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INTERNATIONAL TRADE AND ENVIRONMENT

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ABSTRACT

The relationship between environment and inter/intra national trade has attracted the attention of most of the scientific community, also because of the great risks and consequences that climate change will cause in the coming years if temperature and CO2 emissions are not reduced.

In this paper, the main models explaining this relationship are presented, first between international trade and the environment, with the introduction of the environmental Kuznet curve, the Pollution Haven Hypothesis and the Factor Endowment Theory. The link between a new scheme, i.e. intra-industry trade and the environment, is then explored. Using the same scheme for assessing international trade as a framework of analysis; the scale, technical and composition effect (in addition the selection effect). Finally, considering the positive effect of intra-industrial trade even more than international trade, some instruments that can facilitate the reduction of emissions are presented, such as International Environmental Agreements (IEA) and the Boarder Carbon Adjustment tool to facilitate the creation and accession of countries to trade agreements. In addition, the effect of a trade closure versus a trade opening situation is studied, assessing welfare from both an environmental and socio-economic perspective.

SOMMARIO

La relazione tra ambiente e commercio inter/intra nazionale ha attirato l'attenzione della maggior parte della comunità scientifica, a causa anche dei grandi rischi e conseguenze che il cambiamento climatico causerà nei prossimi anni se la temperatura e le emissioni di CO2 non verranno ridotte.

In questo lavoro, vengono presentati i modelli principali che spiegano tale relazione, prima tra il commercio internazionale e l'ambiente, con l'introduzione della curva di Kuznet ambientale, della Pollution Haven Hypothesis e della Factor Endowment Theory. Ho approfondito il legame tra un nuovo schema, cioè il commercio intraindustriale e l'ambiente, utilizzando come schema di analisi lo stesso schema per la valutazione del commercio internazionale; l'effetto di scala, tecnico e di composizione (in aggiunta l'effetto di selezione). Infine, considerato l'effetto positivo del commercio intra-industriale ancor più del commercio internazionale, vengono presentati alcuni strumenti che possono facilitare la riduzione delle emissioni come gli accordi internazionali con scopi ambientali (IEA) e lo strumento della Boarder Carbon Adjustment per facilitare la creazione e l'adesione dei paesi agli accordi commerciali. Inoltre, viene studiato l'effetto di una chiusura commerciale rispetto ad una situazione di apertura commerciale, valutando il benessere sia da un punto di vista ambientale che socioeconomico.

INDICE SOMMARIO

CHAPTER ONE

INTERNATIONAL TRADE AND ENVIRONMENT: THEORETICAL FRAMEWORK

CHAPTER TWO

INTRA-INDUSTRY TRADE AND ENVIRONMENT: A NEW PATTERN

CHAPTER THREE

POLICIES, ENVIRONMENT, AND INTERNATIONAL TRADE

Introduction

The increasing global warming and the consequent disastrous effects on the planet predicted by mathematical models, although we are already starting to see some consequences such as the warming of the seas and the melting of glaciers, have led many scientists and researchers from various disciplines to take an interest in this subject. From an economic point of view, global warming would bring disastrous effects, with an estimated loss of 8.5% of the GDP of the G7 countries, corresponding to about 5 trillion dollars, if temperatures increase by 2.6°C by 2050.

Hence, what researchers and governments are trying to study and discover is a solution or a tool that could allow a reduction in temperature and CO2 emissions. To achieve this, most of the academic literature has focused on the relationship between trade and environment. In this thesis, I will present the principal theories that can describe the relation between international trade and environment, finding that intra-industry trade has a higher positive effect than international trade, due to scale, technique, composition and selection effect.

Moreover, I present some tools as International Agreement that can be used to reach a reduction of CO2 emissions; indeed, a global problem can be solved only with a shared action of all countries. To facilitate this, I introduce boarder carbon adjustment, a tariff that allows the costs of countries that are signatories to the trade agreement to be equalised with those of non-signatories, thus avoiding the phenomenon of free riding. Finally, I introduce the effect on environment with trade frictions, finding that trade openness has better effect on total welfare, considering it from an environmental and socioeconomic point of view.

CHAPTER 1: International trade and environment: theoretical framework

1.1: International Trade and Environmental Kuznet Curve

The rise in the average temperature on Earth is now an incontrovertible fact. About 97% of scientists claim that the 1.2 degree increase in a temperature in about 100 has an anthropogenic origin, i.e., related to human activity; this is called the 'Greenhouse Effect'.

The greenhouse effect is a climatic phenomenon, which, through the combination of different gases, such as methane (CH4) and carbon dioxide (CO2), shields the sun's rays and retains its heat, raising the temperature to 15 degrees instead of -18 degrees at ground level. This makes it possible to say that the greenhouse effect is fundamental in making the Earth a habitable planet.

At the same time, too great an increase in these gases in the atmosphere can lead to excessive warming of the Earth, resulting in higher temperatures. Humans release many natural gases into the environment, especially carbon dioxide which can be considered the best indicator for measuring the level of pollution in a country (Alvarado et all, 2018). Human effects on the environment are called externalities: if they lead to an improvement in the environment, they are called positive externalities, otherwise negative.

Man's limited vision to date has led to an over-use of non-renewable sources, causing serious damage to today's society and, above all, to the long-term sustainability of future generations. Just think of the melting of glaciers leading to rising sea levels, threatening the existence of many coastal cities by 2100, or the increasingly frequent occurrence of violent and extreme weather phenomena, such as the fire in Australia in late 2019-early 2020 that burned 8 million hectares of land in about 4 months.

For these reasons, the scientific community has become interested in studying the phenomenon that links human activity to the environment, introducing many different empirical and theoretical models. One of the most important models that paved the way for subsequent studies is the Environmental Kuznet Curve by Gene Grossman and Alan Krueger, that relates environment with economic-growth, in which trade is a driver of the economic growth.

This curve has some similarity with Kuznet Curve, presented by Simon Kuznet (Nobel winner for Economy in 1971) who relates income's inequality with income per capita. What you get is a bell shape or "inverted U shape": at an early stage, as income rises, inequality rises but, once a turning point is reached, inequality falls as income rises. Grossman and Krueger readapted this theory, in which they correlated income per capita and pollution. Pollution is difficult to represent because it has several dimensions, like the water, the air, diversity of animal species. For these reasons, their proposed model considers indicators regarding the concentration of dangerous materials in air or water, like Sulfur Dioxide (SO2); suspended particles (divided into "smoke" and "heavy particles"); state of oxygen; pathogenic contamination; and heavy metals concentration. The counterpart is represented, as mentioned above, by income per capita; to isolate the effect of income, authors have included also qualitative and quantitative variables like population size and manufacturing share, both inversely correlated with pollution (higher population, higher emissions, and higher manufacturing share therefore means an economy industry oriented harmful to the environment). Another variable is Trade, positively linked with income per capita.

What they found is the same bell shape in which pollution rises as income rises until a turning point is reached: the relation is negative, and pollution falls as income rises. The large importance to this theory was given also by the Report of 1992 of World's Bank in which "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,1992).

The explanation of this relation is because, in the early phase, citizens and the government are more interested in the return of benefit in a short period, so they invest in economic activities that do not care about environmental sustainability. As income rises because of these investments, levels of pollution rise. When citizens reach a good level of wealth, demand for less polluted air and water start to rise and policy makers are obliged to orient the policy towards greener solutions. Moreover, with the increase of income, the country can invest more in cleaner technologies that pollute less. Basically, with the increase of income, the attention to environment in terms of population and investing rises, which explains the negative slopes of the Environmental Kuznet Curve (greener products and investments in cleaner technologies). Authors found that the turning point varies for different pollutants but is almost in every case equal to $8000.

Diving deeper to the mechanisms, Grossman and Krueger (1991) divided the effect of growth to the environment in three different effects: scale, composition, and technique.

Firstly, the Scale effect represents the effect linked to the size of the economy, thus more output means more input and more natural resources to be used in the production process. Moreover, more products mean more waste and emissions by product, contributing to the degradation of the environment.

The Second effect is the composition effect in which the composition of the activity in the economy determines its effect on the environment. Particularly, there is a degradation effect on the environment if the economy of the country changes from rural to urban or from agricultural to industrial. Environmental degradation can also fall if the economy changes from industry to services, which are technology-intensive and cause less pollution. Basically, effect is the ambiguous because it can go to a direction or another; even if the income grows, the economy changes and "gradually increases cleaner activities that produce less pollution" (Dinda, 2004).

The last effect is the technical effect whereby a rich country can spend more on research and development: this allows the country to replace obsolete, and polluting technologies and plants with newer and greener ones.

These three effects explain the different slopes of the EKC: in the early stages, the scale effect prevails over the others and as economic growth takes place, there is an increase in emissions. Subsequently, as income increases, there is an increase in the prevalence of activities with less pollution impact (composition effect) and greener and more efficient technology (technical effect).

Although the EKC model works quite well from a theoretical point of view, the same cannot be said from an empirical point of view. There are many studies that have found inaccuracies or inconsistencies in the model. The study by Harbaugh and Levinson (2001) revised Grossman and Krueger's model, adding more econometric variables and considering more data regarding air pollution. The results show that the bell shape or inverted U shape strongly depends both on the data sample considered and on reasonable permutations of the econometric specification. Another important contribution in this field has been given by Shafik (1992). The Author introduces ten different economic variables and he found three different patterns: "some indicators vary positively with rising income (water and sanitation), others worsen and then improve (particulates and sulfur oxide) and others worsen steadily (like dissolved oxygen in rivers, municipal solid wastes and carbon emissions)". Thus, the results are therefore of different types and not always in line with the EKC.

Another important contribution is the work by Brian R. Copeland and M. Scott Taylor (2003) in which the authors show that there is no simple relation between pollution and per capita income. Particularly, the reason is due to the endogeneity of the two variables and the effect of the growth to the pollution depends on what generates growth. For this reason, they introduced the model of “sources of growth”: according to that, “income gains brought about by increased trade or neutral technological progress tend to lower pollution, while income gains brought about by capital accumulation raise pollution. The key difference is that capital accumulation favors the production of pollution-intensive goods, whereas neutral technological progress and increased trade do not.” (Copeland, Taylor, 2003).

In conclusion, the Environmental Kuznet Curve is not robust enough: the bell shape holds for some data samples and not for others~~,~~ - it works in some country regions and not in others. It is therefore necessary to introduce other theoretical models, based on the comparative advantages of Ricardo's model, to better explain the relationship between international trade and the environment. The theoretical framework of these models will therefore be presented in the next section.

1.2 Pollution Heaven Hypothesis and Factor Endowment Theory

In this section, I will discuss two alternative theories based on the comparative advantages of countries that give opposite results. The first theory is the Pollution Heaven Hypothesis, a theory against the fact that international trade can have a beneficial effect on the environment.

This theory is based on the fact that the comparative advantage of a country is due to its’ environmental regulation. There are two countries, North and South, which produce two goods, X and Y, and which have two different levels of environmental regulation; good X will be a relatively expensive good in the North, a country with more stringent environmental regulation, and it will have a comparative advantage in production of clean goods. What is then generated is a trade flow in which the citizens of the North country will import good X, while the citizens of the South country will import good Y. Environmental regulation has thus generated a comparative advantage, on which the trade flow is based.

From the environmental point of view, country X has a comparative advantage in the production of the "cleaner" good; thus, in country North there will be a lower level of pollution. Conversely, in country South, producer of the dirtier good, there will be a higher level of pollution. This is due to exogenous differences in emission intensities: "Trade induced by pollution policy

differences creates a pollution haven in the country with weaker policy" (Copeland, Taylor, 2003). Pollution therefore decreases with increasing income not because, as mentioned in the previous paragraph, people become more environmentally conscious and the country can invest more in cleaner technologies, but because richer countries move the production of dirty goods to countries where environmental regulation is more permissive. Thus, there is a comparative advantage in producing dirty goods from the different regulations.

To analyse the welfare effect of trade, two different types of effects must be considered. The first is the welfare effect of international trade, which allows both countries (North and South) to import a good at a lower price (North good X, South good Y). The second effect is related to pollution levels, which will decrease in the North and increase in the South. Thus, the Northern country will gain from trade, while the Southern country will only gain from the first effect. Moreover, if the gain from increased consumption of good Y is more than compensated by the welfare loss from increased emissions, country South will lose completely from trade liberalization. In conclusion, if the environmental regulations are considered as exogenous variables, “then trade may indeed create a pollution haven in the country with weaker pollution regulations. The country that becomes a pollution haven may lose from trade if pollution is sufficiently damaging, while the country with stricter pollution regulations gains both from increased consumption and improved environmental quality” (Copeland, Taylor, 2003).

What might happen is that some countries could deliberately make environmental regulations as light as possible in order to have a comparative advantage in the production of dirtier goods and attract companies to invest in the country. What could therefore be achieved, according to Frankel (The Environment and Globalization, 2003), is a "race to the bottom". According to this hypothesis, governments, frightened by the loss of competitiveness of their companies, would compete to lower environmental regulations (such as CO2 taxes), to attract companies to relocate their subsidiaries in the country: in this way, the country would obtain a benefit from Foreign Investment Direct.

It is easy to see how this leads to the creation of a vicious circle in which the winning solution is not the reduction of environmental regulations, but rather their total absence. However, in the long run this would lead to enormous problems, both from the individual country's point of view and from the aggregate point of view, because the direction would have to be radically reversed, given the enormous damage that pollution can do to the environment and to human health.

Nevertheless, companies are more interested in other factors in deciding where to relocate, such as labour costs or market access, than in the level of environmental regulation. For this reason, the race to the bottom hypothesis has never been proved.

From an empirical point of view, the Pollution Haven Hypothesis must be distinguished by the Pollution Haven Effect, whereby a stricter environmental regulation influences relocation decisions and trade flows. For this theory, the theoretical support is strong, even if from an empirical point of view there are different results. Indeed, in the work of Arik Levinson and M. Scott Taylor (2008), authors used a model in which every manufacturing sector is composed of many heterogenous industries. Every sector can differ in the use of primary factor and in average pollution intensity. In this way, there are sectors that are capital intensive and relatively dirty, and sectors that are labour intensive and relatively clean. Furthermore, the author used the Pollution Abatement Costs (PAC) as a proxy for direct measures of regulation. They found "a positive, statistically significant, and empirically plausible relationship between industry PAC and net imports into the United States" (Levinson, Taylor, 2008), meaning that the stricter is the environmental regulation, the more imports of polluting goods there would be from the foreign trade pattern. Different results are obtained by Levinson and Ederington, (2004), in which authors related imports to the shift to green products in USA manufacturing. They found that a reduction of tariffs did not have increased more the imports from polluting country than from clean countries. If anything, it is true the opposite because "trade liberalization has shifted U.S. industrial composition toward dirtier industries, by increasing imports of polluting goods by less than clean goods" (Ederington J., Levinson A., Minier J., 2004).

Finally, through the study of American trade in toxic chemicals, and particularly studying the Toxics Release Inventory (TRI), Tang (2015) found that "some of these emissions may have relocated abroad, especially to poorer countries with likely lower environmental protection", meaning that the Pollution Haven Effect can be accounted for some sectors and for some countries.

On the contrary, the Pollution Haven Hypothesis, whereby a reduce of trade barriers will shift the production of polluting goods from countries with strict environmental regulation to countries with weaker environmental regulation, has weak theoretical support because environmental regulation is not the only factor that affects trade flows. Indeed, many factors can affect trade flows, meaning that if "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, Taylor, 2004).

Despite the multitude of studies, the Pollution Haven Hypothesis continues to be difficult to prove, both because of the scarcity of data on emissions and because environmental regulation is difficult to measure and different studies introduce different types of proxies (PAC, TRI or others) which are not always effective or, in any case, are difficult to compare. The evidence regarding the Pollution Haven Hypothesis, although it may seem robust, is not sufficient to prove that the hypothesis holds, or, indeed, that it should be rejected. Moreover, one of the main weaknesses of the Pollution Haven models is that trade is only due to differences in environmental policy.

An alternative theory to the Pollution Haven Hypothesis is the Factor Endowments Hypothesis, which assumes that a country's comparative advantage is not due to differences in environmental regulation but rather to differences in factor endowment (abundance of capital or labour) or technology endowment. These factors therefore determine the trade flow, with little or no consideration given to the role of environmental regulation. In this model we have always two countries, North and South, in which the first is relatively abundant of capital and the other one of labour. They trade two different goods, X relatively abundant of capital and Y relatively abundant of labour. In this situation, North will get a comparative advantage in the production of X: instead, South will get a comparative advantage in Y. Consequences of this is that North will export X, the dirty good: South will export Y, the clean good. From an environmental point of view, pollution will rise in the North country and will fall in the South country, meaning that "countries relatively abundant in factors used intensively in polluting industries will on average get dirtier as trade liberalizes, while countries that are relatively abundant in factors used intensively in clean industries will get cleaner with trade" (Copeland, Taylor, 2004).

Results are strongly in contrast with the one of Pollution Haven Hypothesis: indeed, a poor country which has the factors used to produce clean products will not see a rise in its emission but a fall; on the contrary a rich country will see a rise in the level of pollution. From a welfare point of view, both countries get the advantage from a rise in consumption but only the South gets the advantage from an environmental point of view. For this reason, it gets an advantage from both effects and an advantage from trade. On the contrary, the North will have an increase in welfare only if the benefit from a higher consumption will prevail the costs of increased emissions.

Empirical evidence about Factor Endowment Theory is clearly also ambiguous. One of the studies that tries to test the Factor Endowment Theory is the one of Umed Temurshoev (2006) which tested the relation between pollution intensities and capital intensities for USA only. He

found that the correlation is positive and significant but not so high: according to the H-O model, USA, since it is abundant in capital, should have a comparative advantage in production of capital-intensive pollution goods. Furthermore, in case of a bilateral trade between China and USA, empirical verification seems to fail the FEH, because "the capital requirements of extra exports are less than those of extra imports". If the trade USA/rest of the world is considered, USA is importing more capital-intensive goods than exporting them, failing once again the FEH.

Nevertheless, there are also some studies that bring evidence to pursue the Factor Endowment Theory. Indeed, in article by Low, Patrick and Alexander Yeats (1992), the authors found that over 90 percent of dirty-goods production come from OECD countries, meaning that capital-intensive countries specialize in the production of dirty goods.

In this paragraph I analysed both principal theories that can explain the relationship between international trade and environment. From the empirical point of view, both theories have some problems, due to missing data, difficult proxies, or not correspondence with the data. Moreover, the results are ambiguous.

In this section I presented the two theories separately, but they can be linked together: indeed, a country can differ in both their pollution policy and in their factor endowments. In the next paragraph, I will discuss the relative strength of pollution haven hypothesis in contrast to factor endowment theory in determining a comparative advantage in dirty goods. Furthermore, I will use the theoretical framework of Grossman and Krueger to identify the magnitude of scale, composition, and technique effect.

This discussion is fundamental because the comparative advantage can be achieved both with factor endowment and environmental regulations. Indeed, the production of dirty goods can remain in the countries with a stringent environmental regulation.

1.3 ACT model from a theoretical point of view

Pollution Haven Hypothesis and Factor Endowment Theory are the most important theories to explain the relation between international trade and environment. Both are based on the comparative advantage, one given by differences in environmental regulation and the other by differences in factors. Nevertheless, they give different and opposite results, as discussed in the previous paragraph.

Furthermore, these two theories can be also linked together because countries can differ both for environmental regulation and factor endowment: in this way, a new theory is created through the mix of them both.

What can be seen immediately from the combination of the two theories is the initial tension between lowering pollution levels in countries with stringent environmental regulation and raising pollution levels in capital-abundant countries. Copeland and Taylor in (2003) show this tension and demonstrate that "there exists an interval of emission intensities where North has tighter policy than South, but North retains a comparative advantage in dirty goods". For this reason, North will export dirty goods while South will export clean goods.

These kinds of results contrast with the results that we got before. The possibility that a country with a strict environmental regulation can have a comparative advantage in dirty goods has a lot of implications from a welfare point of view. Indeed, both countries will gain from a rising in consumption, but there will be a rise of pollution in the North country. According to this, the South country will gain from the trade because of a positive effect in consumption and in pollution (that will decrease) instead the North country will lose in trade if the benefits from consumption gains will be lower than the costs of increasing of pollution levels.

In these terms, it may also be the case that there would be a relocation of dirty goods companies to countries with stringent environmental regulations, causing a global decrease in pollution levels, contrary to what is theorized by the Pollution Haven Hypothesis.

Similar results can be obtained if we also consider income levels: with the assumption that the Northern countries are richer than the Southern countries, that they have a stricter environmental regulation, and that they are capital abundant, what we get is that "if North is capital abundant and relative factor endowment differences are large relative to real income differences, then North exports dirty goods. On the other hand, if income differences are large relative to factor endowment differences, then a pollution haven emerges in the South" (Copeland, Taylor, 2003). This means that if the factor's endowments are similar between

countries, and North country is richer than South country, the pollution haven effect dominates the capital abundance effect and there will be a pollution haven in the South; if the levels of income are similar between countries and North is more capital abundant relative to the South, then North country will export dirty goods. As we can see, we have different conclusions depending on whether one effect or the other prevails. Furthermore, it is important to point out that there is certainly a correlation between a stricter environmental policy and an export of dirty goods, but this does not mean that stricter environmental regulation has a negative effect on the environment. Indeed, for a given level of capital abundance, stricter environmental regulation would decrease the export of dirty goods, eroding the country's comparative advantage if the comparative advantage comes mainly from the factor endowment.

Since there are different effects that international trade has on the environment, depending on the weight of each effect, it is important to try to figure out the magnitudes of scale, composition and technique effect and also the relative strength of the pollution haven hypothesis respect to factor abundance in determining comparative advantage. From this point of view, W. Antweiler, B. Copeland and M. Scott (2001), achieve this purpose. They present a model based on the H-O model and a simple pollution haven model in which there are two countries, two goods (X and Y) and two primary factors (Capital and Labour). Y is labour intensive and does not pollute, instead X is capital intensive and pollutes. Furthermore, government can influence indirectly the emissions through pollution emissions taxes, which is set in order to maximize the preferences of each groups that split in Green consumers, who care about environment, and Brown consumers, who care less about environment. The Authors find that the levels of pollution depend on scale, composition and technique effect; the first effect has a negative effect on environment because it captures the increase in emissions due to a growing economy; the second effect has instead a positive effect on environment, because if all the terms are constant, an increase in the production of clean goods lands to lower pollution. On contrary, an increase in the production of dirty goods land to higher pollution; finally, the last effect wherein an increase in emission intensity will increase the levels of pollution.

If we consider the situation of a dirty goods exporter, we can see a reduction of emissions due to the three effects; particularly, it must happen that composition and scale effect are overwhelmed by the technique effect. Indeed, trade causes an increase of levels of pollution due to composition (change in the composition of output) and scale (an increase of economy) effect. At the same time there is a rise of income which lets the country to invest in greener technology, lowering the emissions intensity and causing a fall of levels of pollution (technique effect).

In the case of dirty good importer, the composition and the scale effect are negative, and this will bring to a lower emission. For this instance we can find three different cases: the first one in which the country is a clean goods exporter (dirty goods importer) whereby there will be a lowering of emissions; the second case of a dirty goods exporter in which the composition and the scale effect are not compensated by the technique effect and the country will see an increase of levels of pollution; the last case is of a country which exports dirty goods, in which composition and scale effect are more than compensated by the technique effect, leading to lower levels of pollution. The authors also found the magnitudes of the scale and technique effect: an increase of 1 percent in the economic activity "raises pollution concentrations by 0.25 to 0.5 percent for an average country in our sample, but the accompanying increase in income drives concentrations down by 1.25-1.5 percent via a technique effect" (Antweiler, B. Copeland and M. Scott, 2001). Hence, a raise of output and income of 1 percent will cause a fall of pollution concentrations of 1 percent.

About the composition effect, the impact is quite large because an increase of 1 percent of capital-labour ratio, cause an increase of quiet 1 percent in pollution, showing a strong link between factor endowments and trade flows. This link is also demonstrated by plotting the intensity of trade against per capita income. What the authors found is a positive relationship that contradicts the pollution haven hypothesis, which would in turn predict a negative relationship. In fact, richer countries should have a comparative advantage in the production of clean goods, and trade liberalization should shift the demand for pollution to the left, leading to a negative elasticity estimate. What we have is that, since richer countries are capital abundant, this will bring a shift of dirty and capital-intensive production in developed countries.

Thus, factor endowment dominates pollution haven motives in the relation between international trade and environment.

This result is also found by other works, like Walter (1973) and Xu (1999). The first one analysed the imports and the exports of USA, finding that the USA exports principally dirty goods. The second one reports that 80 percentage of environmentally sensitive goods come from OECD countries.

In conclusion, surely both income and capital abundance are important in determining the comparative advantage. At the same time, it seems clear that factor endowments have a dominating role in which country will have a comparative advantage, explaining the consequences from an environmental point of view. Moreover, the relation between international trade and environment can be divided in three different effects (scale, composition,

and technique) which show the positive relationship between trade flows and environment, demonstrating that international trade can have a good effect on the environment.

In the next chapter, I will talk about the intra-industry trade, why it must be considered in literature and the role it has in the international trade. In doing this, I will use the same theoretical framework proposed by Antweiler, B. Copeland and M. Scott with the scale, technique, and composition effect in order to valuate the effect of intra-industry trade on the environment.

CHAPTER 2: Intra-industry trade and environment: a new pattern

2.1 Why intra-industry trade effect is so important?

As seen in Chapter 1, inter-industry trade has a positive effect on environment, even if there are some situations in which it can have a negative effect, raising the concentration of pollution.

Furthermore, the H-O model, on which factor endowment theory is based on, seems to have a dominating effect on pollution haven hypothesis and it explains in a good way the relation between inter-industry trade and environment.

Nevertheless, this theoretical framework seems to fail to explain a new trend that is increasingly appearing within the international trade landscape: namely, intra-industry trade, thus the import and exports of similar products. For this reason, it is necessary to find another model that can explain the relation between environment and intra-industry trade and its effect.

Intra-industry trade represents a great portion of the international trade, quiet 27 percentage of the total. This is because both the developed and developing countries have experienced this kind of phenomena. Indeed, according to Y., Kandogan (2003), the author analysed components of trade between 22 transitions country with their 28 developed and developing trade partners, finding that intra-industry trade Is not explained by H-O model (that explains only inter-industry trade). Furthermore, due to the growing fear and interest in CO2 emissions and their close link to climate change, deteriorating air and water quality, academia must also address intra-industry trade.

Moreover, according to D., Hakura, and F., Jaumotte (1999), Intra-industry trade "stimulates more technology transfer than inter-industry trade because countries are likely to absorb foreign technology more easily when their imports are from the same sectors as their production and export sectors". The diffusion of technology enables the country to undertake greener solutions, allowing CO2 emissions to be reduced. In fact, according to James B. Ang (2009), CO2 emissions are not only inversely related to technology transfer, but also to the country's research intensity and ability to assimilate technology from a foreign country. This is of fundamental importance from the point of view of policy choice because it would give governments more reason to invest in research and development in order to achieve the goals of the Paris agreements.

These elements are also determinants of a country's growth, which we have seen to be, via Grossman and Krueger's Environmental Kuznet Curve, negatively related to CO2 emissions. The relationship between intra-industry trade and economic growth has been studied in many articles, like in the work of D., Backaus (1992) finding a positive relationship not only between these two variables but also between scale effect and GDP rates. Furthermore, in the work by Lewrick, Mohler and Weder (2014), the authors decompose aggregate productivity growth into technological improvements and inter- and intra-industry reallocation, defining the latter as the source of growth, "reflecting in particular the productivity growth of large, incumbent firms and the entry of new firms".

Linked to technology and growth, there is also the role of innovation, which can be pursued both through improved research and development and through an increase in GDP; what is created is therefore a circle in which growth feeds the level of technology that feeds innovation and leads to lower levels of pollution. In fact, intra-industry trade can also fuel innovation because "producing a greater variety and number of goods increases our general knowledge about technology, and greater knowledge implies lower costs of knowledge accumulation. For example, U.S. importation of Japanese cars and trucks has led to improvements in U.S. car and truck manufacturers" (R., Ruffin, 1999). In essence, importing goods from another country allows one to understand and increase one's knowledge about that product. This will result in product innovation, leading to improvements in the industry.

Finally, the last reason to study intra-industry trade is the role that it can have from a policy point of view. Indeed, intra-industry trade facilitated trade agreements because adjustment costs "will be less forbidding for intra-industry rather than inter-industry labour adjustment" (R., Elliott, J., Lindley, 2006) according to smooth adjustment hypothesis (SAH) that differentiates between H-O model in inter-industry trade and intra-industry trade based on economies of scale

and increasing returns. Furthermore, considered the impact that international trade has on environment, trade agreements with environmental provisions lower pollution levels more than trade agreements without environmental provisions.

In conclusion, these evidences show how important the study of intra-industry trade is, considering also the scarce presence of empirical studies in this field (although many show not only a positive effect but also a better impact than inter-industry trade).

The growing presence of intra-industry trade has however increasingly oriented research from country-specific to industry-specific determinants. These determinants will be analysed in the next section.

2.2 Determinants of Intra-industry Trade

The determinants of intra-industry trade have been the subject of discussion and analysis in many works, which have found a multitude of different factors.

One of the earliest works is that of Kang (2002), in which the author identifies several determinants, among which the most important are GDP per capita, consumer preferences, differences in factor endowments, distance and country size.

The positive relationship between intra-industry trade and GDP per capita is explained by the fact that the differentiated demand for products increases as income rises. Thus, the demand for differentiated products is higher in developed countries which will therefore experience a high level of intra-industry trade share.

Another important determinant of intra-industry trade is distance that, according to Bergstrand and Egger (2006), is negatively related. The proxy for which is generally trade costs even if, as pointed out by Anderson and Van Wincoop (2004), the measurement of these costs is difficult, for this reason transport costs are the best approximation.

Bergstrand and Egger also found that the distance coefficient gradually decreased over time. A possible explanation for this is the creation of trade areas that allow for a reduction in trade costs, as well as an increase in the exchange of intermediate goods, which are less subject to distance.

Regarding consumer preferences and factor endowments, they represent different aspects. The first concerns differences in imports compositions while the second one concerns differences

in exports composition. Both two aspects are negatively related with Intra-industry trade share: factor endowments lead to comparative advantage and “the more two countries are different in factor endowment, the less IIT share they are supposed to have in trade between them” (Bergstrand and Egger, ,2006). About consumer preferences, Intra-industry trade, on the other hand, involves trade in similar goods. If two countries have very different consumer preferences, the share of intra-industry trade between the two countries is less likely to be significant.

Finally, the role of distance is difficult to determine in the relation with intra-industry trade. The most common theory is that the larger country can exploit the large market at its disposal, allowing it to develop its industrial structure and achieve economies of scale, thus acquiring a comparative advantage in trade that positively influences intra-industry trade. In contrast, smaller developed countries, due to their small market, specialise in certain sectors. The country therefore tends to export mainly its goods to the market of the larger country because its own market is too small. This leads to a pattern of intra-industry trade. In addition, for small developing countries, intra-industrial trade is in their nature because their production essentially concerns primary goods and low-technology products that are hardly differentiated (in fact, intra-industrial trade is between similar products).

However, it is also important to state that the size of a country does not at the same time determine its GDP per capita, meaning that a large country does not necessarily have a large GDP per capita, a factor that most affects the share of intra-industry trade. Indeed, "Achieving economies of scale in production of medium and high-technology products implicitly assume that producing countries are already rich enough to have sufficient domestic demand on these products", so one can only identify the size of a country with GDP per capita and economies of scale if the country is a developed country, such as the EU countries or the US.

In conclusion, the determinants of intra-industrial trade are the most varied and have different effects in determining a country's share of intra-industrial trade. In the next section, we instead look at the effects of this trade pattern with the environment, using the same theoretical framework developed in the first chapter (scale, composition and technical effects).

2.3 Intra-industry trade and environment

In this section I will talk about the effects of intra-industry trade from an environmental point of view. It can be shown that intra-industry trade has a positive effect on environment, by using the same theoretical framework of Antweiler et all (2001), through the scale, composition and technique effect.

As in the previous chapter, technique effect has a negative sign with emissions, because trade brings the country to improve and develop its technology, becoming greener and more efficient and reducing pollution emissions. Furthermore, from a technological point of view, we already saw, according to Hakura, and Jaumotte (1999) that intra-industry trade allows a better absorption of foreign technology if imports are in the same sector as exports.

Again, scale effect has a negative effect on environment because an increase of trade volumes brings to an increase of emissions, as saw in the first chapter for inter-industry trade.

Regarding composition effect, its relationship with environment is ambiguous. In the literature, the composition effect is exchanged with selection effect. Aralas and Hoehn in (2010) finds the abovementioned effect whereby "a change in the number of product varieties changes the levels of pollution emission". Consequentially, total emissions levels are due to the scale of economy, intensity of production and, finally, the variety of products and number of firms.

Particularly, authors introduce a model based on the neo-Chamberlinian-Krugman type model of monopolistic competition and trade, also incorporating externality pollution in order to evaluate its impact on environment; indeed, firms produce differentiate goods that generate pollution. Firms have identical technologies, and they produce a lot of varieties of goods. Because of economies of scale, firms specialize in the production of a specific good and consumers have same consumer preferences. Authors introduce pollution intensity parameter ei for each variety of product that depends on the fraction of output allocated towards consumption (1 -θi). In this way, it is described the relationship between pollution emission and output. Moreover, author introduce a tax parameter (τ) over pollution emissions produced through production process. Consequently, final producer earns a p equal to pi (1-eτ), meaning that higher is pollution emission, lower will be the final price earned by the producer. One explanation is that there a "trade-off between emission control and allocating goods for consumption. Greater emission intensity implies there is less abatement which in turn implies that there is greater allocation of output for the purpose of consumption" (Aralas

and Hoehn 2010). Moreover, author found also that the number of product varieties is positively related with total labour (L) and negatively related with tax pollution (τ).

Moving now from a situation of autarky to a situation of trade, authors consider two countries with identical preferences, technologies and factor endowments. In Heckscher-Ohlin world, countries with identical factor abundance have no reason to trade. In this model, the relation between price and consumption level of different varieties of products is used to describe the impact of intra-industry trade on environment.

When the two countries start trading, the effect is an increase in labour supply, as also seen by Krugman (1979). Consequently, there is a fall both of price level and consumption of variety of goods: this causes some companies to exit the market and, on the other hand, allows the remaining companies to increase production, exploiting economies of scale, and increasing products variety. Furthermore, falling prices also cause an increase in real income, which helps to raise economic welfare.

Thus, the number of companies in an open economy is smaller than in an autarky, and this lead, consequently, to a lower emission of pollutants.

In conclusion, with an open economy the number of firms in each country decrease, instead the variety of products in each market increase, generating a lower level of pollutant emissions. This is the trade induced selection effect. Consequently, remaining firms can increase production, exploiting economies of scale, generating more pollutants. This is the negative effect of the trade-induced scale effect. Finally, output levels rise, prices fall, and real income rises. “Since environmental quality is a normal good, higher income level promotes stricter environmental policy. A higher emission tax rate leads to greater emission control and thus lower emission intensity. This is the trade-induced technique effect” (Aralas and Hoehn 2010). These three effects characterise the relationship between intra-industrial trade and the environment.

In addition, the authors also study the effects of trade by considering its two components as a whole: the exchange of homogeneous goods, stemming from inter-industry trade where the comparative advantage of a country is determined, as seen in the first chapter, mainly by factor abundance and the exchange of differentiated goods, stemming from intra-industry trade, driven by market structure and increasing returns. What authors found is that “If countries engage in the pollution-intensive production of homogenous and differentiated goods in an integrated economy, then an empirical estimation of the total impact of trade on the environment needs to account for a selection effect in addition to scale, technique and

composition effects" (Aralas and Hoehn 2010). Basically, the effect of intra-national trade on environment is given by the sum of four different effects, whereby all the effects are significant, but scale effect is positively related with emissions, technique effect is negatively related with emissions, selection effect is positively related because a reduction of firms cause a reduction of emissions and composition effect is positively related, because authors found an increasing relationship between level of emissions and capital intensity.

Positive effect of intra-industry trade on environment has been found also in other work, like Swart (2012) and Roy (2017), in which the first considers transportation cost and pollution tax, finding that a domestic firm to enter in a foreign market must cut its emissions to avoid pollution taxes and to compensate transportation costs; the same happens for a foreign firm that wants to enter in a domestic market. The overall effect is a reduction in emissions and a positive effect on environment. Roy (2017) considers two kind of index, the Grubel-Lloyd index to denote the degree of IIT at any point in time and vary between 0 and 1 with higher values indicates greater within-sector trade and index in Brulhart (1994), based on change in trade flows and that measures marginal Intra-industry trade. What the author found is that intra-industry trade is beneficial for environment and that, since trade is witnessed as beneficial for environment, intra-industry trade has a more favourable impact. This evidence, along with that of Aralas and Hoehn (2010), proves that greater trade openness or trade liberalisation leads to lower emissions and preserves the environment.

Moreover, as also reported by the above-mentioned authors, the introduction of a fourth effect in the explanation of the relationship between environment and trade is of fundamental importance because its absence may lead to specification error and biased estimates.

In the next chapter, I will discuss environmental policy implications based on the evidences discussed in these two chapters. In particular, I will discuss how intra-industry trade can facilitate international trade agreements with environmental purposes in order to reduce pollutant emissions, the border tax adjustment instrument to increase the participation of countries in the agreement and, finally, the effect of trade barriers that can reduce emissions, increasing welfare, but, on the other hand, can have very negative consequences for both countries involved from the point of view of income, technology transfer and innovation, which are important factors for growth and for the reduction of CO2 emissions.

CHAPTER 3: Policies, Environment, and International Trade

3.1 International Environmental Agreement and International Trade

In the previous chapter, it Is already seen that intra-industry trade has a positive effect on environment, trough the decomposition of its effects in fours effects.

This evidence brings policy ramifications: indeed, according to Elliot and Lindley (2006), intra-industry trade can facilitate trade agreements because it can reduce adjustment costs associated with trade-induced factor reallocations. To prove this finding, the two authors integrate labour market adjustment into a theoretical scheme of international trade such as that of Heckscher-Ohlin, which assumes free-intersectoral movement of labour and costless adjustment. Furthermore, in response to some criticism of the lack of micro-labor market analysis, Elliot and Lindley introduce a "micro-econometric analysis at a disaggregated multi-sector level for one country, so as to take into account changes in the production demand structures across sectors within a given economy" (Elliot and Lindley, 2006). Particularly, what authors found is that an expansion of trade from intra-industry trade point of view means that changes in imports or exports are "matched" within the same industry, unlike changes in inter-industry trade which are not matched. Hence, factor reallocation requires more resources for inter-industry trade than intra-industry trade precisely to compensate for these non-matched changes.

Furthermore, Baghdadi et al (2003), defined not only the determinants for the decision to join a trade agreement, identified by geographical conditions and economic characteristics, but also whether a trade agreement with environmental forecasts has a positive effect in reducing CO2 emissions. Emissions are assessed according to income, population, land area, openness in relative terms, bilateral trade, and a dummy for RTAs; what the authors found is that trade agreements with environmental provisions lead to convergence and lower emissions. Considering specific agreements such as the European Union, NAFTA and Euro-Med agreements, they show that "the emission pollution gap is 22% lower for country pairs involved in Euro-Med agreements than for similar pairs of countries not involved in RTAs. The effect is slightly less pronounced for EU-27 country pairs, for which the emission gap is about 13% lower than for similar non-EU-27 countries, and more pronounced for NAFTA, for which the emission gap is about 40% lower than for similar non-NAFTA countries" (Baghdadi et al 2003).

Another important conclusion about Environmental Agreement is that, according to Montagna et all (2020), optimal policy set by the country depends on the fact if the country join or does not join the IEA. Indeed, environmental policy can affect the welfare of the country via three

different channels: the first one is terms of trade that can be influenced modifying trade flows, then there is government revenue (2) and global pollution (3).

In the absence of an international agreement, taxes can be set unilaterally by a country (non-cooperation) or in a fully multilateral setting (situation of cooperation between countries). In both cases and if, in the second case, the damage is the same between sectors and countries, the best environmental tax that can be implemented is equal to the cumulative willingness to pay of the consumers in the first case and of different countries in the second case.

The optimal policy in case of an international environmental agreement can be divided into two scenarios: one in which each participating country defines an environmental policy according to its own characteristics and another in which a common tax rate resulting in full policy harmonisation. In order to maximise the common welfare, the optimal tax is derived from "the difference between the signatories cumulative marginal damage of the signatories' emissions and the country-specific effects of the tax on terms of trade and emissions leakage" (Montagna et all 2020). In the second case, the optimal policy will depend on participating countries' marginal willingness to pay for pollution reduction, their terms of trade effects and the externality of the non-participating countries weighted by the participating countries marginal damage. What the authors found is that the welfare of IEA participating countries increases, while the welfare of non-participating countries decreases, due to the trade creation and trade diversion effects of the policy, meaning that terms-of-trade effects of environmental policy are an important incentive for a country to join an environmental agreement.

3.2 Border Tax Adjustment and IEA

In the previous paragraph, it was seen that not only intra-industry trade can facilitate trade agreements, but also that these agreements, with the addition of environmental provisions, can have a beneficial effect both from an environmental point of view, by decreasing emissions, and can lead to an increase in welfare for the participating countries. All these elements show how instruments and incentives should be included to allow trade agreements. Nevertheless, reaching trade agreements to combat climate change must involve the shared action of all countries in the world, which is not easy to achieve for many reasons. One reason is due to the non-excludability of the public good, so that non-signatory countries can benefit from the better welfare due to the reduction of pollution, operated by the signatories, without incurring abatements costs for the improvement of facilities, making them greener. Another reason is linked to the shift of production of polluting goods from signatory countries to non-signatory

countries, fuelling the phenomenon of carbon leakage. One of the instruments to prevent the phenomenon of free riding by non-signatory countries and carbon leakage is the boarder carbon adjustment (BCA). The functioning of a BCA involves solving a market imperfection: in fact, countries adhering to a trade agreement for environmental purposes have to bear additional costs compared to non-signatories, called carbon prices, in the form of taxes so that tS>tNS (where S stands for signatories and NS for non-signatories). The idea of the BCA is to add a tariff τ to imports, so that tS is equal to tNS+τ, which is a full adjusted tariff. If tS is lower, it is a partial adjusted tariff; if it Is higher than tS, it would conflict with the principles of equal treatment under the regulations of WTO. In this way, firms of signatories' countries play in equal terms; it does not happen in non-signatories' countries. For this reason, "signatories' governments could grant their firms an export rebate κ on their exports to non-signatory markets, such that their firms pay only tS $-$ κ on exports" (Al Khourdajie, 2020).

Academic literature considers the BCA from three different perspectives: the first concerns its applicability from a practical point of view, which seems to be feasible as it does not contravene WTO principles. The second point of view concerns whether this tariff can be justified: the academic literature agrees that this tariff corrects a market imperfection because non-signatory countries have lower costs. Moreover, according to Stiglitz, the absence of carbon prices de facto constitutes a subsidy for dirty production, hence BCA levels out this situation and removes this incentive to produce 'dirty' goods.

The third point of view defines the effectiveness of this measure from an environmental point of view, showing how an import tariff, more than an export rebate, can lead both to a reduction in carbon leakage but also to a "noticeable overall reduction of emissions as they also curtail consumption" (Al Khourdajie, 2020). BCA import tariff have three different effects which lead to a general increase in welfare. The first effect relates to the differences in profits between signatory and non-signatory countries, which narrows but does not disappear. Moreover, signatory governments benefit from this tariff, which at the same time represents a loss for non-signatory countries. The last effect concerns consumers who are disadvantaged in the signatory countries of the agreement because they have to pay higher prices than consumers in non-signatory countries. Nevertheless, according to the conclusion of the article of Al Khourdajie (2020) "signatories' welfare increases under the BCA-regime compared to the No BCA-regime and, in most cases, the reverse is true for non-signatory countries. Thus, joining an agreement becomes more attractive under the BCA-regime rather than under the No-BCA regime", giving an important reason to join an agreement.

3.3 Impact of Trade barriers

Given the BCA's tool to incentivise a country to join a trade agreement, which we have seen to be an effective tool in reducing emissions, in this section we look at the effect of a trade closure on CO2 emissions. The academic literature is very poor in studying this topic: many studies refer to the effects of trade openness on the environment, as has been analysed in the previous chapters, and some study the effects of reduced sanctions or tariffs (Jakob et al., 2014) for the creation of an international trade agreement. What is missing, however, is the study of a contrary situation and its effects on the environment.

In the previous chapters, we showed how trade liberalization can improve air quality, demonstrating that intra-industry trade, more than inter-national trade, has a positive impact on the reduction of emissions. Despite this, scenarios of trade closures have emerged around the world, as demonstrated by the anti-trade policies implemented by Donald Trump towards China, and vice versa. On these data, article by Liu et all (2019), studies this effect from both an environmental and a socio-economic aspect. Authors use Computable General Equilibrium model (CGE), in which economic agents optimise their behaviour under given resource and technology constraints: it means that household maximize their utility based on budget constraint while firms maximize their profit under technology and resource constraint. Moreover, due to data of China and USA interactions, their policy will have repercussions on other countries and CGE model can capture these effects because it is a good model to study interactions among different agents in macroeconomic system.

What authors found is that trade frictions have weakened bilateral trade, reducing deficit's trade of USA with China. It also caused not only a reduction in the GDP of the US and China, but also of many other countries in 2019 indirectly, even if in the long term "economic losses caused by trade friction on the conflicting parties have a certain permanence, while the non-participants can benefit indirectly" (Liu et all, 2019).

From an environmental point of view, the trade war between the US and China has led to a reduction in CO2 emissions, although there has been an increase caused by other countries: nevertheless, the overall effect shows a reduction of emissions in 2019. It is important to underline how trade frictions in the long term can lead to a reduction in energy consumption and have a beneficial effect on air quality, reducing greenhouse gases and air pollutants. If, on

the other hand, trade frictions are not continuous, the effect of reducing emissions will not be significant.

However, the reduction of CO2 emissions, and thus improving the environment, is not sufficient to make a difference in the effort to combat climate change. Thus, given the reduction in GDP and the loss of welfare from an economic point of view, added to the insufficient environmental improvement, trade frictions would lead to a total loss of welfare, which means that they are not a suitable tool for combating climate change. What could happen, according to Fuchs et all (2019), is that China's import of soybean would no longer come from the US but rather from Brazil, causing large-scale deforestation of the Amazon for soybean production; the Food and Agriculture Organization of the United Nations (FAO) estimates that the area dedicated to soybean production could increase by 39% (13 million hectares) to supply Chinese demand.

In conclusion, "free trade, with preference on carbon-free goods, and a simultaneously implemented environmental policy (e.g., carbon tax) could be better policy options for keeping residents' welfare whilst improving environment" (Liu et all, 2019). Moreover, the improvement of International Trade Agreement with environmental provisions is a good tool to face the challenge of climate change and improve both environmentally and socio-economically by increasing welfare.

Conclusions

In this thesis, it has been showed the effect of trade on environment. It has been demonstrated the effect of international trade and how the trade has transformed from inter-national to intra-national, caused by many reasons, one of them being the high composition of intra-industry trade. Moreover, intra-industry trade has a positive impact on environment, more than international trade, even if both bring to a reduction of emissions, through the combined effect of four different effects, as the scale, technical, composition and selection effect.

It was also shown how intra-industry trade can more easily lead to a trade agreement and how the latter can reduce emissions, especially if it is concluded with environmental provisions. Furthermore, to make it easier to conclude such an agreement, it was shown that the Boarder Carbon Adjutment (BCA) instrument is the ideal tool for this purpose.

Finally, since trade openness we have seen to be positive for the improvement of the environment, from a CO2 emission point of view, in the last paragraph I treat the situation of trade frictions, showing how it causes a reduction of CO2, but it is not enough to increase the welfare, since it has some repercussions from a socio-economic point of view.

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