. Good proxies are Environmental Taxes, but not all governments adopted them.

Second, data on pollution are very scarce. It is not obvious that governments conduct monitoring and control projects; their willingness depends by the concern of the country's public opinion and by the expected political return. It is therefore plausible to expect rich information from high-income countries (according to the theory) and a poor collection of data from developing countries. This is a big concern for scholars, because they are missing information from the countries that most should provide evidence for the Hypothesis. They try to overcome the issue using energy consumption as a proxy for pollution emitted; however, this methodology is not flawless. It follows that the majority of studies relies on databases coming mostly from developed countries, first of all United States. Thus, it may represent a big bias for results.

To conclude this section, it is useful to remark that even if the literature has sometimes found evidence for a decrease in pollution due to temporary shifts in trade patterns, is not enough to conclude that the Pollution Heaven Hypothesis holds. Unfortunately, it cannot be rejected, since results from studies could have been affected by variables bias or data gaps.

1.4: NEW PATTERNS OF TRADE: INTRA-INDUSTRY TRADE

As seen in previous sections, impact of Inter-Industry trade on Environment is surprisingly considered positive, although some evidence detects a negative consequence of trade; certain countries could find a comparative advantage in polluting goods and exploit it. Although the Ricardian and Heckscher-Ohlin paradigm is well-established, it is not able to explain a relatively recent tendency within international trade i.e. the simultaneous export and import between countries in the same industry, the so called Intra-Industry Trade (IIT). According to Brülhart the 27 percent of the world trade was in the form of IIT. The concerning literature is still small, but it has already produced interesting findings and studies.

Brülhart conducted a very accurate study on the characteristics and the evolution of Intra-Industry Trade in the world, dividing the observation in two samples: one formed by developed countries and the other comprising all countries (Brülhart, *An account of global intra-industry trade, 1962–2006*, 2008). He founded a secular increasing path of IIT, which accelerated from the middle 80's and interested almost all the countries taken in exam. The percentage of IIT is highest in high-income countries, while is virtually not-existing in low income nations. It appears to be related to the total trade size and to the level of income per capita. The decomposition by sector shows that the IIT share globally is higher in "Machines & Transport Equipment" and "Chemicals", followed by "Manufactures". The smaller portion is recorded in "Crude materials" and "Fuels". The most relevant results come from the disaggregation of the products traded by the stage (primary, intermediate and final). It's evident that *intermediate goods* are the most traded within the same industry, a trend that has become sharper from 1975. The author supposes that this result is due to world-wide phenomena of processing trade in vertically fragmented industries. The hypothesis is strengthened by a different empirical finding: at a deeper level of analysis (5-digit), IIT among lower and middle countries has grown more rapidly than the others since around 1980.

Brülhart concludes remarking that the process of global increasing in IIT indicates a gradual convergence of world economies, since IIT is more recurring among similar countries in sector composition.

IIT is measured worldwide using the Grubel-Lloyd index, introduced by Herb Grubel and Peter Lloyd in 1971.

$$GL_i = \frac{(X_i + M_i) - |X_i - M_i|}{X_i + M_i} = 1 - \frac{|X_i - M_i|}{X_i + M_i}$$

where X_i denotes the export, M_i the import of good *i*

It compares total trade of product *i* and the difference between export and import of the same product; it assumes values between 0 and 1. The value is 0 when exports (imports) are much larger than imports, so the country is engaged in inter-industry trade of product *i*. When is 1, export and import balance each other, thus the trade is within the same industry.

Since "old trade theories" were not able to explain such phenomena, Paul Krugman in 1979 formulated a "new trade theory", introducing in the model the economies of scale and product differentiation. The relation between the existence of economies of scale and the Intra-Industry-trade among countries is complex and not easy to explain; here the attempt is to clarify it in few words.

Consider two countries which have the same characteristics: firms benefits from economies of scale with increasing returns (constant marginal costs and decreasing average costs), the economies produces a large variety of goods *n* so that each firm specializes in just one different product. Since all goods enter symmetrically in the utility functions of consumers, and the product variety is large enough, each firm's pricing policy will have a negligible effect on the marginal utility of income. Given these conditions, each firm behaves like a monopolistic competitor. In equilibrium, under the full employment assumption, firms gain zero profit, and the real price *p/w* and product variety *n* are functions of the total number of consumers *L*. Now, following the neoclassical trade theories, these two countries would have no incentive to trade, since they are not different in labor productivity or factor endowment. Instead, following Krugman, they can both gain if they engage in trade. According to the model, assuming identical tastes and no trade costs, a trade opening would have the same effect of an increase in the labor force as well as consumers number L. This leads to a decrease of real price and individual consumption of each good *i*, but the total variety of goods *n* increases as well as the output of each good. Since all goods will have the same price, expenditures on each country's goods will be proportional to the country's labor force L (number of consumers)

$$M = wL \cdot L^*/(L+L^*)$$
$$= wL^* \cdot L/(L+L^*)$$ where "*" identifies foreign elements
$$= M^*$$

It is demonstrated that both firms and consumers are better off with trade; consumers enjoy the increased real wage *p/w* and the new enlarged variety of products *n+n**, while firms increase their productions. Thus, this explains the Intra-Industry Trade: countries that are similar regarding the economic size, sectoral composition and consumers preferences produce different varieties of can engage in trade, within the same industry still obtaining benefits for producers and consumers.

Successive works added elements to the new theory; in particular, Anderson and van Wincoop (2004) challenged international trade economists to lend much more consideration to the importance of "trade costs" in influencing the pattern of international trade. Jeffrey H. Bergstrand and Peter Egger resumed their work, and demonstrated the impact of transportation costs on the Intra-Industry Trade. Their analysis focused on a sample of OECD countries and their share on IIT, showing that "the level of trade costs should negatively impact the share of intra-industry trade" (Bergstrand and Egger, *Trade Costs and Intra-Industry Trade,* 2006).

Brülhart and others have claimed that the correlation between IIT and economies of scale should not be taken for granted. These authors suggest that the Krugman's theory of infinitely decreasing average costs give birth to a temporarily IIT increase, but in the long run leads to its elimination in favor of industrial specialization. "The reduction of distance costs sharpens the competitive advantage of the bigger incumbents. Since the bigger firms are the ones with the larger home market, the NTT (New Trade Theory) suggests integration leads to a concentration of industrial activity in those countries that had previously offered the largest markets for a particular range of products. If, however, there are rigidities which slow down the re-location of industrial activity in an integrating area, then integration leads to an initial surge of IIT." (Brülhart, 1995)

1.4.1: Determinants of IIT

Other studies have analyzed the determinants of IIT; the main of them are GDP per capita, difference in consumers' preferences, size, and distance. GDP is by far the most important determinant of IIT index. Its influence is specified in several ways; GDP, GDP per capita, joint income of trading countries are usually associated with high levels of IIT among countries. Instead, differences in income levels are correlated with lower IIT (Brülhart, 2006; Kang, 2010).

Distance is also very influential in determining the degree of IIT, since it is generally used as a proxy for trade costs. It may be distorting identifying overall trade costs with the narrower definition of transport costs, but as pointed out by Anderson and Van Wincoop (2004) the measurement of such trade costs is extremely difficult; so that the transport costs are the best approximation. Studies' results show a negative relation between such costs and IIT (Bergstrand and Egger, 2006), but it appears the coefficient of distance have been gradually shrunk in absolute magnitude during time. A possible explanation is the creation of Free Trade Areas and the consequent reduction of transport and trade costs, as well as the increased trade in intermediate goods, less subject to distance magnitude.

Consumers' preferences and factors endowment could affect the trade patterns between pairs of countries; the former influence the composition of a country' s imports, while the latter regards the country's exports. It follows that the more two countries differ in preferences and endowments, the more the sectoral composition of their economy and trade flows will result in less Intra-Industry Trade. Finally, the effect of the countries' market size is not well defined yet, but the common argument is the following: large countries can enable domestic firms to produce elevated quantities of output, therefore developing economies of scale in various industries, giving them comparative advantage in international trade. As previously seen, this positively influences the IIT. On the other side, small countries are more likely to specialize in a limited number of industries, orienting them towards inter-industry trade.

1.4.2: IIT and the Environment

The impact of Intra-Industry Trade on the environment can be analyzed using the same framework for inter-industry trade, which is the division in scale, composition and technique effect. (Alaras and Hoehn, 2010)

As usual, an increase in size of trade volumes leads to an increase in emissions, due to production and transport (scale effect). The technique effect has an expected negative sign, because trade exchanges favor the adoption of cleaner and more advanced technologies by the commercial partners, therefore reducing emissions intensities of production. In addition, the increased welfare resulting from the trade activity stimulates the adoption of better environmental policies. Specifically to IIT, Hakura and Jaumotte remark "Intra-Industry trade is more effective for technology transfer because countries are more likely to absorb foreign technologies when their imports are from the same sectors as the products they produce and export" (Hakura and Jaumotte, *Role of Inter- and Intra-industry trade in technological transfer*, International Monetary Fund, 1999).

Again, the role of composition effect is, at best, ambiguous. Some studies suggest that instead of a composition effect, the Intra-Industry Trade is characterized by a *selection effect*, driven by the number of firms and of product varieties. Alaras and Hoehn (2010) investigated the existence of a selection effect, namely a reduction of the number of firms in an open economy due to the Intra-Industry Trade. The authors started from the Krugman's model, adding a pollution-intensity parameter e_i for each variety of products, and a tax τ over polluting emissions generated through production processes. Consequently, the final price earned by the producer is $p^F{}_i = p_i(1-\tau e_i)$. This implies the higher the emissions intensity, the lower the final price of goods. Since the theory has demonstrated that high value of welfare produce stringent environmental policies, the situation depicted in the model seems surely plausible. Following the model, the number of product varieties is positively related with total labor L (the sum of consumers) and negatively influenced by the pollution tax rate.

Consider now a second country identical to the one already described. If they both engage in trade, the effect is similar to an increase in labor supply, as seen in Krugman

(1979). The price of single goods' varieties falls as well as the consumption. On the other hand, the varieties of product increase. A direct consequence is the exit of domestic firms that earn negative profits when they cannot compete with foreign firms or products. Surviving firms expand production as they take advantage of economies of scale. It follows that in an open economy, the number of firms is lower than in autarky; *ceteris paribus*, a smaller number of firms generates less emissions (Alaras and Hoehn, *Intra-industry Trade and the Environment: Is There a Selection Effect?* 2010). The last statement could appear in contrast with the model characteristics (if L increases, n increases), but is useful to remind that *n* refers to the total number of firms in the countries involved. To summarize, in each country the number of domestic firms decreases, but due to trade openness, the variety of products in each market (thus the number of total firms) increases. These conclusions are supported by the empirical analysis, which finds a positive and significant relation between selection effect and environmental quality

The positive impact IIT on environment is sustained also by the research of Swart (2012). The author builds a model taking into account pollution taxes and transportation costs. The findings support the positive relation between the selection effect induced by IIT and the environmental quality. Considering two similar countries engaged in trade, it follows that a domestic firm willing to enter in the foreign market has to cut its emissions to avoid environmental taxes and to compensate transportation costs; thus, foreign consumers will purchase only domestic "clean" products. Since the same mechanism is applied for foreign firms entering in domestic market, the overall effect is the adoption of cleaner technologies, decreasing emissions.

Unfortunately, the number of studies concerning the environmental impact of Intra-Industry Trade is still restrict, but the general findings show engaging in Intra-Industry Trade leads benefits to nations' environment (Alaras and Hoehn 2010; Leitão, Dima, Stefana, 2011; Roy J., 2017).

1.4.3: IIT in Europe

European Union is, by its own nature, a perfect subject for studies concerning the Intra-Industry Trade. Largely composed of developed nations, the European Union (EU) has been considered as a community of advanced economies; the majority of European countries are characterized by relatively equal level of development, labor productivity and scarcity in natural resources, so that intra-European trade had been largely dominated by intra-industry type of trade (Kang, 2010). However, the relatively recent access to European community of the so called CEEC, Central and Eastern European Countries have changed partially the economic scenario, due to the differences in economic development and the past experience of being under the influence of the former Soviet Union. These new economies could have affect the EU trade patterns through a myriad of mechanisms: increased specialization according to comparative advantage, enhanced scope for scale economies in a larger European market, changing factor supplies through movements of workers and capital, stiffer competition from CEEC competitor firms, to name but the most obvious (Brülhart, 2004).

Empirical analysis draws a clear scenario: IIT in Europe still holds a prevalent role, resulting in around 70 percent of the Intra-trade among EU 27. More notably, countries entered more recently seem to have benefited a lot from their new status; empirical findings demonstrate they have engaged in quite high levels of IIT with the other European countries, contrasting with the assumption of some authors, overall Marius Brülhart.

Few authors have entered in the study of IIT in the European Union, due to the relatively newness on the theory; among them, the one who contributed more is Marius Brülhart. His focus is the pattern of trade among European Countries, argument linked with the New Trade Theories (NTT).

The work of Brülhart that is taken in analysis is based on the comparison between trade (export) data and employment data. The former being the most utilized in empirical research due to the great availability of data and their high levels of disaggregation, the latter being, in author’s opinion, the most appropriate variable to look at (Brülhart, *Evolving geographical specialization of European manufacturing industries*, 2006).

His aim is to investigate the geographical specialization of manufacturing in Europe, if there is a convergence of economies as predicted by the theory or the fall in trade costs incentives the creation of specialization clusters. The paper in exam analyses the geographical specialization of 32 manufacturing sectors over the 1972-1996 period, based on annual employment and export data for 13 European countries. Data are measured using the *Locational Gini Index* each industry-year observation; its value range is [0, 1] and it is positive related with specialization. The values of the index point an apparent contradiction: opposite trends in broad employment and export specialization. Analysis of trade data suggests a process of industrial dispersion, in line with NTT, which leads to increasing IIT; employment data tell a story of spatial concentration in EU manufacturing sectors. These findings are confirmed by the regression analysis. To solve this contradiction the author introduces a division among sectors based on intense-in-use factors of production. It emerges that the strongest specialization appears in traditional, low-tech industries; both labor-intensive and resource-intensive industries are most geographically specialized. Conversely, the technology-intensive industries appear least geographically concentrated. The author marks the decreased importance of center-periphery paradigm in the specialization patterns, and assesses the link between the fall in trade costs and increasing specialization. However, this link is not strongly confirmed by data, and part of the research rejects this hypothesis.

Concluding, the research around the IIT phenomenon has produced interesting results, but little empirical evidence. Moreover, very few studies have inferred about the environmental impact of IIT in the European context. The current paper aims to give its contribution by estimating the relation between Intra-Industry trade levels among European Countries and the emissions of CO_2 and the other greenhouse gases produced by the single countries.

CHAPTER 2: DATA ANALYSIS

The aim of this chapter is to conduct a graphic and statistical analysis evaluating the variables taken into consideration, and to identify which one of them can be useful in the assessment of the impact of inter-industry and intra-industry trade on the European Greenhouses emissions.

2.1: DATA DESCRIPTION

The focuses of this paper are the countries that have joined the European Union (EU) until 2016. It is important to note they became part of the EU indifferent historical periods, and this may have led to different behaviors.

	COUNTRY	YEAR OF ENTRANCE
EU 15	Belgium	1957
	France	1957
	Germany	1957
	Italy	1957
	Luxembourg	1957
	Netherlands	1957
	Denmark	1973
	Ireland	1973
	United Kingdom	1973
	Greece	1981
	Portugal	1986
	Spain	1986
	Austria	1995
	Finland	1995
	Sweden	1995

Table 1: EU 15 countries

	COUNTRY	YEAR OF ENTRANCE
CEECS	Cyprus	2004
	Czech Republic	2004
	Estonia	2004
	Hungary	2004
	Latvia	2004
	Lithuania	2004
	Malta	2004
	Poland	2004
	Slovakia	2004
	Slovenia	2004
	Bulgaria	2007
	Romania	2007

Table 2: Central and Eastern European Countries

According to literature, the sample is divided in EU 15 and "Central and Eastern European Countries" (CEECS) to identify differences in results.

2.1.1: Dependent variable

This section analyzes the evolution of Greenhouse Gases (GHG) emissions over time. These gases are carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), per fluorocarbons (PFCs), hydro fluorocarbons (HFCs), Sulphur hexafluoride (SF6) and nitrogen tri fluoride (NF3). All of them are weighted for their Global Warming potential and the results expressed in CO2 equivalents, thus aggregated in one variable "GHG Emissions”. The coverage period is 1990-2014.

Data are taken from Eurostat Database: http://ec.europa.eu/eurostat/data/database and are measured in millions of ton

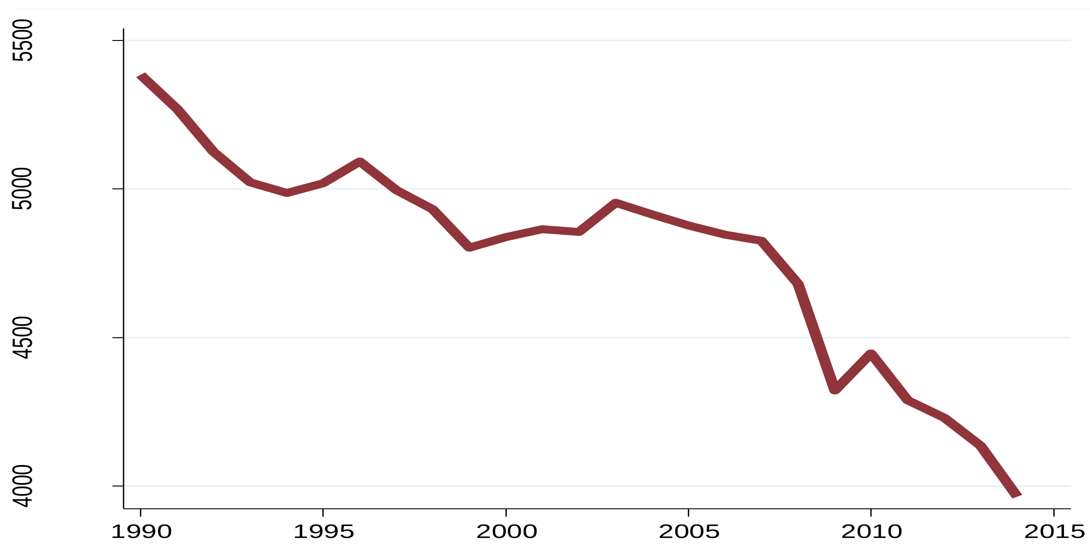


Table 3: Evolution of GHG emissions

Values show a strong fall in GHG Emissions; they passed from 5385 million of ton in 1990 to 3964 in 2014, with a decrease of 26 per cent.

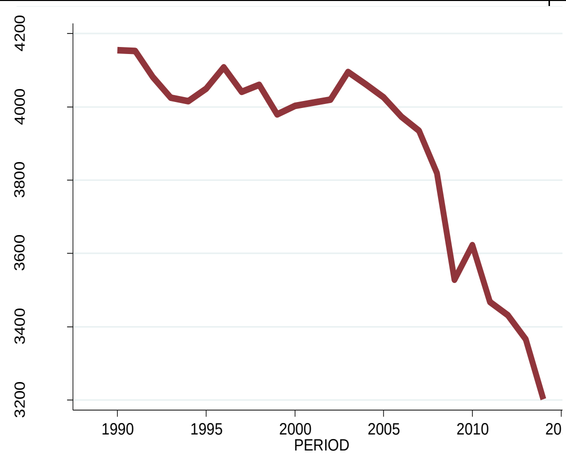
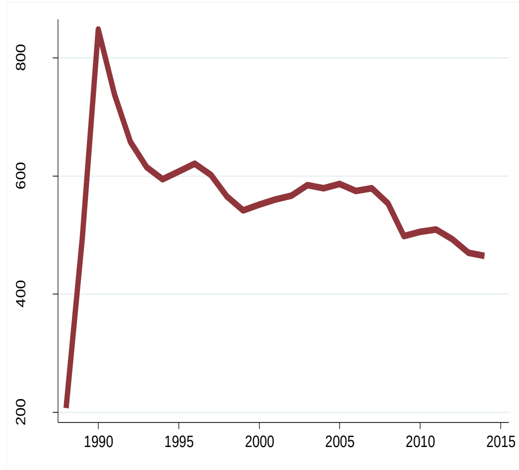
EU 15	CEECS
	

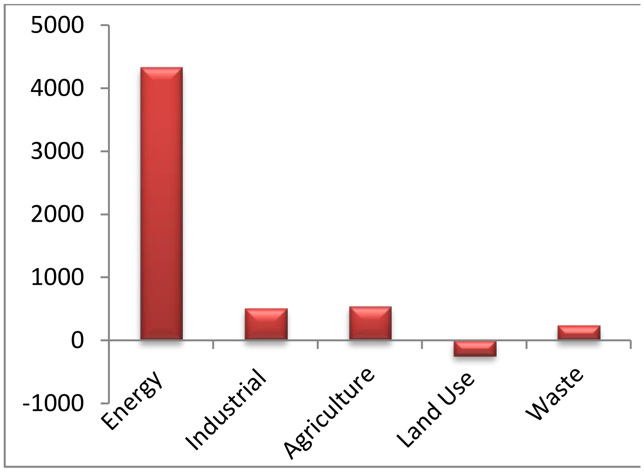
Table 4 Evolution of GHG emissions; EU 15 and CEECS

Analyzing separately the emissions, EU 15 countries show a strong decrease from 2003. CEECS show a very similar path; the low values in the first years depend from monitoring issues. During the periods 1994-1996 and 1999-2005 emissions deviate from the decreasing trend in both groups reaching new peaks. Explanations are over the scope of this paper; nevertheless, a suggestion could be that both peak periods coincide with the years of entrance in the European Union of new nations. Thus, the emissions peaks could reflect adjustments in policies and trade flows.

Composition

Emission data are taken as aggregate from the most polluting sectors: Energy Production, Industrial Processes, Agriculture, Waste Management and Land Use.

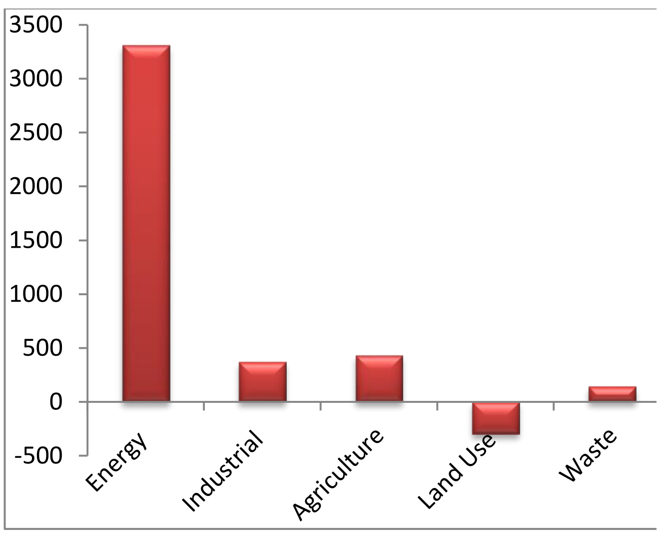
1990



Sector	Value	%
Total	5385	*100%*
Energy	4331	*80.4%*
Industrial	507	*9.4%*
Agriculture	544	*10.1%*
Land Use	-249	*-4.6%*
Waste	239	*4.4%*

Figure 2: Composition of GHG emissions 1988

2014



Sector	Value	%
Total	3964	*100%*
Energy	3309	*83.5%*
Industrial	371	*9.3%*
Agriculture	433	*10.9%*
Land Use	-297	*-7.5%*
Waste	140	*3.5%*

Figure 3: Composition of GHG emissions, 2014

It is evident that Energy Production leads the emissions, its percentage increasing over time. Land use emissions have a negative sign. It means that policies concerning reforestation and land disposal are returning a positive effect; providing more natural sinks to absorb CO_2. In addition, emissions from waste management have improved. Overall, sector emissions in EU 27 do not seem to have changed composition over time.

2.1.2: Independent Variables

Passing now to the analysis of the factors influencing the magnitude of emissions, the following variables are identified in the literature as the most relevant.

Total Trade

Total trade is calculated as the sum of Import plus Export between a country and its trade partners. This analysis considers only trade flows among the EU 27 countries.

Data for the period 1988-2015 are taken from Easy Comext, the European Union Database for International Trade

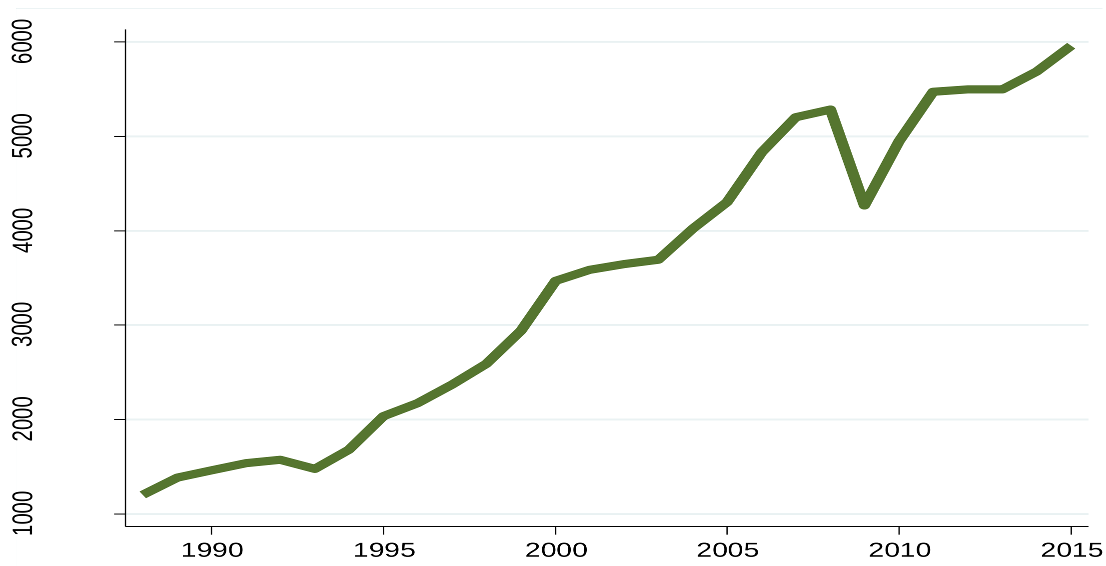


Figure 4: Evolution of Intra EU 27 Trade

Trade data are expressed in billions of euro, and unequivocally show a strong increase in trade among EU countries. This is not surprising, since one of the main reasons for the creation of European Economic Community and then Union was the improvement of free trade among members. The total value of exchanged goods shifted from 1200 billion of euro in 1988 to 5961 billion in 2015, with a net increase of roughly 400%. Note that in years 2008-2010 was registered a drop of trade flows; certainly, it reflects the impact of financial crisis that exploded in that period.

EU 15	CEECS

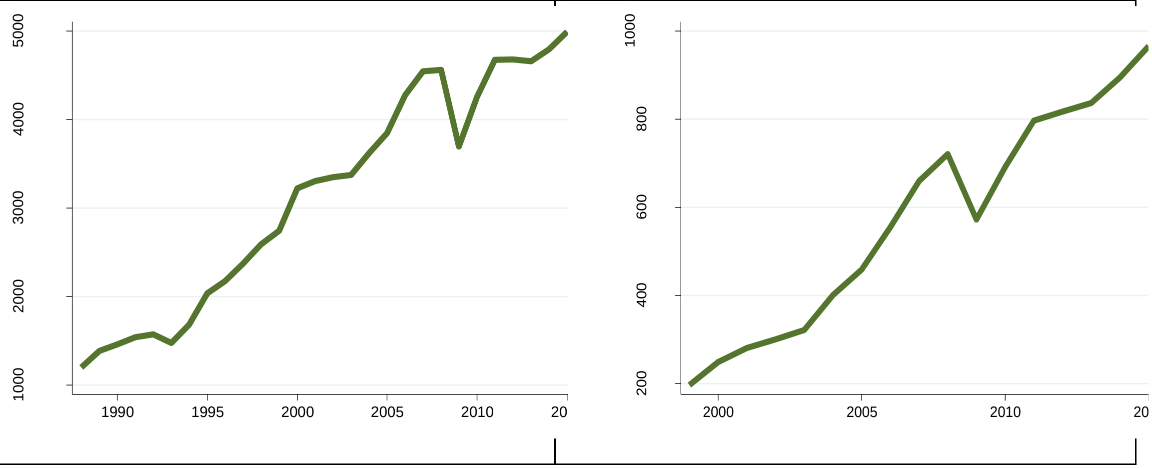


Figure 5: Evolution of Intra EU 27 Trade; EU 15 and CEECS

Dividing the sample, the analysis does not show different trend. Note that data for CEECS start from 1999.

Sector composition

According to the Standard International Trade Classification Rev.4, Eurostat Database provides data about trade divided in ten main economic sectors. “0: food and live animals. 1: beverages and tobacco. 2: crude materials, inedible, except fuels. 3: mineral fuels, lubricants and related materials. 4: animal and vegetable oils, fats and waxes. 5: chemicals and related products. 6: manufactured goods classifies chiefly by material. 7: machinery and transport equipment. 8: miscellaneous manufactured articles. 9: commodities and transactions not classified elsewhere” (United Nation Statistics Division).

1988

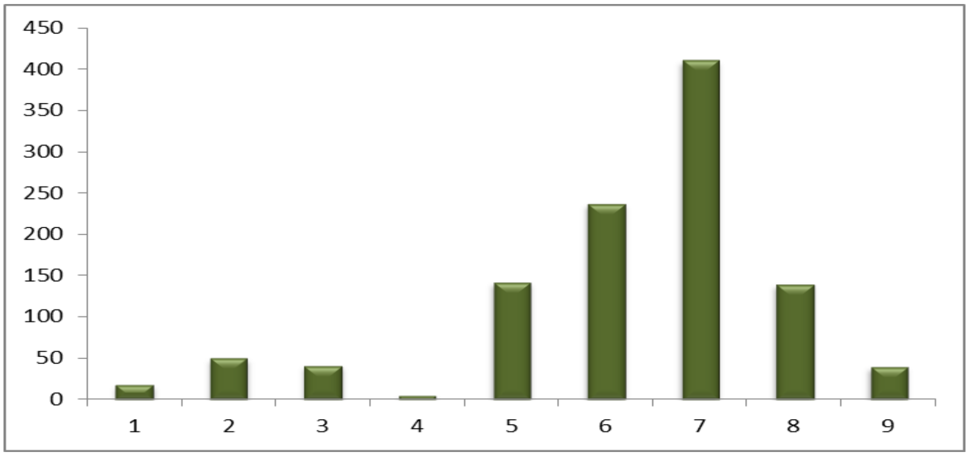


Figure 6: Sector composition of Intra EU 27Trade, 1988

Table 5: Sector composition of Intra EU 27 Trade, 1990; data in billions

Total	**1199**	**100%**
0: Food and Live Animals	**120**	**10%**
1:Beverages and tobacco	**17**	**1.4%**
2: Crude Materials	**49**	**4.1%**
3: Mineral Fuels	**41**	**3.4%**
4: Animal and Vegetable Oils	**5**	**0.4%**
5: Chemicals Products	**142**	**11.8%**
6: Manufactured Goods	**237**	**19.7%**
7: Machinery Equipment	**410**	**34.2%**
8: Miscellaneous Manufactured Articles	**139**	**11.6%**
9: Commodities not classified elsewhere	**40**	**3.3%**

2015

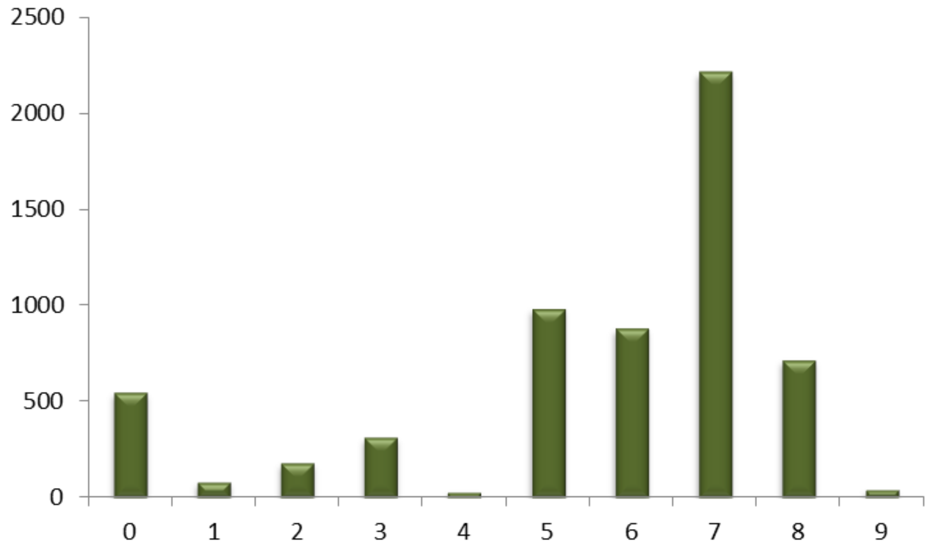


Figure 7: Sector composition of Intra EU 27 Trade, 2015

Table 6: Sector composition of Intra EU 27 trade in 2015; data in billions

Sector	Billions of €	%
Total	5961	**100%**
0: Food and Live Animals	544	**9.1%**
1:Beverages and tobacco	79	**1.3%**
2: Crude Materials	178	**3.0%**
3: Mineral Fuels	312	**5.2%**
4: Animal and Vegetable Oils	28	**0.5%**
5: Chemicals Products	982	**16.5%**
6: Manufactured Goods	877	**14.7%**
7: Machinery Equipment	2211	**37.1%**
8: Miscellaneous Manufactured Articles	715	**12.0%**
9: Commodities not classified elsewhere	35	**0.6%**

The sector that drives the Intra trade among EU 28 is Machinery and Transport Equipment. In this broad category are comprised equipment for energy production, industrial processes and motor vehicles. This is not surprising since the advanced EU economies rely mostly on energy consumption and industrial productions

From the evolution over time of trade sector composition, emerges that all sectors have maintained their share, with the exception of 7, and 9, commodities not classified elsewhere. The former shows a strong increase in percentage share starting from 1992 to 2001, and then declines until 2011. During the following years the percentages increment up to 37.1% in 2015.

Table 7: Sector composition of Intra EU 27 trade in 1988 and 2015, EU 15 and CEECS; data in billions

	1988				2015			
	EU 15		CEECS		EU 15		CEECS	
Sector	**Bln €**	**%**	**Bln €**	**%**	**bln€**	**%**	**bln€**	**%**
Total	1199	**100%**	-	-	4995	**100%**	966	**100%**
0	120	**10.0%**	-	-	473	**9.5%**	72	**7.4%**
1	17	**1.4%**	-	-	69	**1.4%**	11	**1.1%**
2	49	**4.1%**	-	-	152	**3.0%**	26	**2.7%**
3	41	**3.4%**	-	-	273	**5.2%**	38	**4.0%**
4	5	**0.4%**	-	-	24	**0.5%**	4	**0.4%**
5	142	**11.8%**	-	-	8762	**17.5%**	106	**11.0%**
6	237	**19.7%**	-	-	707	**14.2%**	170	**17.6%**
7	410	**34.2%**	-	-	1793	**35.9%**	418	**43.3%**
8	139	**11.6%**	-	-	596	**11.9%**	119	**12.3%**
9	40	**3.3%**	-	-	33	**0.7%**	2	**0.2%**

The division in sub samples shows very similar compositions, the only exception is the percentage of Machine and Transport Equipment which in CEECs is ten percentage points higher.

GDP

Values of GDP are measured in billions of euro. Data are taken from Eurostat Database and are available only starting from 1995

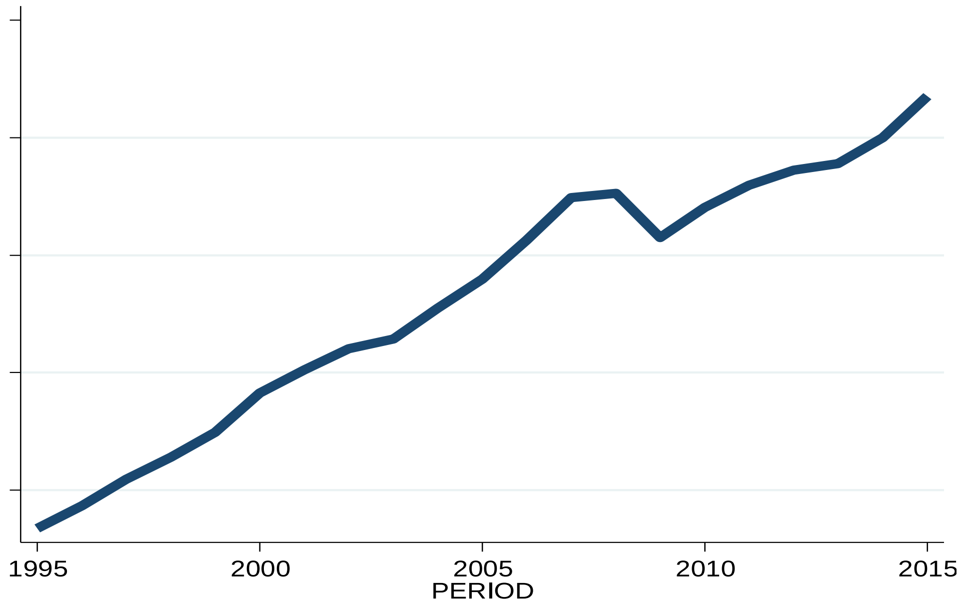


Figure 8: Aggregate EU 27 GDP evolution

The aggregate GDP exhibits a tremendous upward trend, with a little shift caused by the financial crisis. Its value passed from 7.346 billion in 1995 from 14.708 in 2015.

Table 8: Countries classification according to GDP in 2015

Reporter	GDP bln	Reporter	GDP bln	Reporter	GDP bln
Germany	3.032.82	**Austria**	339.90	**Slovakia**	78.69
UK	2.580.06	**Denmark**	271.79	**Luxembourg**	51.22
France	2.181.06	**Ireland**	255.82	**Bulgaria**	45.29
Italy	1.642.44	**Finland**	209.15	**Slovenia**	38.57
Spain	1.075.64	**Portugal**	179.54	**Lithuania**	37.33
Netherlands	676.53	**Greece**	175.70	**Latvia**	24.35
Sweden	447.01	**Czech Republic**	166.96	**Estonia**	20.25
Poland	429.79	**Romania**	159.96	**Cyprus**	17.64
Belgium	410.35	**Hungary**	109.67	**Malta**	9.25

Intra-Industry Trade

Intra-Industry Trade is defined as the simultaneous import and export within the same sector. It is measured with the Grubel-Lloyd index, the difference between import and export over the sum of them.

$$GL_i = \frac{(X_i + M_i) - |X_i - M_i|}{X_i + M_i} = 1 - \frac{|X_i - M_i|}{X_i + M_i}$$

To obtain the aggregate data for the EU 27, IIT ratios of single countries in each sector are weighted to the amount of total trade in the same sectors, to obtain country-level IIT values.

$$IIT_k = \sum_i (1 - \frac{|(X_i - M_i)|}{X_i + M_i}) * (X_i + M_i) / \sum_i (X_i + M_i) \qquad \text{for each country } k$$

The next step is to sum together the countries IIT, weight for country's *k* total trade (with the other EU 27 countries) and divide the result for Aggregate Total Trade among EU 27.

$$IIT_{agg} = \sum_k (IIT_k * TT_k) / \sum_k TT_k \qquad \text{with TT is Total Trade with the EU 27}$$

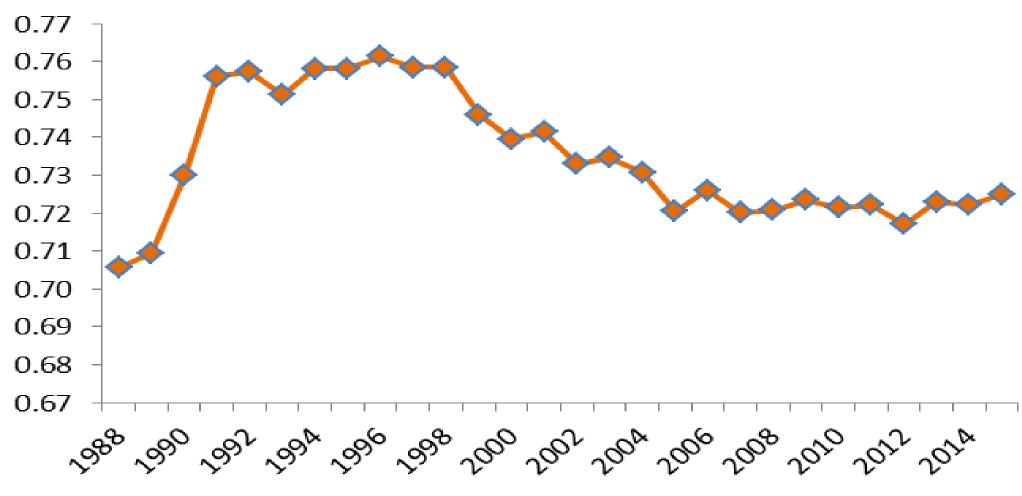
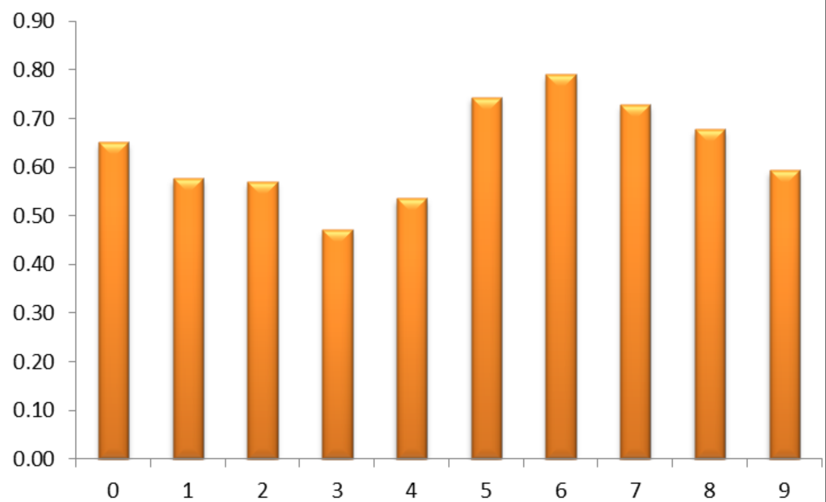


Figure 9: Evolution of aggregate IIT among EU 27

IIT among European trade exhibits a large percentage. More than 70% of trade in constituted by imports and exports almost equal. It seems to present a decreasing trend, however the negative variations are in few decimal points; thus, it can be judged as being steady over time.

IIT per sector

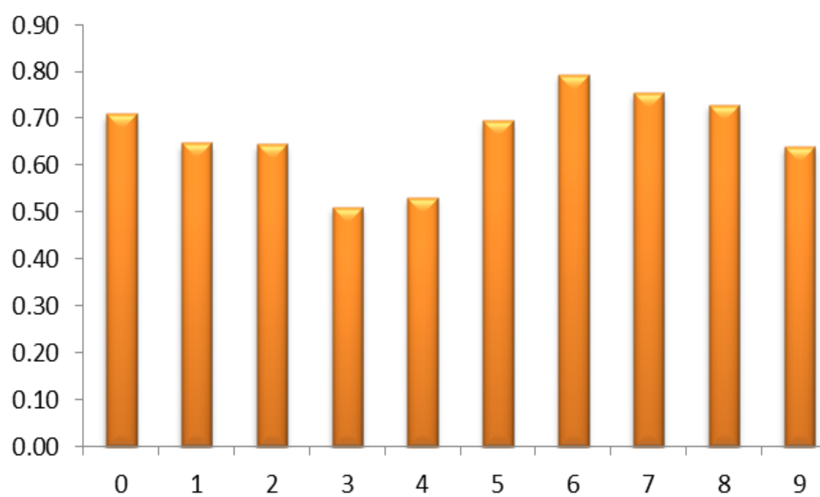
1988



Sector	IIT
0	0,65
1	0,58
2	0,57
3	0,47
4	0,54
5	0,74
6	0,79
7	0,73
8	0,68
9	0,59

Figure 10: Sector composition of EU 27 IIT, 1988

2015



Sector	IIT
0	0,71
1	0,65
2	0,64
3	0,51
4	0,53
5	0,70
6	0,79
7	0,76
8	0,73
9	0,64

Figure 11: Sector composition of EU 27 IIT, 2015

Sectors that display the highest levels of IIT are the Manufactured Goods and Machinery Equipment, which are the sectors more traded among EU 27. Comparing the values at the beginning and the end of the sample period, all economic sectors have increased their IIT levels, except for Chemicals. High levels of Intra-Industry Trade could reflect a gradual convergence of European economies.

Table 9: Sector composition of IIT, 1988 and 2015; EU 15 and CEECS

	1988		2015	
	EU 15	CEECS	EU 15	CEECS
Sector	**IIT**	**IIT**	**IIT**	**IIT**
Total	0,71	-	0,72	0,74
0	0,65	-	0,72	0,68
1	0,58	-	0,68	0,46
2	0,57	-	0,64	0,66
3	0,47	-	0,50	0,56
4	0,54	-	0,53	0,54
5	0,74	-	0,70	0,63
6	0,79	-	0,78	0,85
7	0,73	-	0,75	0,77
8	0,68	-	0,72	0,76
9	0,59	-	0,65	0,48

Surprisingly, CEECS countries exhibit a total IIT slightly greater than EU 15. EU 15 present higher IIT in Food and Live Animals, Beverages and tobacco, Chemicals and others. CEECS in contrast have very intense levels of IIT in Manufactured Goods.

Population

Population values are expressed in millions of people. Source is again Eurostat database.

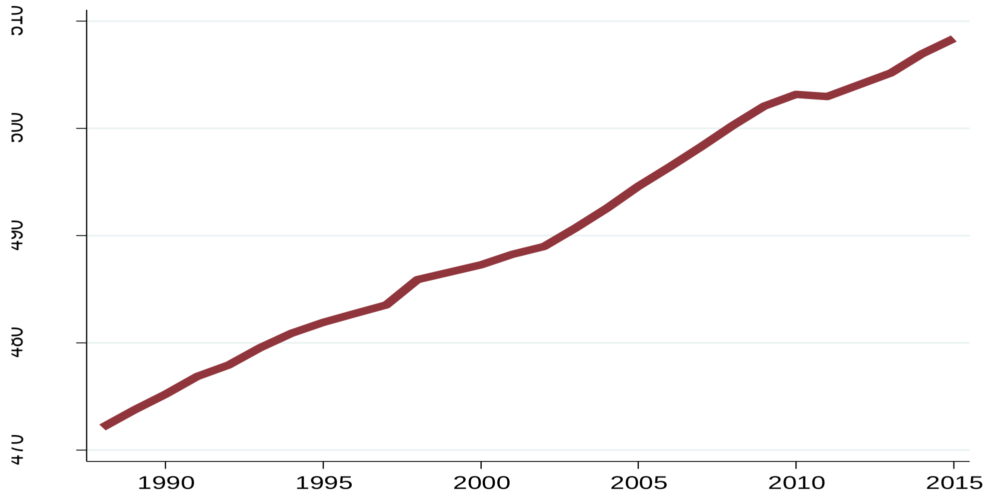


Figure 12: Evolution of aggregate EU 27 population

European population increased by 8% in the sample period, moving from 482 to 508 million of people.

Environmental taxes

“An environmental tax is one whose tax base is a physical unit (or a proxy of it) of something that has a proven, specific negative impact on the environment. Environmental taxes can be of four types: energy, transport, pollution and resource taxes” (Eurostat). Data are in millions of euro

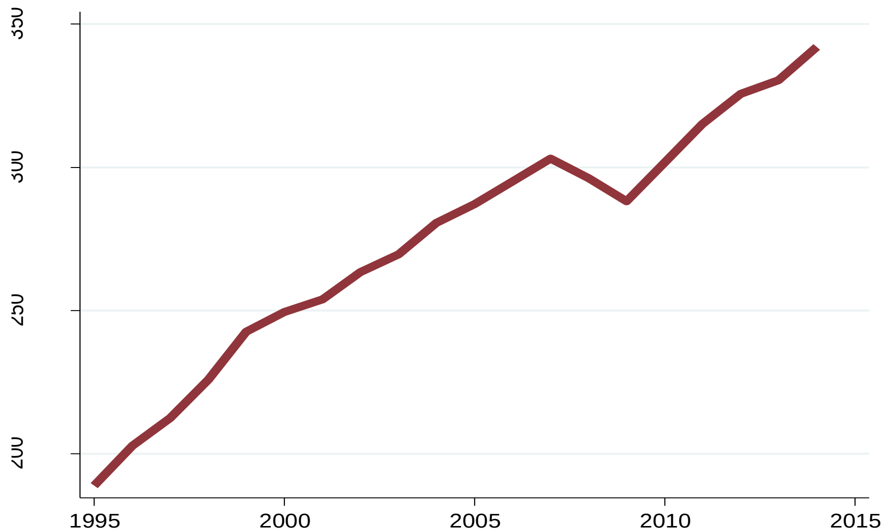


Figure 13: Evolution of aggregate EU 27 Environmental Taxes

Environmental taxes show upward values, in parallel with Total Trade and GDP. Thus, can be taken as an additional indicator of the development level of a country. In addition, they are part of the national GDP, so it is plausible to expect very similar trends and results.

2.2: GRAPHIC ANALYSIS

In this section are employed graphic tools in order to confront the emissions with the possible explanatory factors, and to observe the interactions between variables. The key data analyzed in the previous paragraph are not useful taken in themselves; to obtain a meaningful analysis there is the need of creating new variables that could be compared across countries, accounting for their scale (GDP or Population size).

A new set of variables is built: "CO2 on GDP" (co2gdp) which measures the polluting intensity of the welfare in country *i*, expressed in thousands of ton on millions of euro. "GDP per capita" (gdppc) which measures the income per capita in country *i*. "Trade Openness" (tradeopeness) which measures the relevance of the total trade between country *i* and the other "European Countries". IIT (iit) which measures the intensity of Intra-Industry Trade for country *i*. "Population" of country *i* at the year *t*. Percentage of "Environmental Taxes on GDP" (pc_abatementcosts) which measures the weight of environmental taxes over the GDP. It is expressed as "Abatement Costs". In addition, is created the variable Capital to Labor ratio (K/L) using the Gross Fixed Capital Formation over the number of workers for each country. Data for Capital are taken from Eurostat Database, instead information on Employment are provided by Penn World Table.

For the graphic analysis, there have been utilized three types of graphics; the first puts into relation the emissions (thousands ton), total trade (import + export in millions of euro) and the GDP expressed in millions of euro. The second relates emissions on GDP, expressing the pollution intensity of the country's welfare, and the GDP per capita, which indicates the population welfare. The GDP per capita is expressed in euro/unit of population in Poland, Romania, Malta, Estonia, Slovakia, Latvia and Lithuania; for the other countries the value GDP per capita is expressed in hundreds of euro/unit.

Finally, the third kind of graphics compare the evolution of Intra-Industry Trade index with the Trade Intensity (total trade/GDP), measuring the openness towards Intra-EU trade of a country.

The aim of this analysis is to find empirical evidence for a series of hypothesis. First of all, the theory sustains strongly the positive relation between trade and GDP, being the former the driver of the latter, as well as the negative relation between economic growth (GDP) and emissions; the implication is that the richer a country becomes, the more it improves its environmental quality.

Further, this paper wants to investigate the relation between IIT and emissions, in particular if it is negative or positive.

Countries are divided according to the two samples EU 15 and CEECs.

EU 15

From the graphical analysis of the key data, emerge some common trends. In general, it's evident the positive relation between GDP and Total trade, and the negative one with the CO_2 emissions. From the aggregate data of EU 27, trade between European members increased about 4 times, the GDP increased by one hundred percent, and the emissions have decreased by 26%. The second common feature is a drop in total trade and GDP in the years 2008-2010; this is a clear consequence of the financial crisis in 2008

This tendency is shared by all EU 15 countries, with differences according to the economic development. Advanced economies like Germany, France, Belgium, Netherlands, Sweden, UK and Denmark show a linear decrease in emissions together with a steady increase in GDP and Total Trade; countries like Portugal, Italy, Greece, Spain, Ireland and Austria, present the increase in GDP and Total trade as well, but increasing emissions until 2008 and then decreasing. Finland and Luxembourg have a more discrepant trend for emissions. Finland show a cyclical series of increase and decrease in emissions, while Luxembourg presents an initial decrease in emissions, followed by a period of increase and finally a decrease from 2010.

Regarding the second type of graphs, they combine the polluting intensity of GDP with GDP per capita. Overall, the trend is much more linear and with less difference among countries; during the period 1990-2015, emissions intensity has decreased while the income per capita has steadily increased. Only Portugal and Finland exhibit different features in the graphs; unstable lines displaying periods of strong decrease alternating with increase periods. Some countries (Spain, Greece, Finland, UK, Ireland, Netherlands and Portugal), show a modest increase in polluting intensity around 2010 and in the following years. Due to the broad differences among these countries is difficult to identify a common reason that justifies this behavior; more likely it is caused by internal causes.

The third graphs display the evolution of the importance of the trade among EU 27 countries (trade openness) and of Intra-Industry Trade.

Focusing on the IIT, as expected it assumes quite high values among EU 15, in accordance with the theoretical framework; a basic assumption is that IIT is higher between rich and similar countries. In the following table the value ranges for the period in analysis are displayed.

Table 10: Evolution of EU 15 IIT values

Values of IIT	Reporter
0.7<IIT<0.9	Germany, Spain, France, UK, Italy
0.6<IIT<0.8	Belgium, Austria, Denmark, Netherlands, Portugal, Sweden
0.5<IIT<0.7	Finland, Luxembourg, Ireland
0.3<IIT<0.6	Greece

Analyzing the evolution of the IIT emerges a picture different from forecasted. There are some countries with an IIT increasing overtime, Denmark and Greece (strong increase) and Germany with Portugal. Nevertheless, the majority if countries exhibit a decreasing or steady index: Belgium, Spain, France and Sweden are decreasing in IIT, even if with low variations. UK, Netherlands and Ireland show a substantial decreasing trend, with up and down movements. Finally, Austria and Italy appear to have a constant IIT index, while Finland and Luxembourg showing an unstable trend.

As regards the Trade Openness evolution, here as well are delineable different paths. Some countries show an increasing trend, a big fall around 2008 followed by a partial recovery, which translates in a decreasing trend in the last years. Those are Austria, Belgium, Denmark, Finland, France and Sweden.

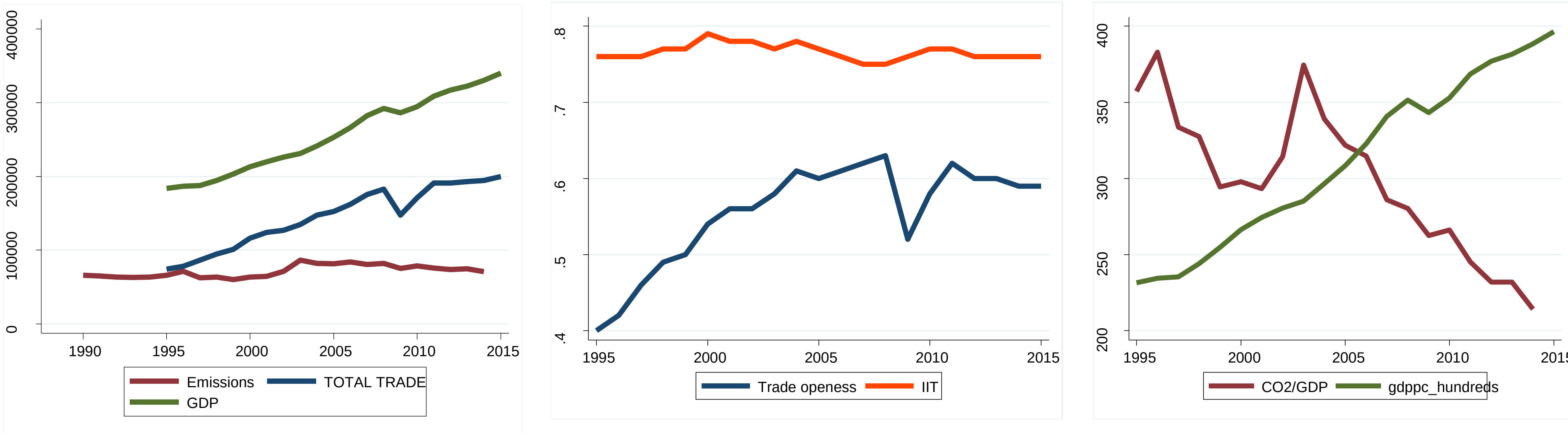
Spain, Germany, Finland, Greece, Italy and Portugal show a similar path, with one difference consisting in final upward trend. United Kingdom, exhibits a quite steady direction, without being particularly affected by external shocks. Ireland and Luxembourg are the outsiders; Ireland starts with very high levels of Trade Openness terribly declining over time. Luxembourg has a strong decreasing tendency but more volatile. Finally, Netherlands shows an increasing trend with huge falls over time.

Table 11: Evolution of EU 15 Trade Openness values

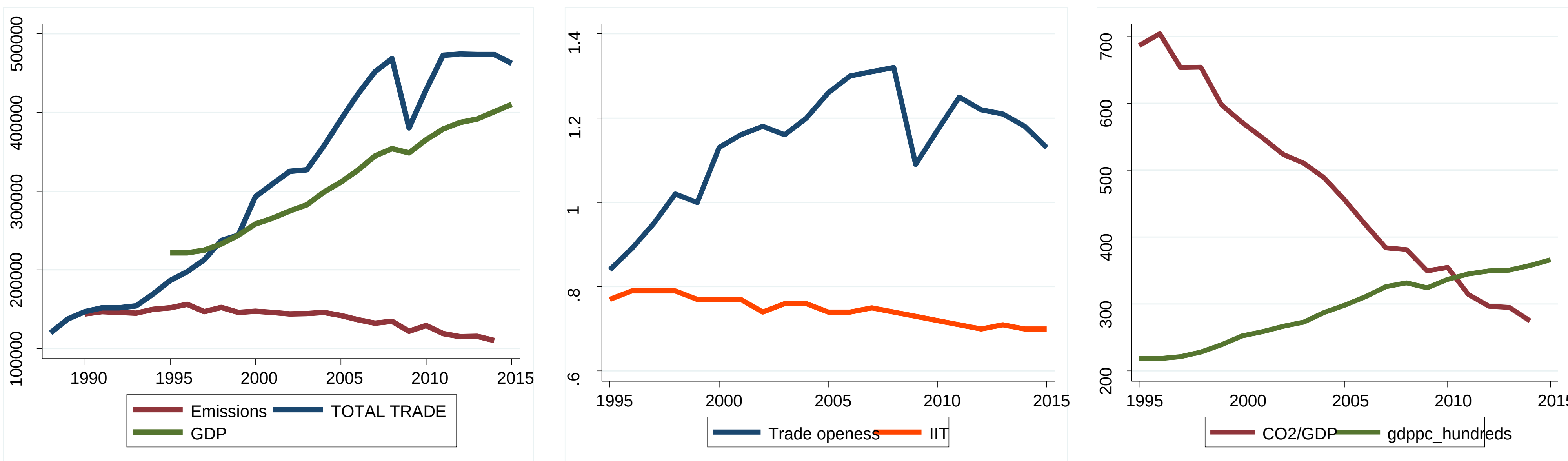
Values	Reporter
0.8<TO<1.4	Belgium
0.4<TO<.08	Austria (+), Ireland (-), Luxembourg (-), Netherlands (+)
0.4<TO<0.5	Denmark, Germany
0.3<TO<0.5	Portugal, Sweden
0.2<TO<0.4	Spain, Finland, France, UK, Greece, Italy

The (+) or (-) notation indicates an increasing or decreasing trend over time. Looking at these values, it is noticeable that the majority of the EU 15 countries have an amount of Intra-EU trade that is considerably inferior respect to GDP. One deduction could be these countries are strongly engaged in trade with extra-EU partners. Belgium represents a unique case: the TO value is higher than the GDP.

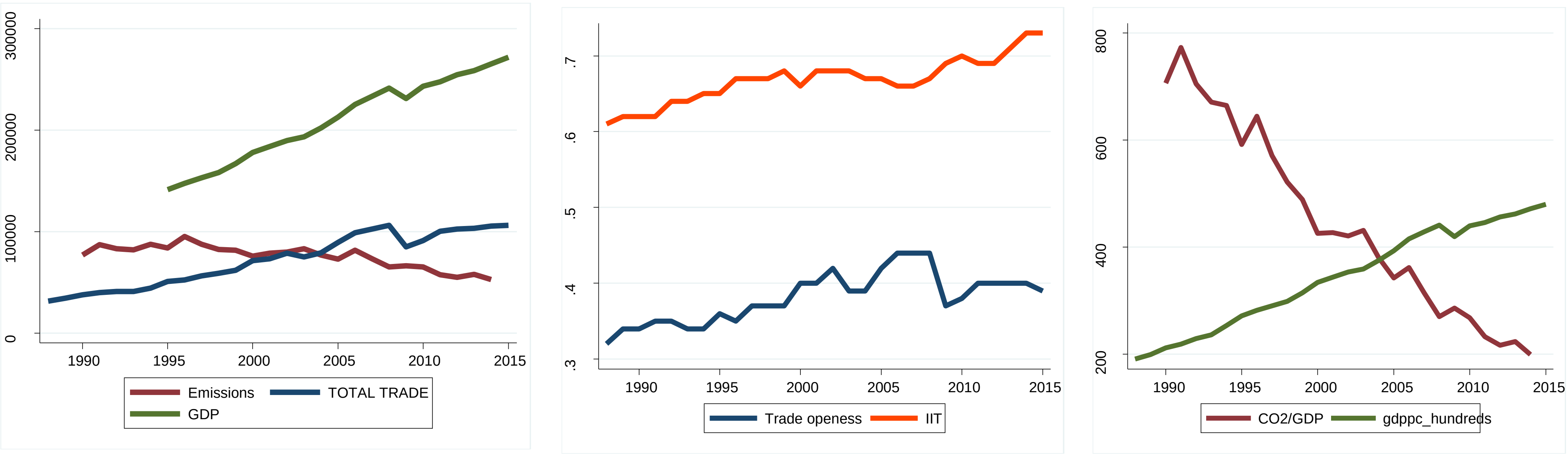
AUSTRIA



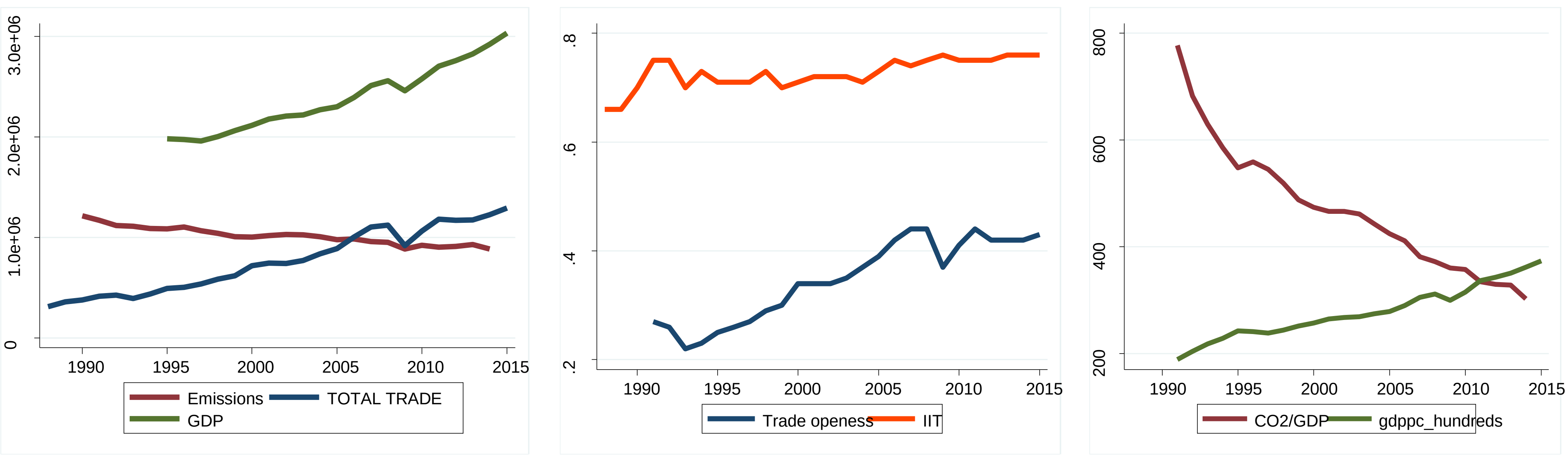
BELGIUM



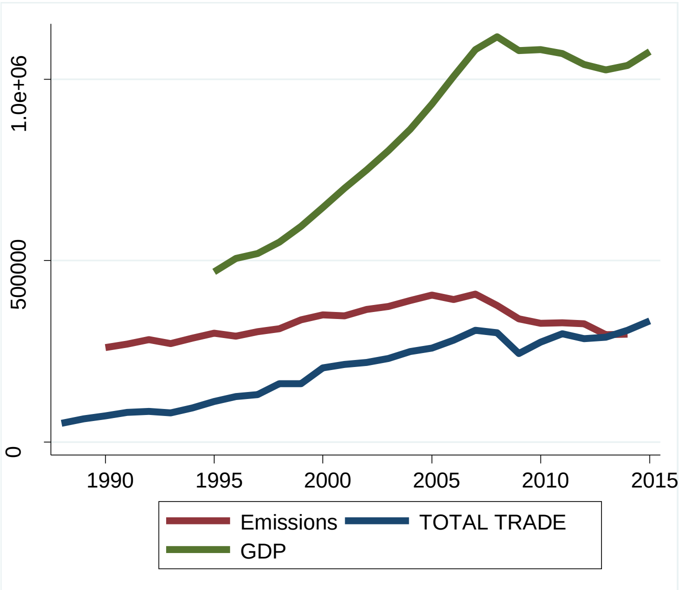
DENMARK

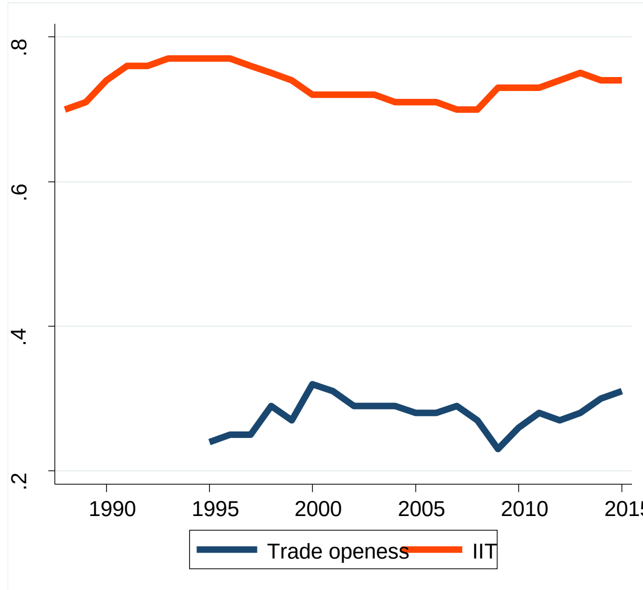


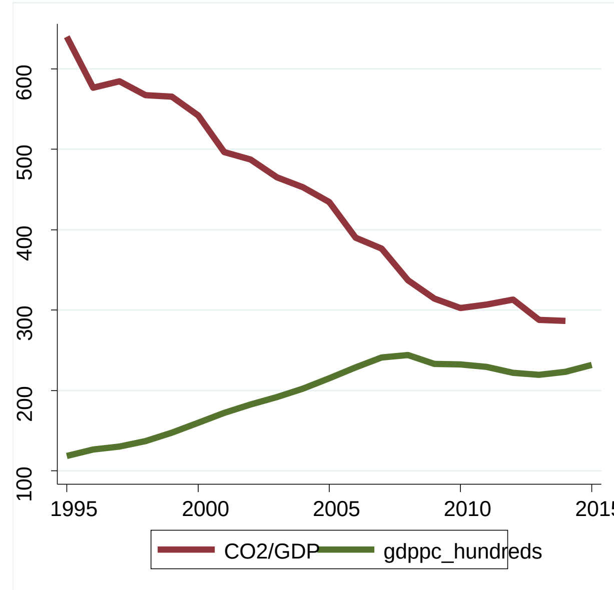
GERMANY



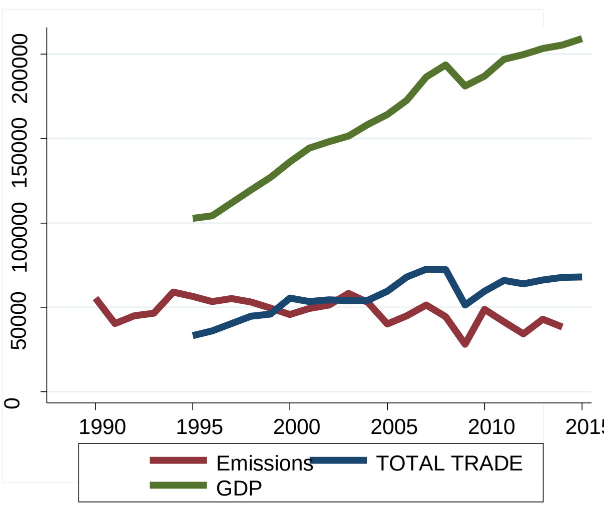
SPAIN

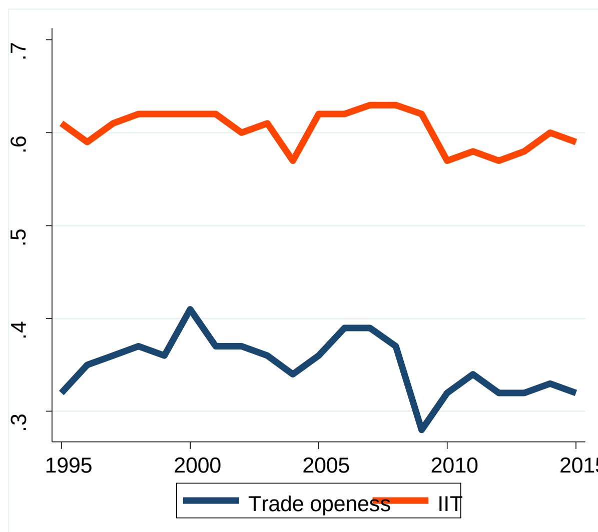


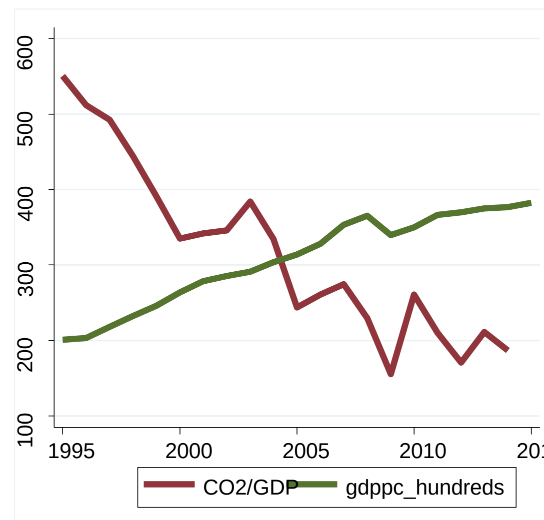




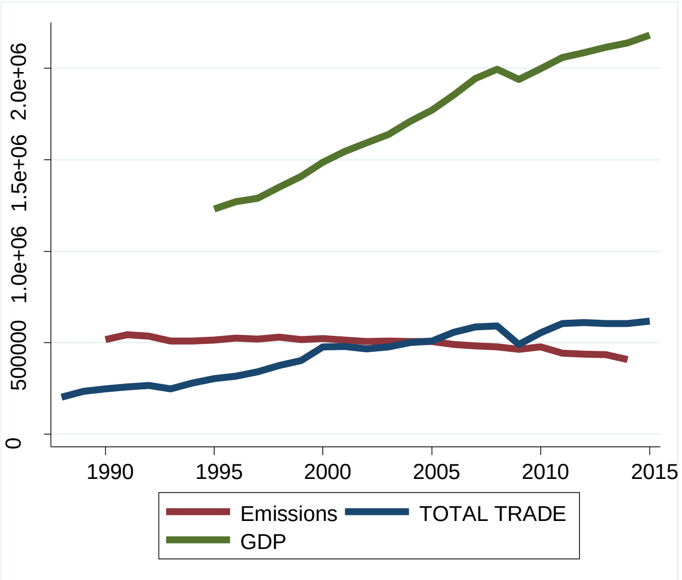
FINLAND

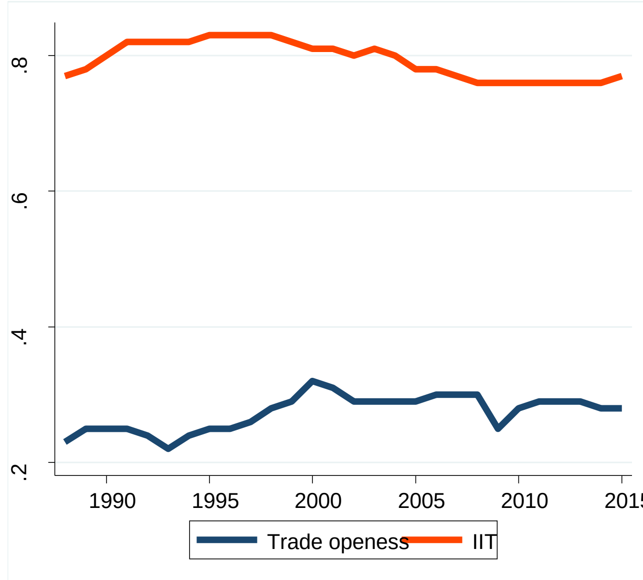


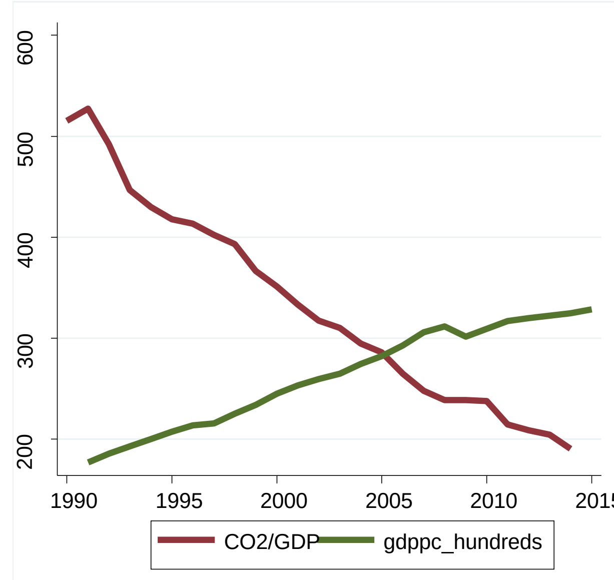




FRANCE







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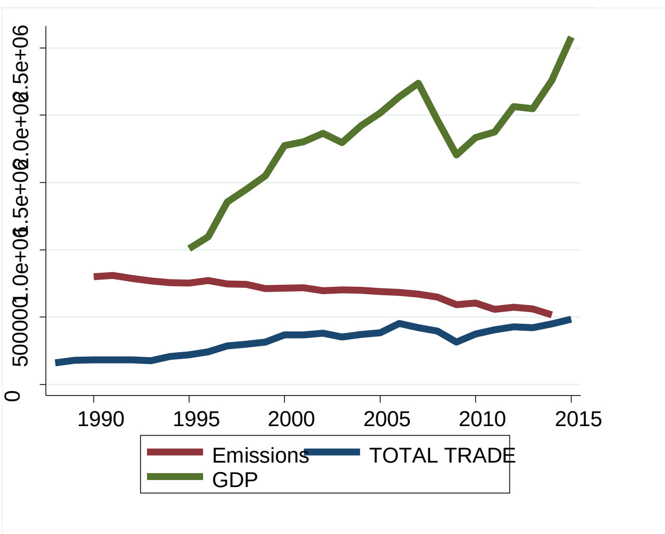

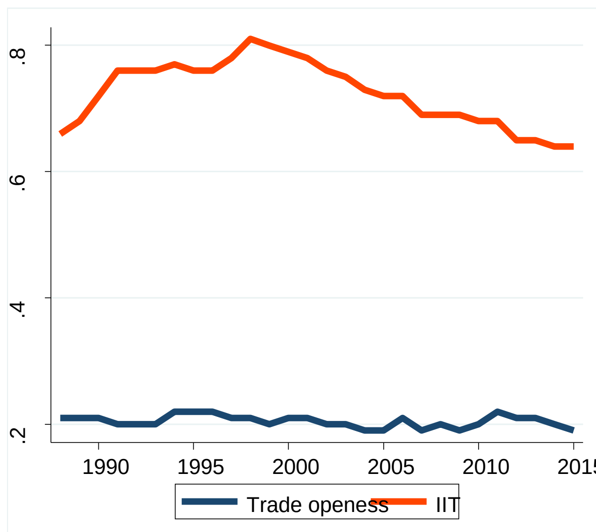

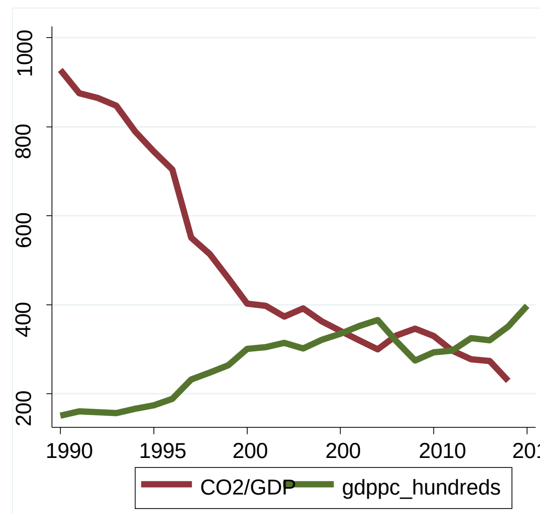

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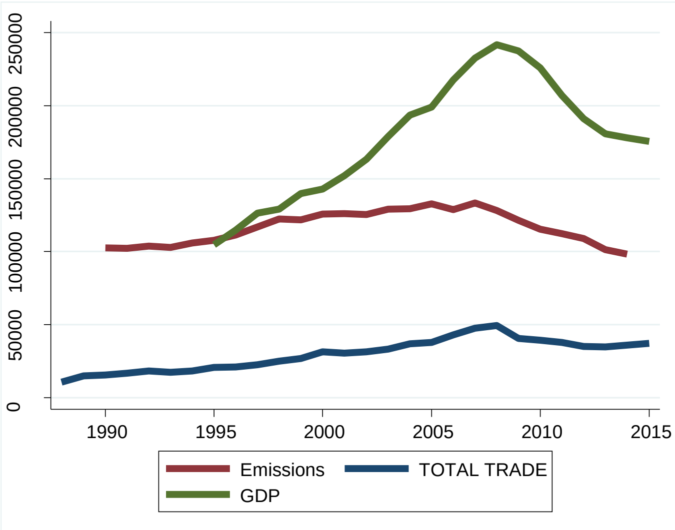

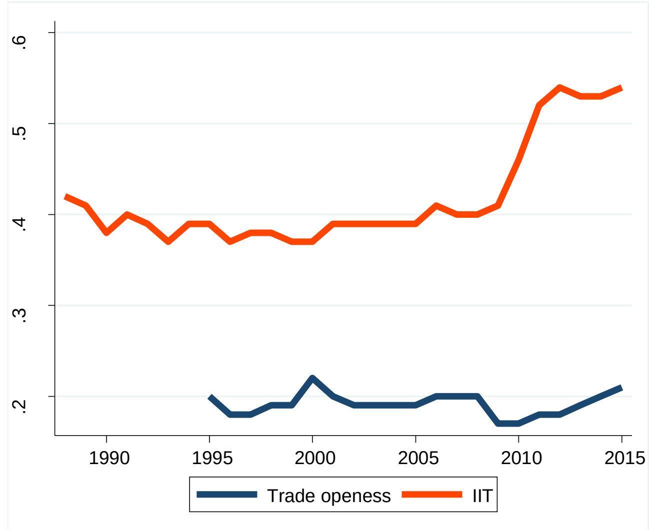

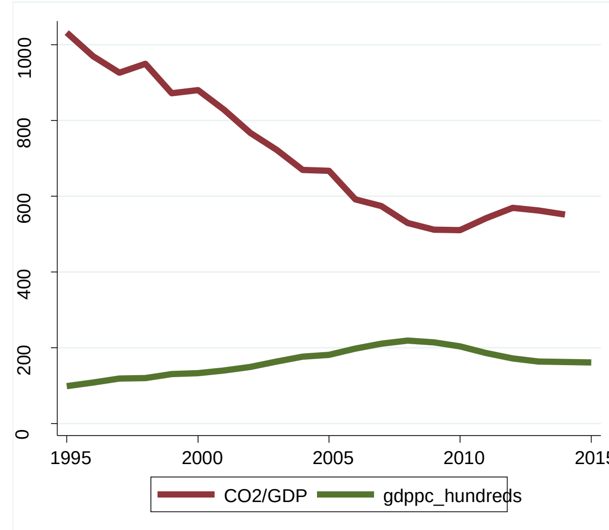

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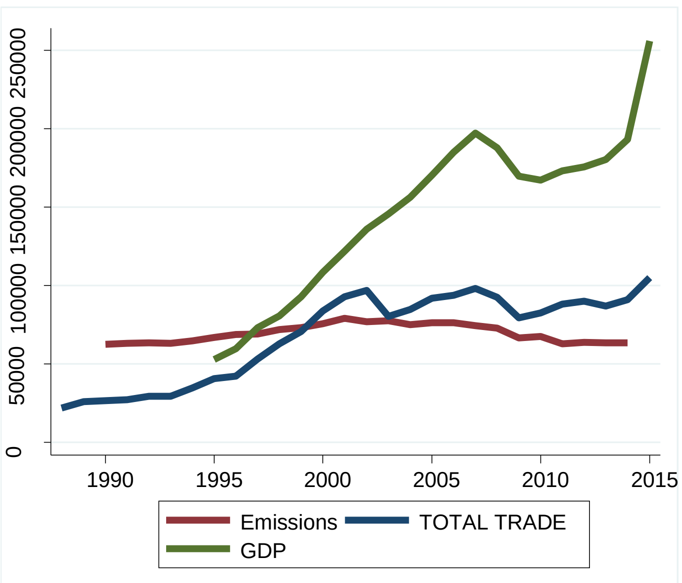

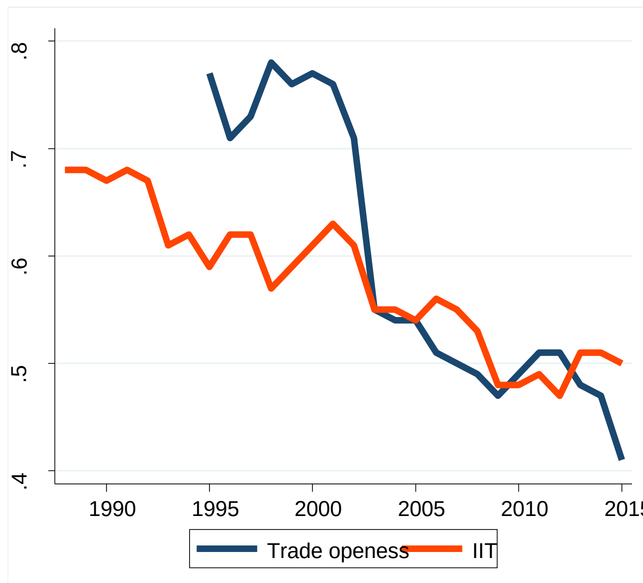

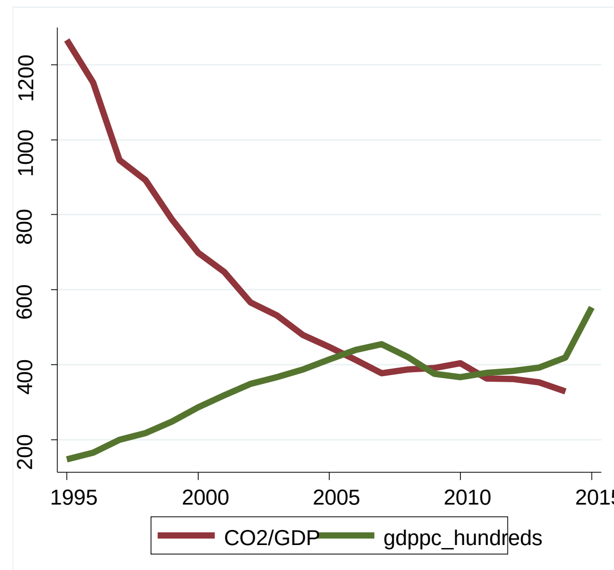

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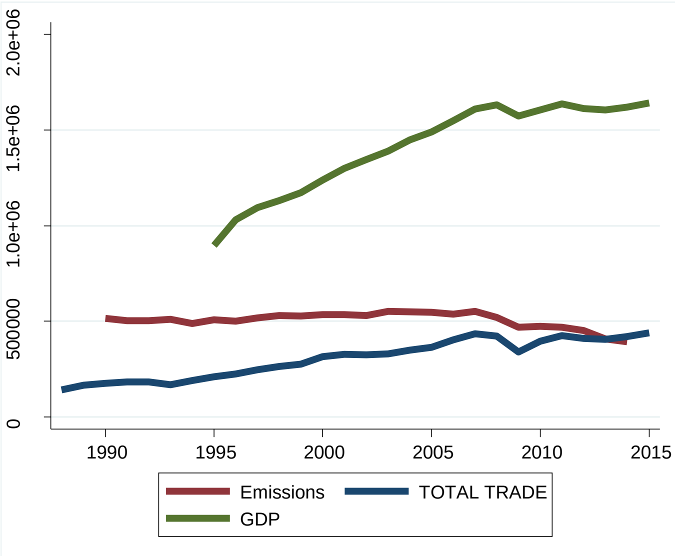

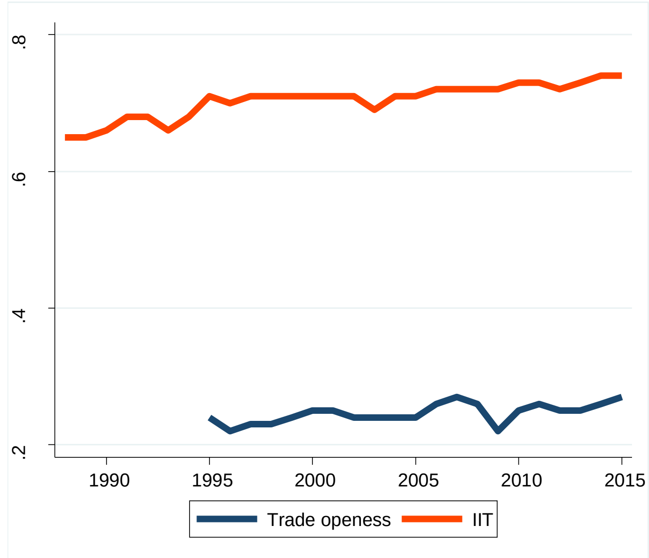

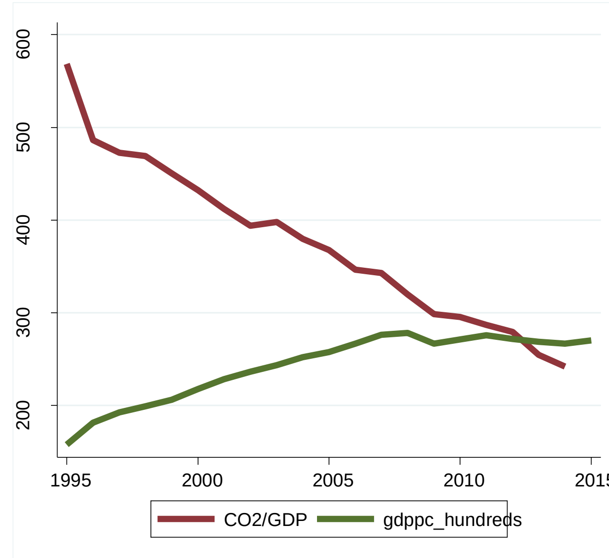

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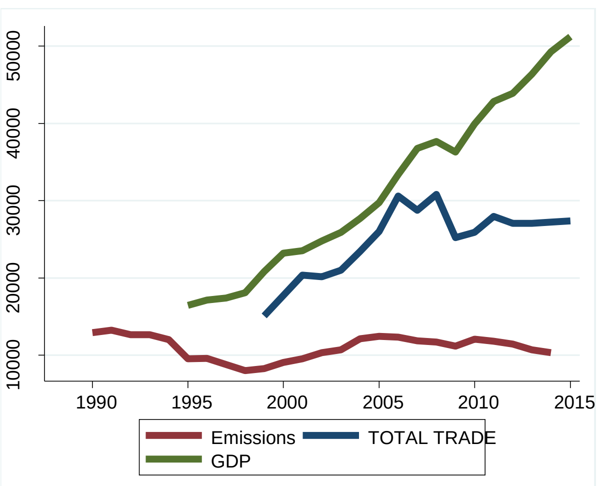
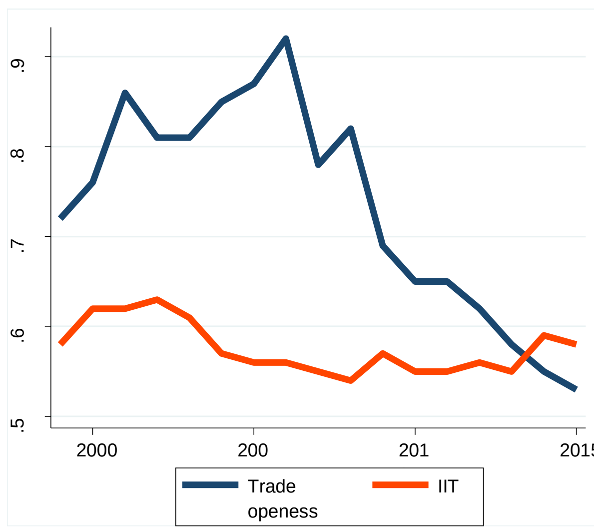
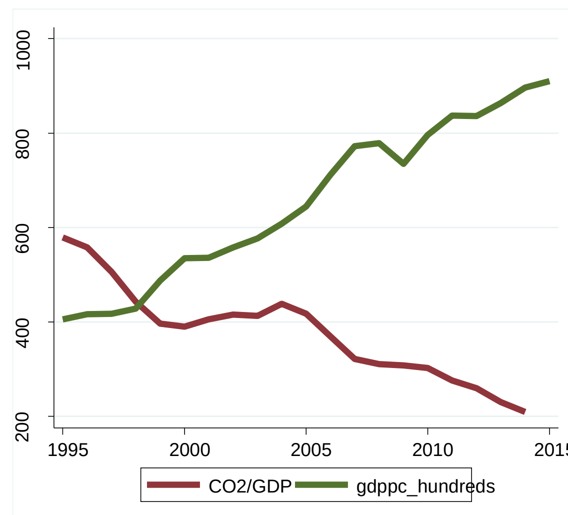
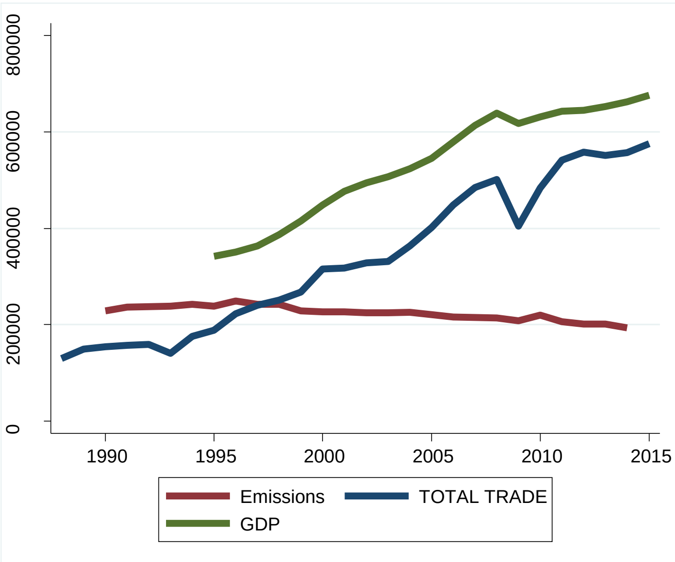
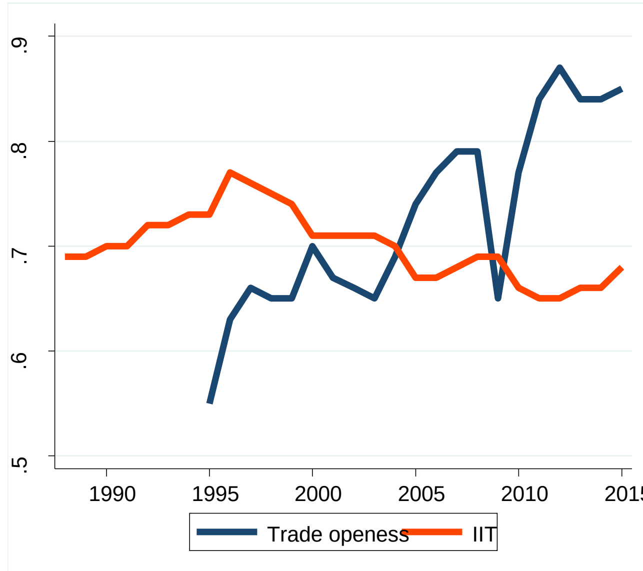


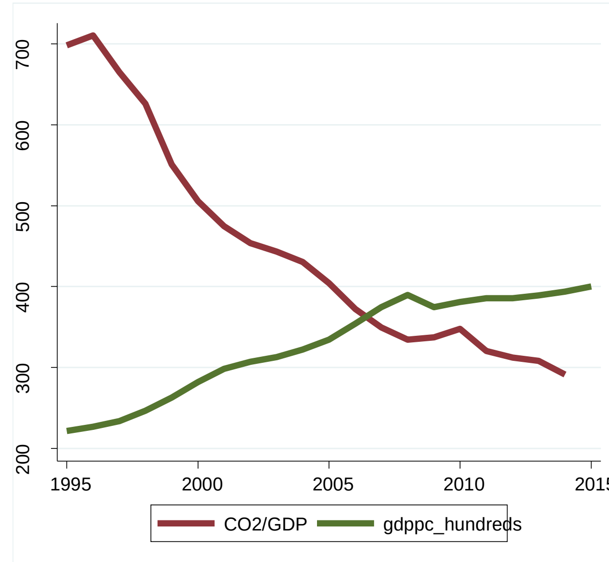




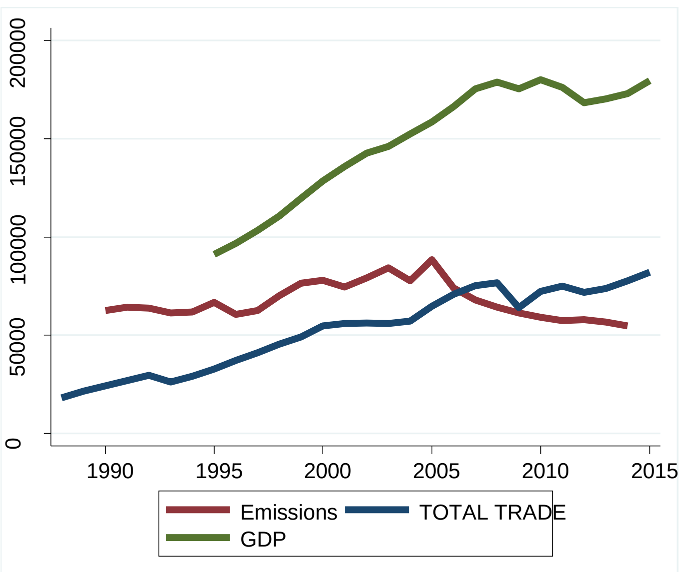
NETHERLANDS

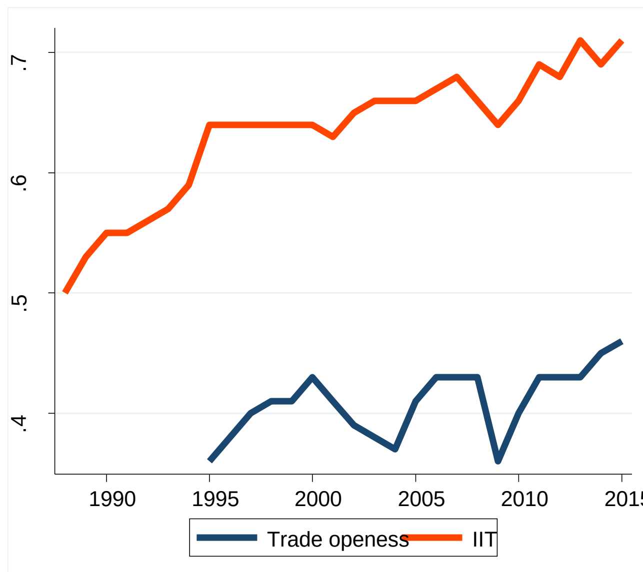


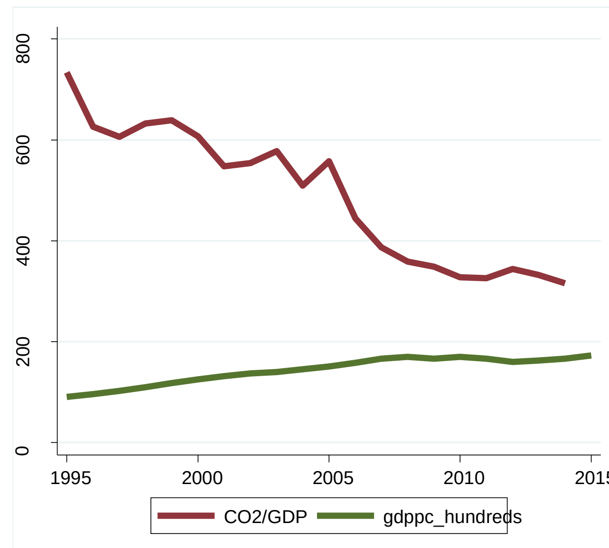




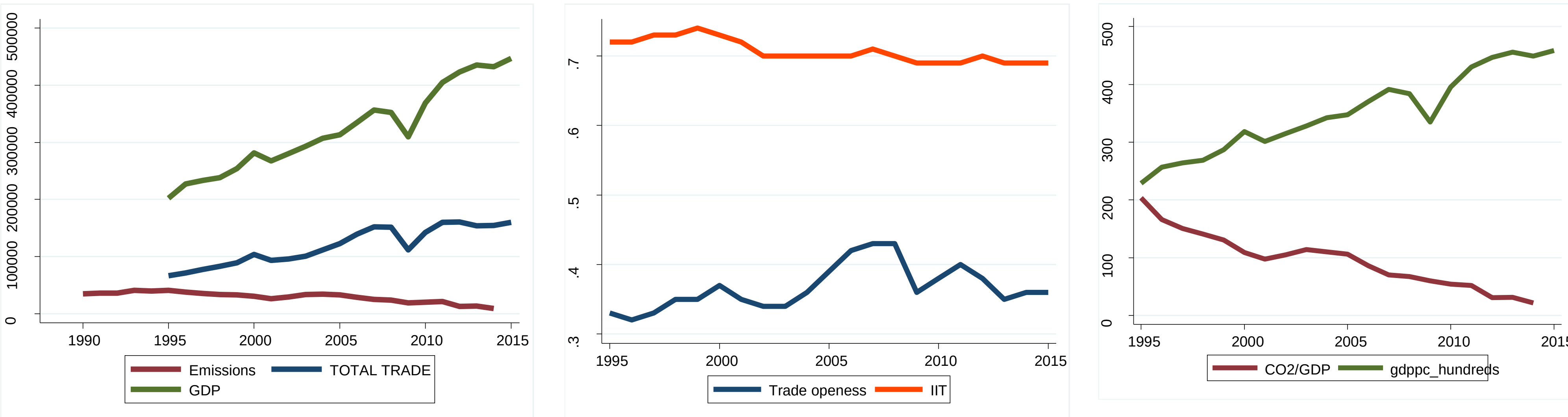
PORTUGAL







SWEDEN


0
100000
200000
300000
400000
500000
1990
1995
2000
2005
2010
2015
Emissions
TOTAL TRADE
GDP
.3
.4
.5
.6
.7
1995
2000
2005
2010
2015
Trade openess
IIT
0
100
200
300
400
500
1995
2000
2005
2010
2015
CO2/GDP
gdppc_hundreds

CEEC

The same analysis is now performed for the CEEC block

Again, a strong and positive relation is confirmed for GDP and Total Intra-EU trade. Regarding the emissions trend, here the situation is a bit different respect to EU 15. The majority of countries, Bulgaria, Czech Republic, Hungary, Lithuania (with ups and downs), Poland, Poland, Slovenia, Slovakia, start with high initial levels of emissions declining over time. This could be an effect of European environmental policies. Malta and Latvia show instead increasing emissions, Cyprus as well, but with a declining tendency from 2008. Among all, Estonia exhibits a curious path: big initial fall, followed by a strong increase around year 2000, falling until 2010 and then increasing again.

The second graph, as above, gives a uniform scenario. CO_2 intensity of welfare is strongly decreasing while the GDP per capita rockets upward.

Concerning the Trade Openness-IIT graphs, a comparison with EU 15 is unavoidable. In the first group of countries, emerges, more or less clearly, the following picture: the main countries have reached a high level of Intra-Industry Trade with the other European countries, but the importance of Intra-EU trade compared to their GDP is lower than expected.

Among the CEEC countries, the tendency appears to be the inverse. Most of the countries exhibit high levels of Trade Openness with lower levels of IIT index

Going deeper in the analysis, different sub-groups of countries are found, sharing almost all a common rising trend. The majority of them, in fact, show an upward trend for Trade Openness: Bulgaria, Cyprus, Czech Republic, Hungary, Lithuania, Latvia (decreasing in the last years), Poland, Romania, Slovenia and Slovakia. Estonia is difficult to evaluate, due to the continuous alternation of decrease and increase periods. Among all of them, only Malta exhibits a decreasing trend with a strong increase after 2010.

A panoramic of the values is reported in the following table.

Table 12: Evolution of CEECs Trade Openness values

Values	Reporter
0.6<TO<1.4	Czech Republic, Estonia, Hungary, Slovenia, Slovakia
0.5<TO<0.7	Bulgaria, Malta (-)
0.4<TO<0.9	Lithuania, Latvia,
0.3<TO<0.6	Poland, Romania,
0.1<TO<0.3	Cyprus

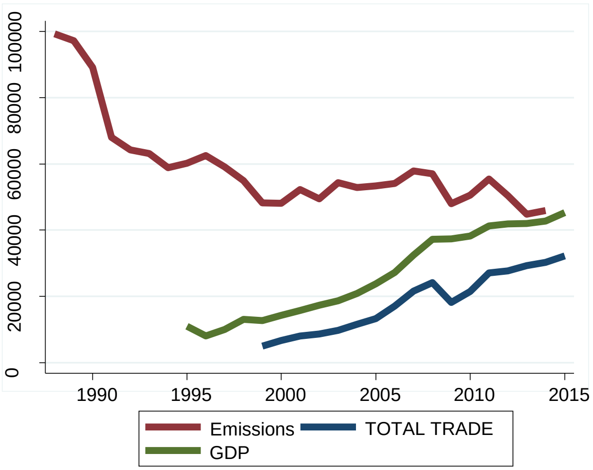
It is immediate to see how greater are the values compared with EU 15; furthermore, almost half of the countries examined have trade with the other European members the equivalent of their GDP.

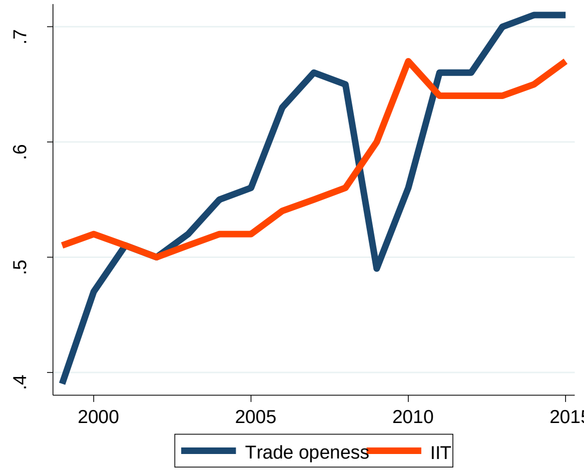
The analysis of IIT is more complex. Half of the countries (Bulgaria, Lithuania, Latvia, Poland, Romania, and Slovenia) exhibit an increasing trend of IIT index, information that could be interpreted, according to the theory, as the convergence of the "peripheral" economies in the EU towards the centrals. A considerable part of them, however, has a steady path (Czech Republic, Estonia, and Hungary) or decreasing (Malta and Slovakia). Cyprus has a not defined tendency.

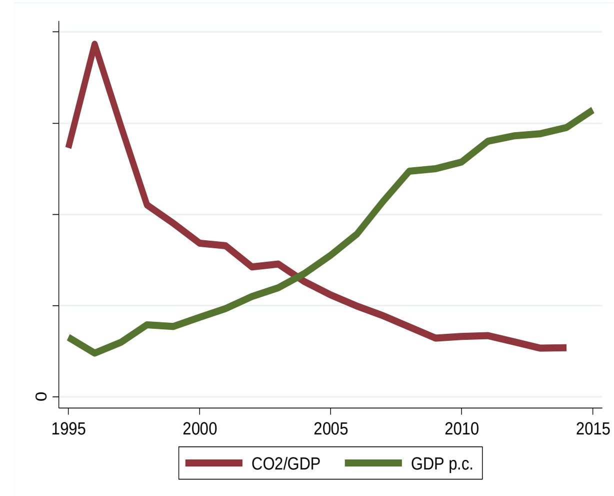
Table 13: Evolution of CEECs IIT values

Values	Reporter
0.7<IIT<0.8	Czech Republic, Hungary, Poland, Slovenia, Slovakia (-)
0.4<IIT<0.8	Bulgaria, Estonia, Romania
0.4<IIT<0.6	Lithuania, Latvia, Malta (-)
0.1<IIT<0.3	Cyprus

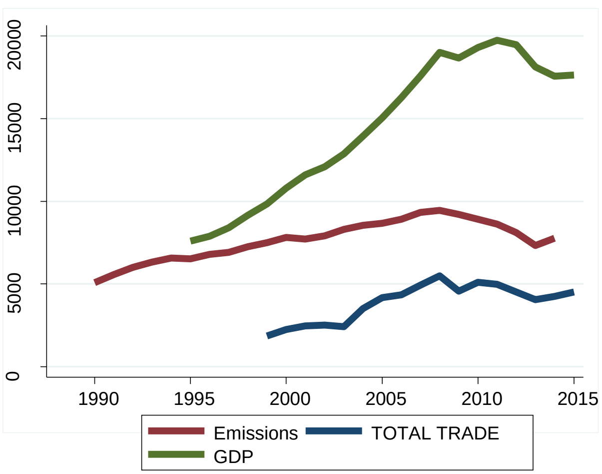
BULGARIA

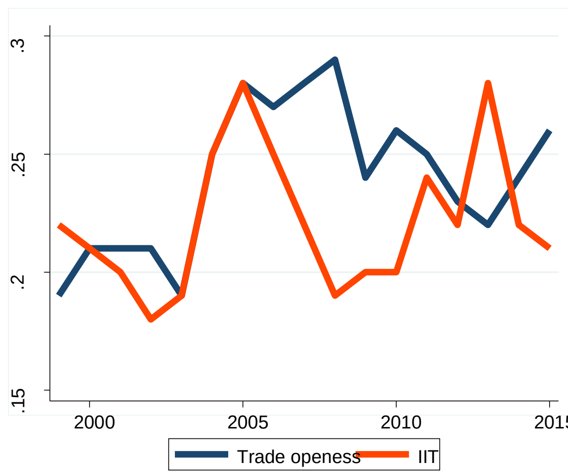


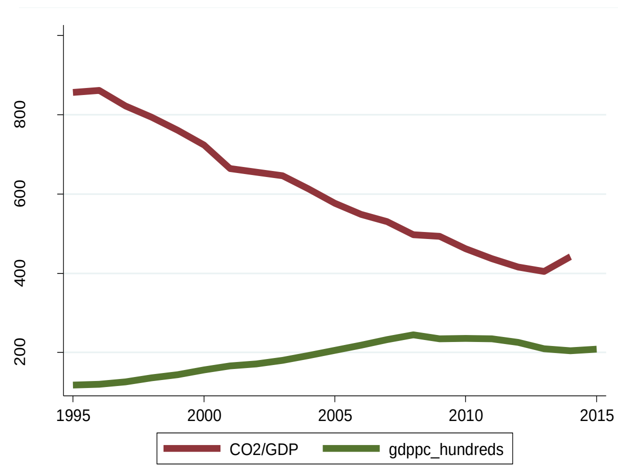




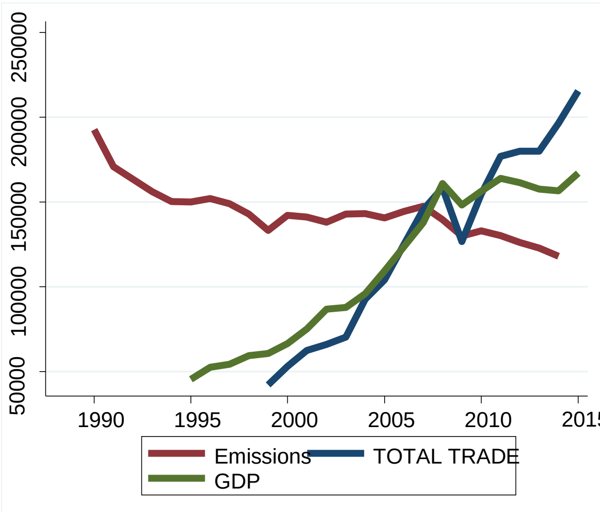
CYPRUS

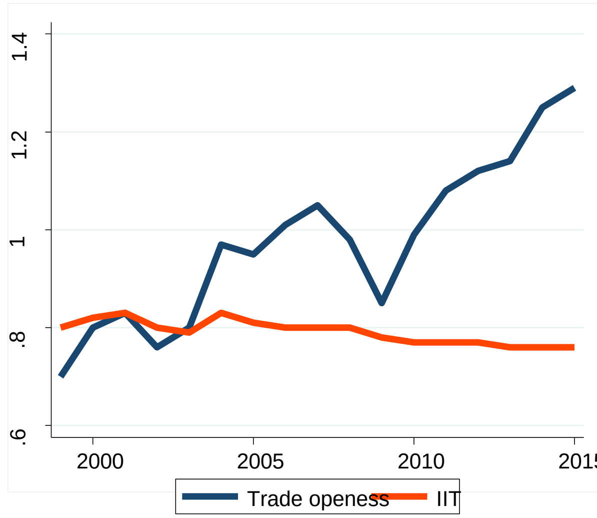


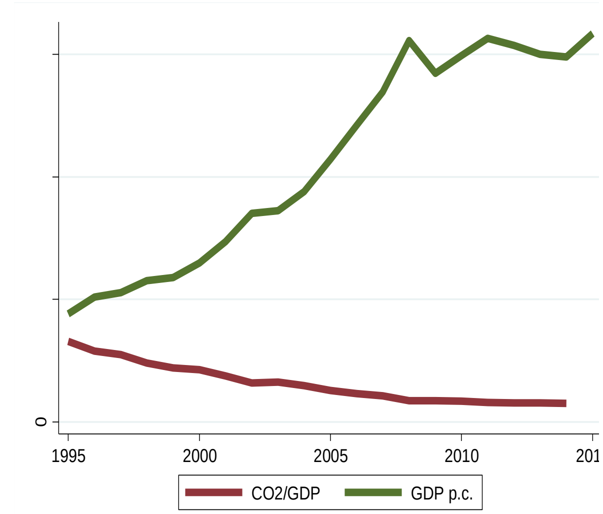




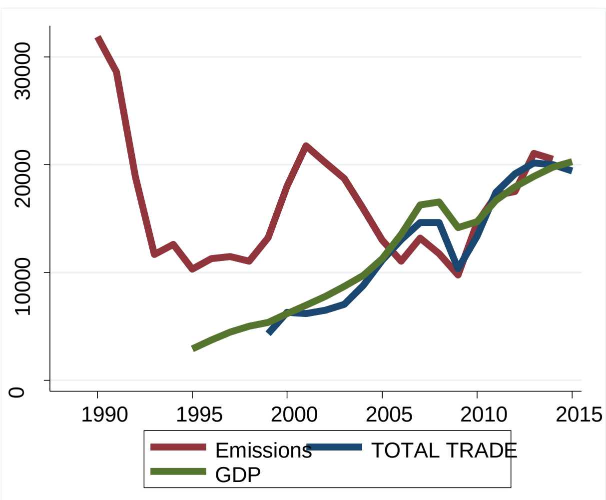
CZECH REPUBLIC

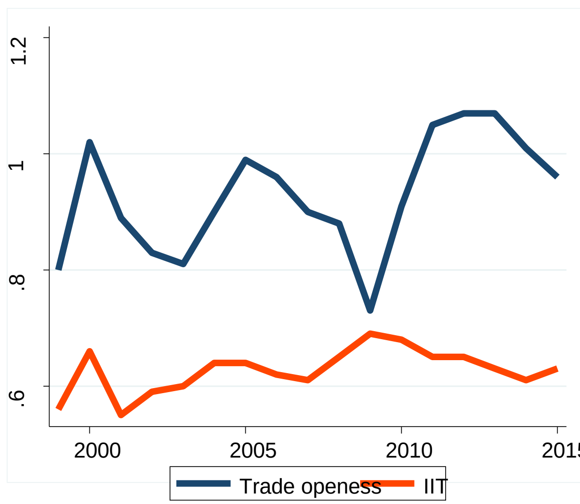


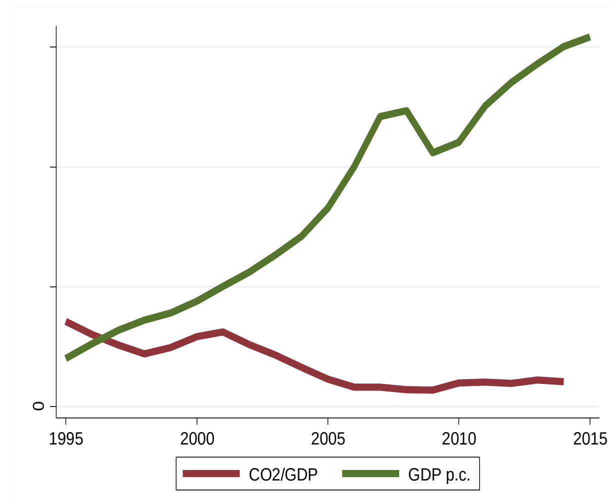




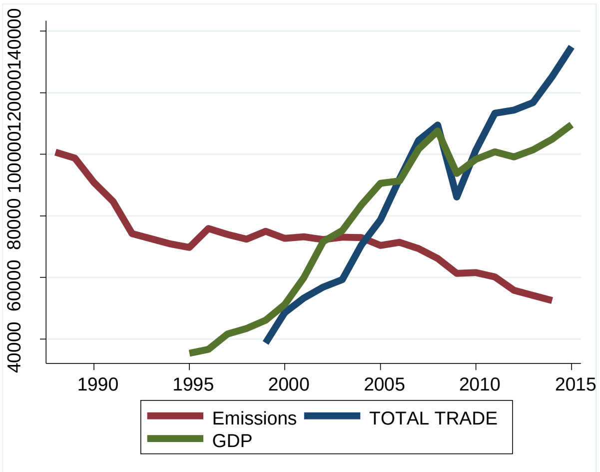
ESTONIA

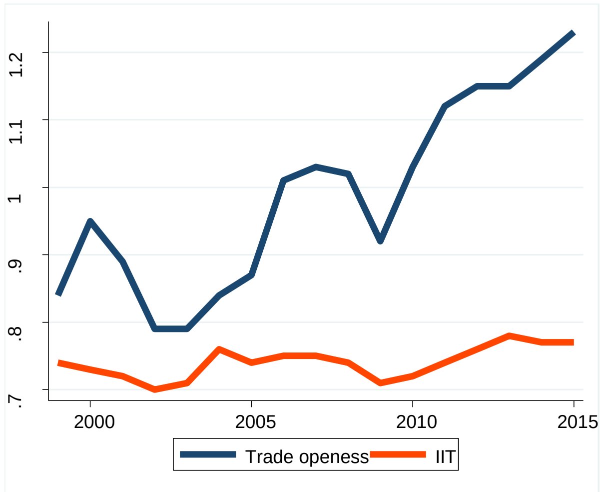


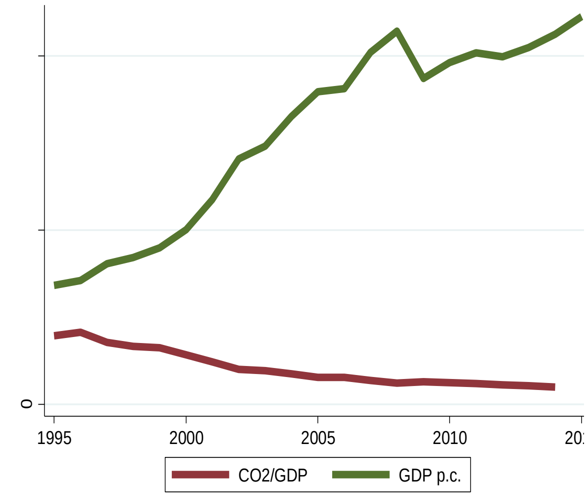




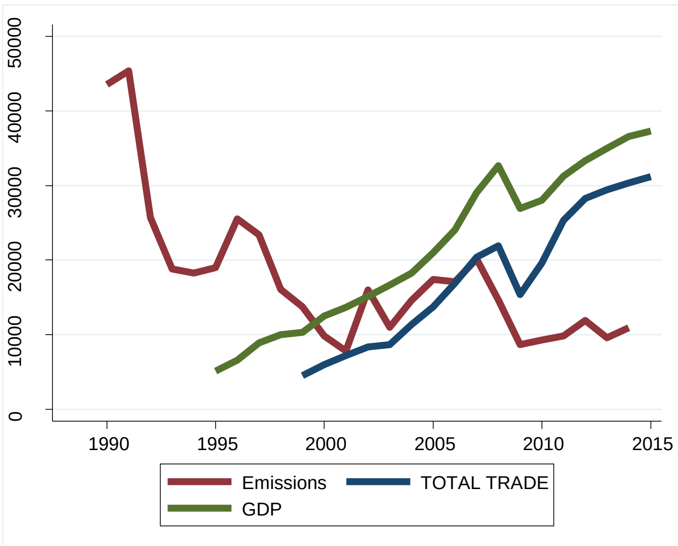
HUNGARY

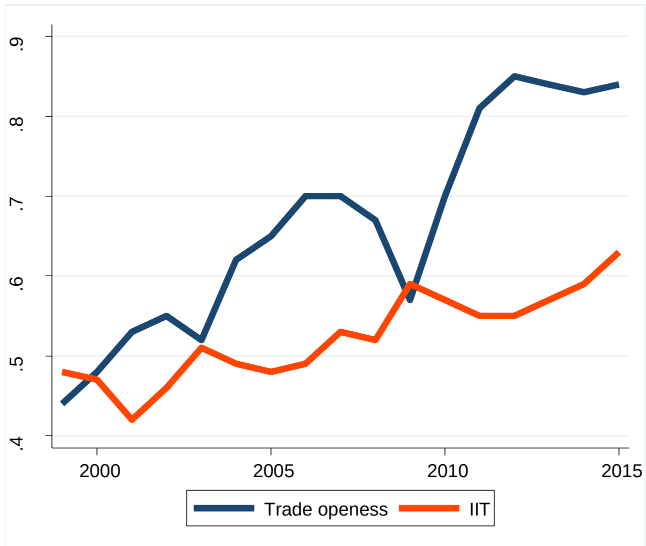


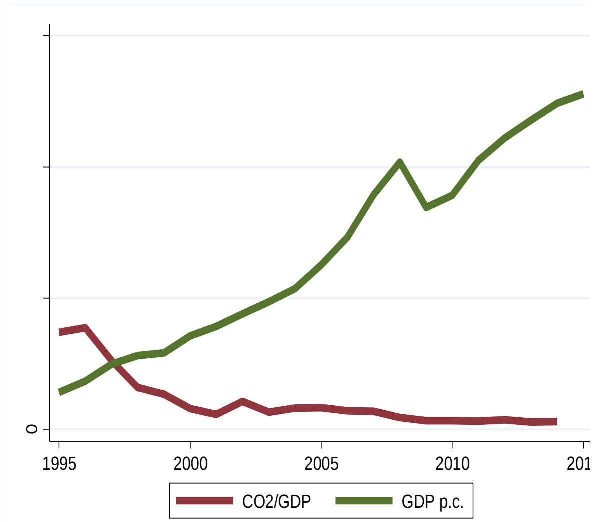




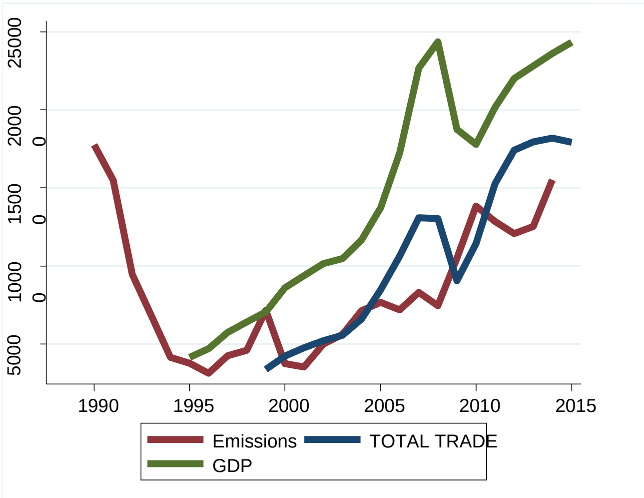
LITHUANIA

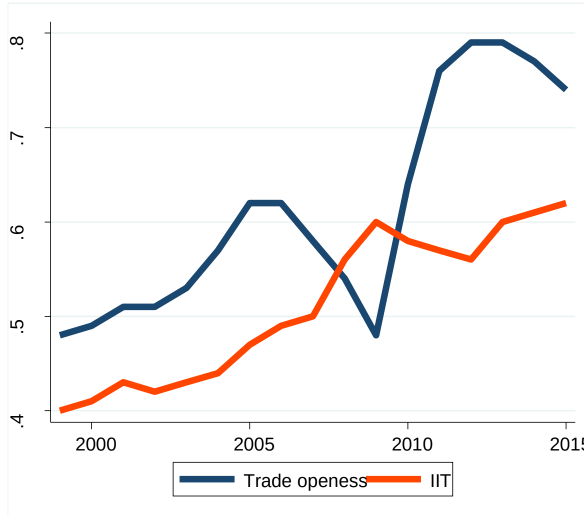


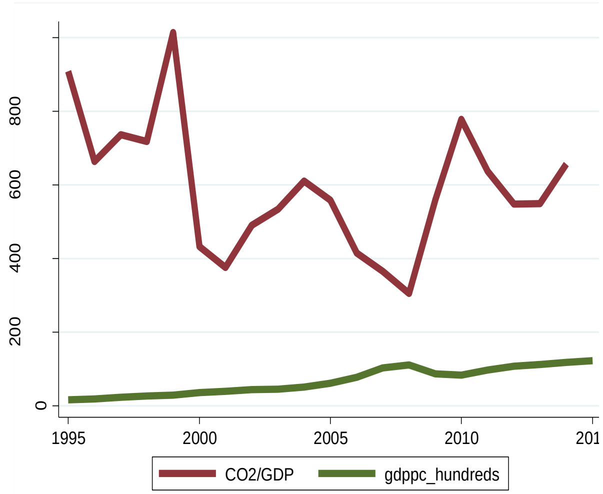




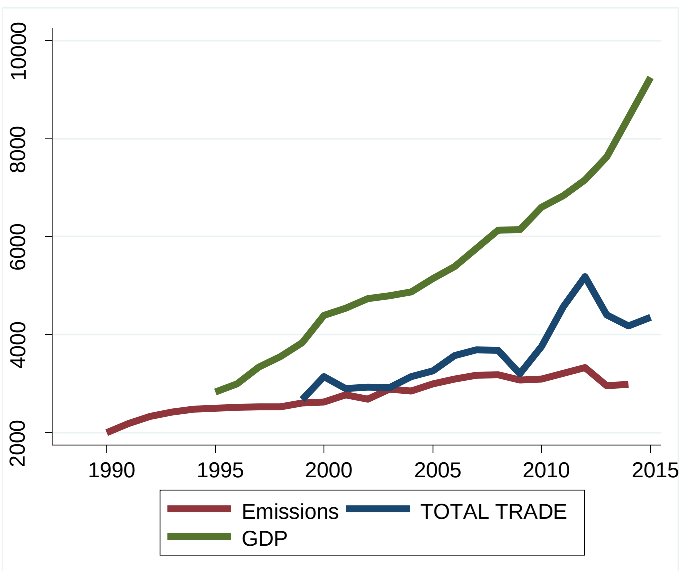
LATVIA

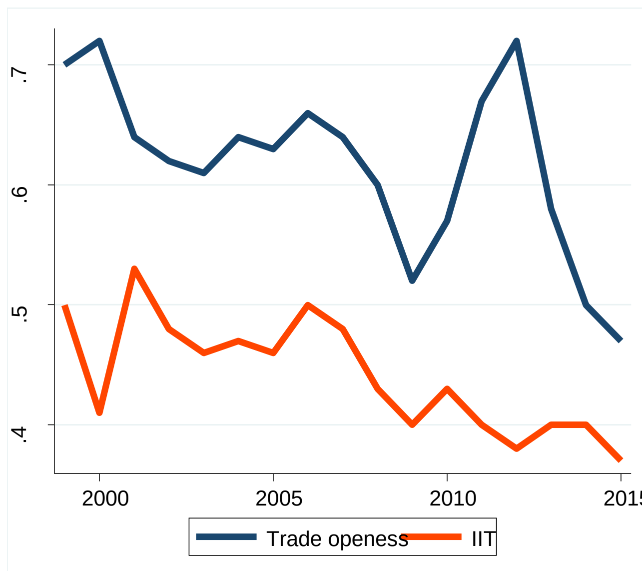


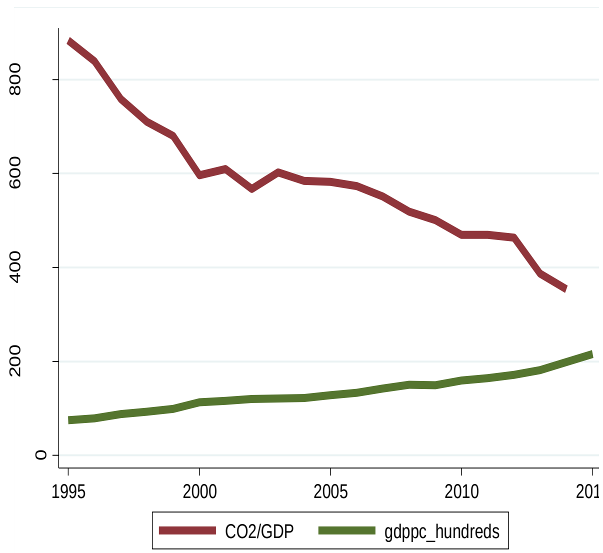




MALTA







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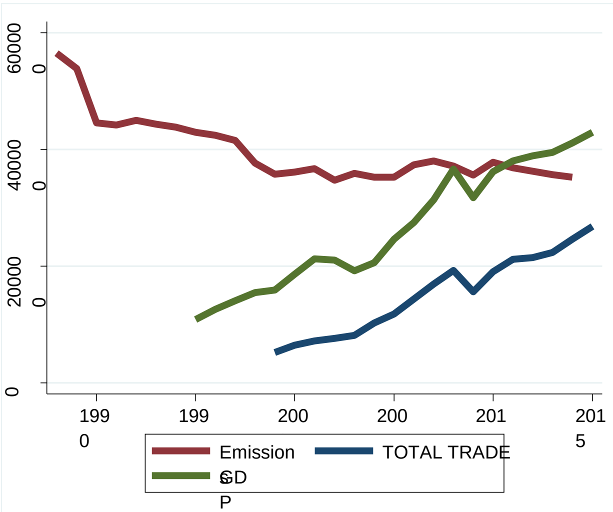

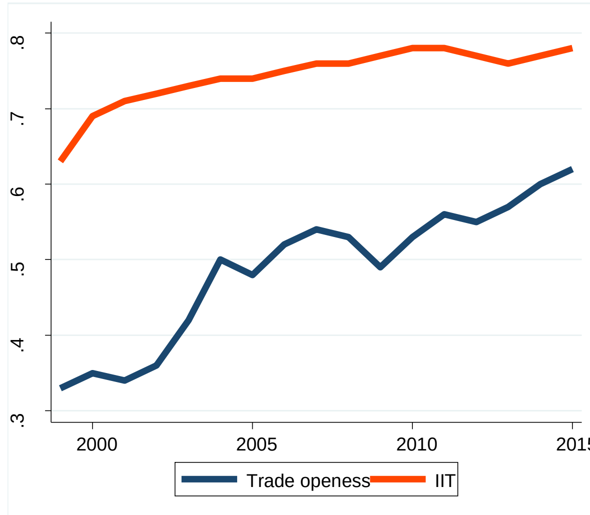

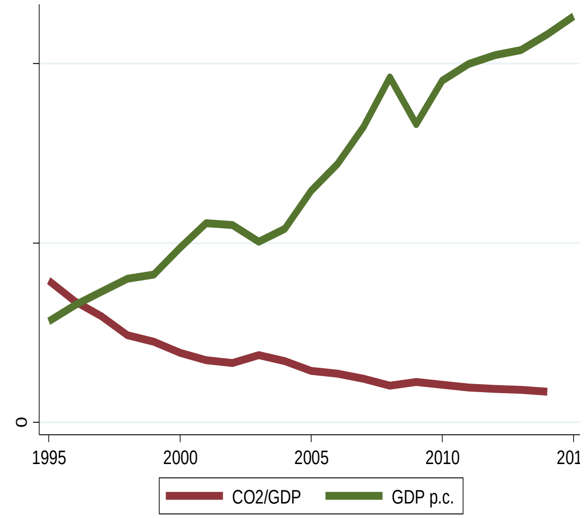

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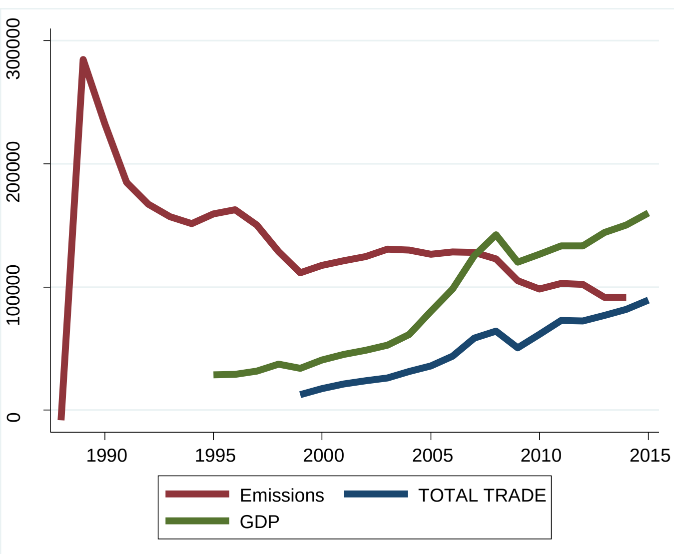
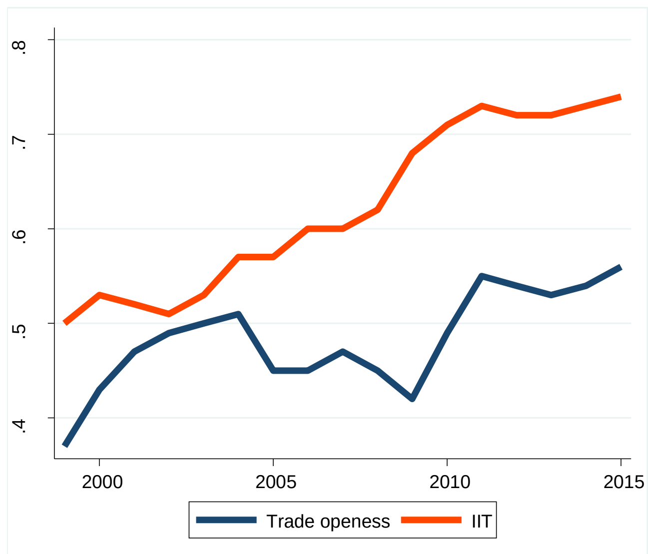
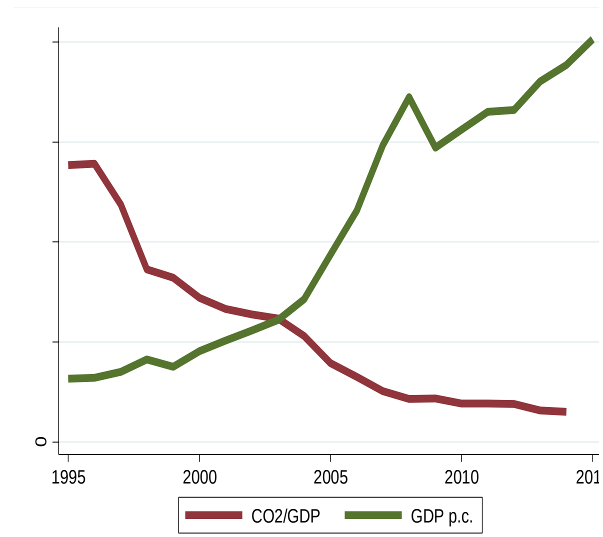
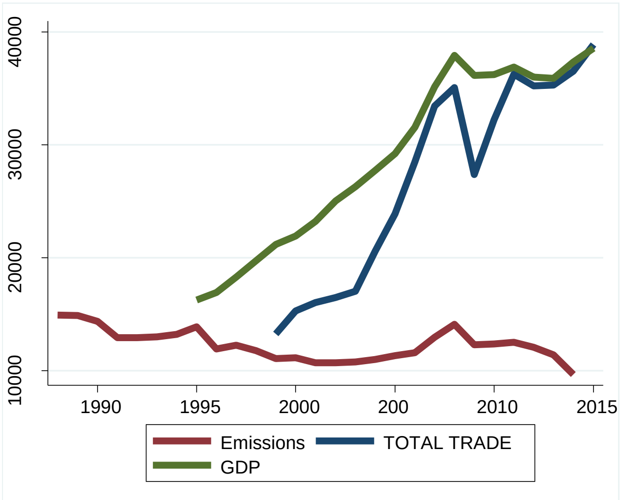
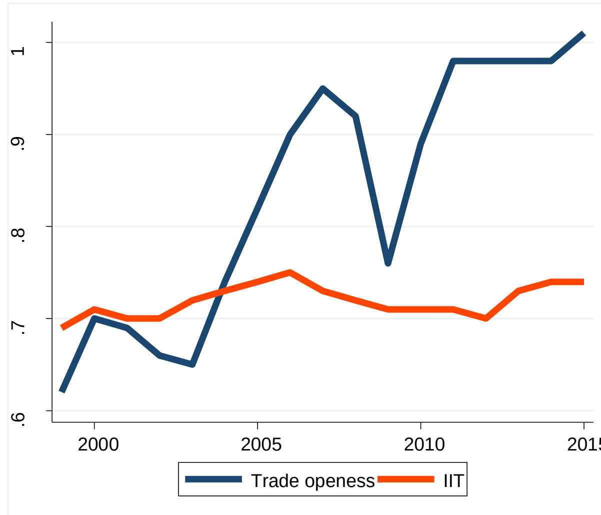


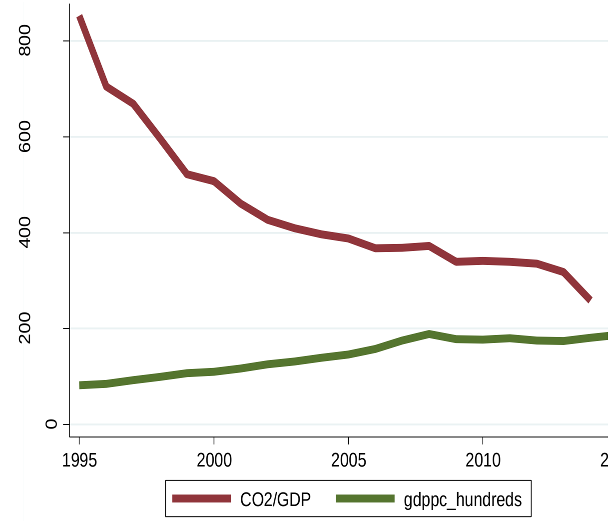




SLOVENIA







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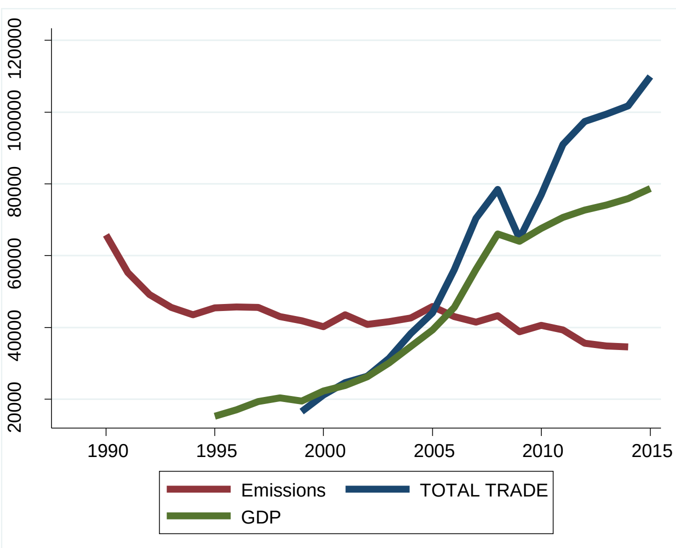

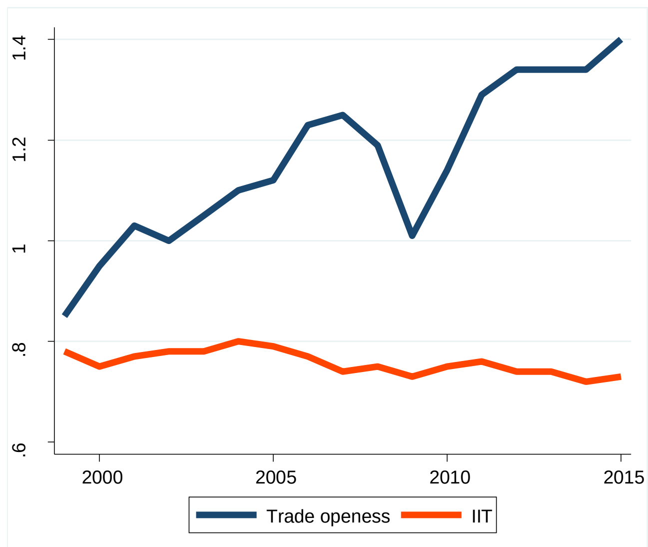

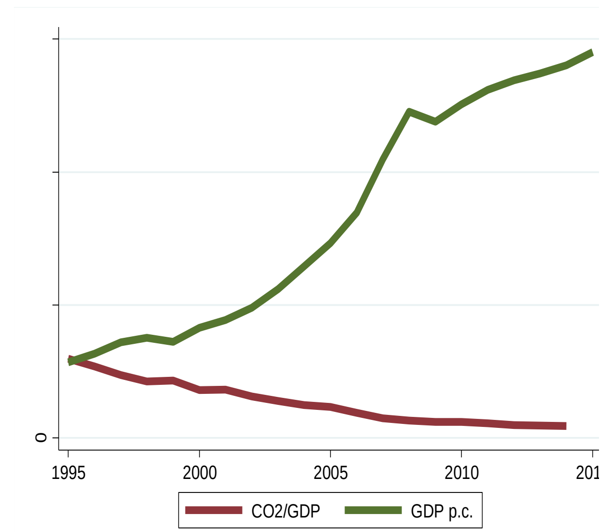

2.3: DESCRIPTIVE STATISTICS

Using the software STATA, descriptive statistics are calculated for the variables Pollution Intensity (CO2/GDP), Trade Openness, GDP per capita, Intra-Industry Trade, Environmental Taxes/GDP (Abatement Costs) and Capital to Labor Ratio (K/L).

Variable	Obs	Mean	Std. Dev.	Min	Max
co2gdp	566	804.7179	886.0672	21.53	7731.5
tradeopeness	540	.5426852	.2941275	.17	1.4
gdppc	598	20967.82	14669.1	964	90977
iit	592	.6504054	.1312758	.18	.83
pc_abateme~s	540	2.630824	.6565213	.8959339	5.303284
K_L_ratio	559	1573.238	970.1426	14.45987	5162.493

2.3.1: Correlations

For the sake of the analysis, it is useful to inspect if the independent variables are correlated with the emissions and if they are, to observe the sign of the presumed correlation

pwcorr emissions totaltrade gdpinmln_n iit environmentaltaxes population_n, sig

	emissi~s	totalt~e	gdpin~_n	iit	enviro~s	popul~_n
emissions	1.0000					
totaltrade	0.8800	1.0000				
	0.0000					
gdpinmln_n	0.9628	0.9860	1.0000			
	0.0000	0.0000				
iit	0.2204	0.2120	0.2145	1.0000		
	0.0000	0.0000	0.0000			
environmen~s	0.9802	0.9842	0.9972	0.2021	1.0000	
	0.0000	0.0000	0.0000	0.0000		
population_n	0.9936	0.9030	0.9782	0.2143	0.9898	1.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	

Results show a high correlation between the emissions and the other variables, and according to the p-values (rows underneath) are significant. However, independent variables are highly correlated among each other. To solve the issue, are analyzed the correlations among variables relativized on GDP.

	co2gdp~j	tradeo~s	gdppc_~j	iit	K_L_ra~j	pc_aba~s
co2gdp_adj	1.0000					
tradeopeness	0.1774	1.0000				
	0.0000					
gdppc_adj	-0.5410	-0.1131	1.0000			
	0.0000	0.0075				
iit	-0.1241	0.1940	0.0635	1.0000		
	0.0043	0.0000	0.1341			
K_L_ratio_~j	-0.5749	-0.1532	0.8880	0.0156	1.0000	
	0.0000	0.0006	0.0000	0.7287		
pc_abateme~s	-0.2389	-0.0885	0.1835	-0.0978	0.1481	1.0000
	0.0000	0.0477	0.0000	0.0286	0.0006	

These findings are much more satisfying. All the variables are correlated with emissions on GDP and the p-values guarantee for the significance. In addition, independent variables seem poorly correlated among themselves, with the exception of K/L and GDP per capita.

Table 14: Scale of variables for the regression

Scale of variables:	
Co2gdp_adj	Hundreds of ton
% Abatement Costs	Percentage
GDPpc_adj	Thousands of euros
Tradeopeness	Percentage
Pop	Mln of units

Key variables are now relativized at Population, to test if they can express better the relation between emissions and independent variables.

	co2pc	tradep~j	gdppc_~j	iit	K_L_ra~j	abatem~j
co2pc	1.0000					
tradepc_adj	0.6073	1.0000				
	0.0000					
gdppc_adj	0.5547	0.7667	1.0000			
	0.0000	0.0000				
iit	-0.0021	0.1139	0.0635	1.0000		
	0.9610	0.0079	0.1341			
K_L_ratio_~j	0.4334	0.6298	0.8880	0.0156	1.0000	
	0.0000	0.0000	0.0000	0.7287		
abatementc~j	0.5592	0.6836	0.9196	0.0505	0.8124	1.0000
	0.0000	0.0000	0.0000	0.2595	0.0000	

The correlation matrix exhibits values less fitting than the precedent set of correlations. IIT is considered not significant correlated with the emissions per capita, and since is the variable this paper seeks to investigate, this set of variables is not appropriate. In addition, independent variables seem to be correlated.

The graphic and descriptive analysis has provided a set of variables with which the environmental impact of trade among EU 27 countries may be examined. The next and final step is to build a regression model and to examine the results.

CHAPTER 3: REGRESSION MODEL

In this final chapter, the econometric model is built combing the variables found correlated with the environmental variable. Is used a linear model approach, starting from a general model and adding several specifications; data are organized as panel covering the period 1995-2014.

3.1: ECONOMETRIC MODEL

Following the surrounding literature, in this analysis is developed a multivariable linear regression, using Emission on GDP as dependent variable, and Trade Openness (*TO*), GDP per capita (*GDPpc*), Intra-Industry Trade (*IIT*) index and Abatement Costs (*pcAC*) as explanatory variables.

Before proceeding, it's useful to recapitulate the hypothesis and the results expected. According to the literature, Trade Openness has a positive impact on the Environmental Quality, thus a negative sign is expected for the estimation. The same for Intra-Industry Trade, with less uncertainty since the trade-induced composition effect is substituted with a selection effect that does not have ambiguity. GDP per capita is widely assumed as beneficial, since it reflects the economic growth of a nation. Finally, there is uncertainty regarding the impact of Environmental Taxes, because no availability was found about econometric analyses involving such parameter. The initial hypothesis assumes Environmental taxes negative estimated, since they are supposed to act as a deterrent for pollution.

3.1.1: Regression Equation

The estimated equation is thus

$$E = \beta_0 + \beta_1 TO_{it} + \beta_2 GDPpc_{it} + \beta_3 IIT_{it} + \beta_4 pcAC_{it} + \varepsilon_{it} \qquad (1)$$

where *i* represents countries and *t* the years of observation.

Looking at the panel data, it is reasonable to assume the existence of unobservable effects specific for each country; thus, fixed country effects are added to improve consistency

$$E_{it} = \beta_0 + \beta_1 TO_{it} + \beta_2 GDPpc_{it} + \beta_3 IIT_{it} + \beta_4 pcAC_{it} + \sum_i d_i + \varepsilon_{it} \qquad (2)$$

where $\sum_i d_i$ indicates a set of country dummies. Results show high correlation between error term and explanatory variables. To solve the issue, the equation is estimated considering for random effects:

$$E_{it} = \beta_0 + \beta_1 TO_{it} + \beta_2 GDPpc_{it} + \beta_3 IIT_{it} + \beta_4 pcAC_{it} + \sum_i u_i + \varepsilon_{it} \qquad (3)$$

Even this approach is not flawless; thus is decided to adopt a mixed model, with both random and fixed effects. In addition, the model considers also for time invariant effects, developing a set of year dummies $\sum_{1995}^{2014} d_t$.

$$E_{it} = \beta_0 + \beta_1 TO_{it} + \beta_2 GDPpc_{it} + \beta_3 IIT_{it} + \beta_4 pcAC_{it} + \sum_i d_i + \sum_{1995}^{2014} d_t + \sum_i u_i + \varepsilon_{it} \qquad (4)$$

3.2: AUGMENTED MODEL

Now is considered a different hypothesis. Following the framework developed by Antweiler, in the equation is added the Capital to Labor ratio, which should reflect the composition effect underlined by the author. Thus the term K/L represents the composition effect and the income per capita term reflects the combined effect of scale and technique. The equation is

$$E_{it} = \beta_0 + \beta_1 TO_{it} + \beta_2 GDPpc_{it} + \beta_3 IIT_{it} + \beta_4 K/L + \beta_5 pcAC_{it} + \varepsilon_{it} \qquad (5)$$

In Antweiler’s paper is assumed non-linearity in the relation between emissions and K/L, as well between emissions and GDP per capita. The authors supposed that low level of Capital to Labor ratio give a country comparative advantage in the production of clean goods; instead, high levels of K/L allow producing more efficiently polluting goods. So then is introduced a quadratic term for K/L, which is supposed to have positive sign with the emissions, while the linear K/L term is supposed to be negative. The same mechanism is applied to GDP per capita: low levels of GDP are associated with low consideration of the environment thus with lax regulations. High income per capita leads to demand for environmental quality and to stricter policies. More important, increase in welfare brings technological progress, which favors the adoption of more efficient and cleaner technologies.

Thus the equation becomes:

$$E_{it} = \beta_0 + \beta_1 TO_{it} + \beta_2 GDPpc_{it} + \beta_3 GDPpc_{it}{}^2 + \beta_4 IIT_{it} + \beta_5 K/L_{it} + \beta_6 K/L_{it}{}^2 + \beta_7 pcAC_{it} + \varepsilon_{it}$$

(6)

Furthermore, in his paper Antweiler seeks to isolate the trade-induced changes in composition effect and scale-technique effect. To analyze them, he introduces a series of interaction terms between Trade Openness and K/L and Trade Openness and GDP per capita. To emulate his method, TO*K/L and TO*GDPpc are introduce. The final equation is:

$$\begin{aligned} E_{it} = {} & \beta_0 + \beta_1 TO_{it} + \beta_2 GDPpc_{it} + \beta_3 GDPpc_{it}{}^2 + \beta_4 IIT_{it} + \beta_5 K/L_{it} + \beta_6 K/L_{it}{}^2 + \beta_7 pcAC_{it} \\ & + \beta_8 TO \cdot GDPpc + \beta_9 TO \cdot GDPpc^2 + \beta_{10} TO \cdot K/L_{it} + \beta_{11} TO \cdot K/L_{it}{}^2 + \varepsilon_{it} \end{aligned} \qquad (7)$$

3.3: REGRESSION RESULTS

The estimation of initial equations (2) (3) (4) gives the following results

Table 15: Initial model regression results

	Fixed Effects	**Random effects**	**Mixed model**
	(2)	(3)	(4)
VARIABLES	co2gdp_adj	co2gdp_adj	co2gdp_adj
tradeopeness	**-8.621***	**-5.963***	**-4.462**
	(1.523)	(1.368)	(1.735)
gdppc_adj	**-0.301***	**-0.291***	**-0.0411**
	(0.0273)	(0.0245)	(0.0502)
iit	**-28.94***	**-21.63***	**-22.98***
	(3.329)	(2.988)	(3.250)
pc_abatementcosts	**0.564**	**0.402**	**0.286**
	(0.446)	(0.430)	(0.433)
Constant	**35.13***	**29.21***	**25.52***
	(2.559)	(2.439)	(3.350)
Observations	501	501	501
R-squared	0.397	0.185	0.816
Number of countrynum	28	28	28

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Results seem to confirm the suppositions; all the explanatory variables show a negative and significant relation with emissions. The only exceptions are the abatement costs which are not significant. When the mixed effect models accounts for countries and year dummies, *GDPpc* loses significance, while *Trade Openness* and *IIT* continue to remain negative and significant; also notably, an important share of dummies has significant coefficients. A possible inference is that the major responsible for the decrease in emissions are country-level policies or the adoption of new technologies; fixed effects that are detected by the country and year dummies. Thus the role of income per capita loses significance.

3.3.1: Testing the augmented model

The aim of replicating the work of Antweiler, Copeland and Taylor is to find whether or not their framework holds with different panel data and in a specific context as the European Union. Testing the Eq. 5

Table 16: Augmented model results

	Fixed Effects	**Random effects**	**Mixed model**
VARIABLES	co2gdp_adj	co2gdp_adj	co2gdp_adj
tradeopeness	**-7.880*** **	**-5.519*** **	**-3.692** **
	(1.529)	(1.371)	(1.762)
gdppc_adj	**-0.202*** **	**-0.174*** **	**0.0236**
	(0.0364)	(0.0347)	(0.0549)
iit	**-27.90*** **	**-21.13*** **	**-22.37*** **
	(3.326)	(2.984)	(3.270)
K_L_ratio_adj	**-1.698*** **	**-2.003*** **	**-1.193*** **
	(0.415)	(0.419)	(0.416)
pc_abatementcosts	**0.309**	**0.142**	**0.128**
	(0.449)	(0.430)	(0.439)
Constant	**35.40*** **	**30.12*** **	**25.30*** **
	(2.546)	(2.435)	(3.367)
Observations	488	488	488
R-squared	0.418	0.222	0.819
Number of countrynum	27	27	27

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Results from the regression are the same as the previous equations. The new variable K/L is negative and significant. Mixed effects model with dummies reflects the same previous scenario. GDPpc per capita is not significant while dummies are. Note that the Trade Openness variable is still negative and significant as well as IIT, not included in the original framework. Abatement Costs are still not significant.

Non-linearity

Accounting for the non-linearity of the relation between Emissions and K/L and Income are introduced in the regression also in the quadratic form.

Table 17: Non linearity results

	Fixed Effects	**Random effects**	**Mixed model**
VARIABLES	co2gdp_adj	co2gdp_adj	co2gdp_adj
tradeopeness	**-1.125**	**-1.201**	**0.103**
	(1.555)	(1.257)	(1.707)
gdppc_adj	**-0.536*** **	**-0.449*** **	**-0.433*** **
	(0.0754)	(0.0678)	(0.130)
gdppc_adj2	**0.00358*** **	**0.00314*** **	**0.00331*** **
	(0.000739)	(0.000691)	(0.000951)
iit	**-21.89*** **	**-14.18*** **	**-18.65*** **
	(3.100)	(2.678)	(3.116)
K_L_ratio_adj	**-5.387*** **	**-6.253*** **	**-4.741*** **
	(0.848)	(0.836)	(0.890)
K_L_ratio_adj2	**1.066*** **	**1.201*** **	**0.964*** **
	(0.156)	(0.154)	(0.157)
pc_abatementcosts	**-0.110**	**0.0428**	**-0.145**
	(0.410)	(0.382)	(0.410)
Constant	**36.01*** **	**29.87*** **	**32.77*** **
	(2.330)	(2.134)	(3.579)
Observations	488	488	488
R-squared	0.523		
Number of countrynum	27	27	27

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Regression results of Eq.6 now differ from Antweiler's paper. He found evidence for composition effect estimating positive effects for low level of K/L and negative for the squared term. His conclusions are that composition effect has a detrimental impact on environment but its effects diminish while it increases.

"An increase in the capital labor ratio raises emissions - consistent with a positive composition effect - albeit increases in this ratio have a diminishing impact much as we may expect. This diminishing effect probably reflects a lower average pollution intensity of capital equipment in high-income countries." (Antweiler, Copeland, Taylor, 2001)

The findings of this paper are the opposite: are found a slightly negative coefficient for K/L and a large positive one for the squared term. Regarding the income effect, the same results of Antweiler are obtained. Negative and significant coefficient sign for GDP per capita and slightly positive for GDP per capita^2 "Finally, the income per capita terms indicate a strong and significantly negative relationship between per capita income levels and concentrations. We again find a diminishing effect but it is less pronounced than that for the capital to labor ratio" (Antweiler, Copeland, Taylor, 2001). Surprisingly, while in the previous models without the quadratic terms GDP per capita turned to be insignificant with the dummies specification, in this case is still significant; furthermore, the trade openness variable has lost its significance. From these observations, could be argued that quadratic term of Income per capita reflects the impact of Trade Intensity on emissions. IIT in contrast, is still negative and significant.

Interaction terms

To properly isolate the trade induced effects, interaction terms between Trade Openness and GDP per capita and K/L are estimated, both in linear and quadratic form.

Table 18: Interaction model results

	Fixed Effects	**Random effects**	**Mixed model**
VARIABLES	co2gdp_adj	co2gdp_adj	co2gdp_adj
tradeopeness	**2.631**	**1.088**	**4.890**
	(3.315)	(3.080)	(3.676)
gdppc_adj	**-0.406****	**-0.454*****	**-0.198**
	(0.159)	(0.155)	(0.196)
gdppc_adj2	**0.00120**	**0.00194**	**-0.000163**
	(0.00218)	(0.00216)	(0.00224)
iit	**-22.47*****	**-14.61*****	**-19.48*****
	(3.358)	(2.890)	(3.347)
K_L_ratio_adj	**-4.956****	**-4.599****	**-4.895****
	(2.096)	(2.076)	(2.135)
K_L_ratio_adj2	**1.083****	**1.056****	**1.132****
	(0.471)	(0.467)	(0.473)
TO_INC	**-0.204**	**0.0371**	**-0.299**
	(0.275)	(0.263)	(0.273)
TO_INC2	**0.00386**	**0.00182**	**0.00511**
	(0.00358)	(0.00353)	(0.00353)
TO_COMP	**-1.022**	**-3.150**	**-0.199**
	(3.539)	(3.483)	(3.667)
TO_COMP2	**-0.00311**	**0.261**	**-0.250**
	(0.767)	(0.757)	(0.779)
pc_abatementcosts	**-0.0188**	**0.102**	**-0.0280**
	(0.423)	(0.398)	(0.424)
Constant	**33.91*****	**28.60*****	**29.72*****
	(2.768)	(2.628)	(4.222)
Observations	488	488	488
R-squared	0.526		
Number of countrynum	27	27	27

Standard errors in parentheses

Findings from the final regression (Eq.7) are striking and generate more confusion than light. First of all, the variable for trade intensity TO is not significant anymore in any scenario. GDP per capita is significant in models without dummies but with dummies becomes insignificant. IIT is significant and negative in each case. Capitals to Labor ratios, both linear and quadratic, maintain the same sign as the previous regression and their significance. But when it comes to interaction terms, results are very poor. Each of them is insignificant, contrary to the findings of Antweiler. The only possible conclusion is that this paper has not been able to replicate *in toto* the results of Antweiler, Copeland and Taylor, i.e. to isolate composition and scale-technique effect.

3.4: DISCUSSION

Despite the apparent final failure, the analysis conducted brings some interesting findings. First of all, in the basic regression model the main variables have obtained low p-values which witness their significance. Moreover, their coefficients are in line with the surrounding literature. Antweiler Copeland and Taylor, 2001, Frankel and Rose, 2003 Cole, 2004 found negative coefficient signs for Trade Openness, in line with the results contained in the current paper. The authors also share findings for GDP per capita or Income Effect. It's important to note that adding year and country dummies the effects of GDP are absorbed by such variables, sustaining the hypothesis by which the main effect of income on the Environment is to produce more stringent policies and more efficient technologies. Sadly, Environmental Taxes turned out to be insignificant in every scenario, so no inference can be performed on them. Finally, the Intra-Industry Trade ratio, the core of the analysis, appears to be strongly negative and significant related with emissions; thus, beneficial for the Environment

Proceeding with the analysis, the attempt to replicate the Antweiler framework leads to mixed evidence. The adoption of the new variable K/L and of the non-linear relations between emissions and GDP per capita and emissions and Capital to Labor gives results consistent with the initial hypothesis. Furthermore, the coefficients if Trade Openness and IIT don't change in sign. The only difference is the response of GDP per capita, that is predicted to be beneficial for the Environment at lower, initial values, but when it increases, this beneficial effect declines, becoming even detrimental for the environment. A possible explanation could be that authors such Antweiler and others used measures of *concentration* of pollutants such SO_2, which account mostly for emissions generated by production processes and have a strong local impact. The environmental variable used in the current paper (GHG *intensity*) instead, accounts also for emissions generated by consumption (transport, use of products, etc.), with a global recognized effect. Thus, this could lead to different results. The explanation could be extended in explaining the non-significance of interaction terms: differences in observations, econometric methodology and dependent variables make difficult to obtain the same results of other models.

In order to increase the robustness of results, the Augmented Dickey-Fuller test is performed on the single variables to check if they are stationary. Results from level variables indicate stationarity if a time trend is taken into account. The panel data would deserve deeper analyses of possible econometric issues; unfortunately, in this study was not possible to conduct them.

CONCLUSION

This paper attempts to verify the relation between trade among 27 European countries and their national emissions. More specifically, we want to assess if the impact of European trade is beneficial or detrimental for the Environment. We started with a revision of the literature to examine previous results; the majority of the literature estimates a positive relation between Trade and the Environment. The framework developed by Antweiler was adopted as ground base of the analysis. Trade impact can be divided into three distinct effects: scale (negative), technique (positive) and composition (ambiguous).

After that, we focus the attention on Intra-Industry Trade and its characteristics, and we found that it's supposed to have a more beneficial impact on Environment than Inter-Industry Trade. Since IIT does not allow countries to shift production between more polluting or less polluting goods, the trade-induced composition effect is substituted with selection effect. With the opening to trade, domestic firms have to face the foreign competition (since they are producing different varieties of the same product) and the pollution costs, represented by the policies adopted by the government. It follows that some firms, both in domestic and foreign country are forced to leave the market, thus reducing total pollution under the assumption: less firms equal to less pollution. Furthermore, IIT is considered to be a good vehicle through which Nations can exchange technologies and progress. For its characteristics, IIT develops broader among countries with similar features (population, GDP, preferences etc.) and with high levels of income. Thus, European Union is a perfect example to take. We decided then to focus our analysis on the patterns of trade among EU 27 and to compare them with the emissions of Greenhouse Gases (CO_2 equivalent).

Data analysis shows a strong correlation between increase on GDP per capita and decrease of emissions. The relation between trade, IIT and emissions is more difficult to forecast, since Trade Intensity and Intra-Industry trade are higher in the most polluting sectors, Manufactured Goods and Machinery. Thus, it is an optimum test for our hypothesis.

Finally, we built the regression model and obtain results. Results that are perfectly in line with the literature: Trade Openness and IIT have negative relation with the emissions. Thus, from the data we have, it can be inferred that trade among European countries and particularly simultaneous export and import within the same sector are beneficial for the environment.

We are aware of the limits of our analysis: there is no perfect match between data since we are comparing emissions from all activities of a country and only the trade with nearby European countries, without considering Extra-EU trade. So, probably are missing some variables that could give more precise explanations, but that is beyond the scope of this paper. Our scope was not to assess the relationship between trade and Environment worldwide valid.

Our scope was to assess the consequence of Intra-EU trade, a sort of evaluation of the environmental goodness of European Union and its mechanism of integration, overall trade. And, looking at the data, seems we reach it.

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