Humanities and Social Sciences Faculty

International Relations Degree

Bachelor's Thesis

Green growth and economic development

The role of green energies

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In appreciation to

My director, Juan, for his patience and support in this learning process.
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The VG Team. Words are unnecessary when we have each other.

ABSTRACT

Policy measures for sustainable development have gained prominence in recent decades, both at the national and international levels. Sustainable development is complemented by sustainable economic growth, which inevitably involves diversification of energy sources: energy transition and renewable energies have become a cornerstone of national economic growth and development. Nonetheless, the role of the environment has been overlooked in the study of international relations, nor have renewable energies occupied an important space in the study of growth and development economics. Classical theories of international relations, such as realism, liberalism, or international political economy, do not have a clear stance on the role of the environment in the global arena. In contrast, critical branches such as green theory have emerged adopting a holistic perspective on international relations. From the viewpoint of growth economics, other strands also emerge that include the role of renewable energies: green growth. Through a model of green economic growth, this study analyses 4 Parties to the Paris Agreement (2015), to analyse whether green energy together with development policies can drive sustainable economic growth in different regions of the world. Conditional economic convergence is ultimately the result of policies at the national level, yet they must be motivated by commitment at the international level.

Keywords:

Green growth, Renewable energies, Sustainable development, Growth economics, Paris Agreement, Economic models, International economy

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INDEX OF ABBREVIATIONS

COP	Conference Of the Parties
CRGE	Climate Resilience and Green Economy Strategy
DICE	Dynamic Integrated model of Climate and the Economy
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GEG	Green Economic Growth
GHG	Green House Gases
IPE	International Political Economy
IR	International Relations
OECD	Organization for Economic Cooperation and Development
SDGs	Sustainable Development Goals
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	UN Framework Convention on Climate Change
WB	World Bank

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I. INTRODUCTION

i. Purpose and motives of the investigation

Over the last decade, the battle over climate change has been at the heart of the global agenda. This debate has been characterised by the democratic participation of almost all countries in the world, which, through the efforts of international organisations, have managed to reach agreements that set a turning point in the field of environmental policymaking. Numerous scholars have incorporated the environmental dimension into growth economics and development, and IR have also experienced this evolution of the academia. The political arena has embarked on a race towards the energy transition, which in addition to achieve net zero C02 emissions, requires innovation processes to develop new green energy sources.

The purpose of the investigation is to investigate the role of green energies in economic growth, with special attention to how it can affect least developed countries. By applying an economic model to countries with different development and energy profiles, this investigation will reach conclusions on whether economic convergence can be achieved through green economic growth. In addition, green economic growth depends very much on development economics, which are directly related to effective policy making and the legitimacy of international organisations.

This research serves as a preliminary study of the role of green energies in economic growth and development, and its main purpose is to set a precedent for future research. Future research should focus on other variables that are crucial to the purpose of the investigation, but that have been overlooked because of the limitations of this research, such as public investment and intervention, FDI, wealth redistribution, and regulation of international energy cooperation.

ii. Relevance of the subject

The most recent, measurable proof of an international agreement aiming at sustainable development are the Sustainable Development Goals. Designed by the United Nations Department of Economic and Social Affairs, these 17 goals were adopted by all UN Members, creating a Development Agenda for 2030. These goals focused on "ending poverty, protecting the planet, and improving the lives and prospects of the world's population; the ultimate goal is to achieve sustainable development. The UN defined it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (United Nations, n.d.) In order to reach the Goals by 2030, the UN Secretary-General Antonio Guterres called in September 2019 for a Decade of Action: all sectors of society should be mobilized in order to achieve the Goals, enhancing global and local action. The Secretary-General also pointed out the urgence of tackling growing poverty, inequalities, the vulnerability of women and girls, and the climate emergency. The different 17 goals can be consulted in the Annex I: The Sustainable Development Goals.

In addition, the Conference of the Parties to the UN Framework Convention on Climate Change (UNFCCC) has been promoting action on environmental issues since it was first held in Berlin, 1995. The Conference of the Parties (COP) is a supreme decision-making body of the UNFCCC; all member States of the Convention are represented at the COP, which is an annual meeting aimed at addressing environmental issues and climate emergencies. The first COP (COP1) was held in Berlin, Germany in March 1995. The latest COP was the COP27 in Sharm el-Sheikh, Egypt in November 2022. (UNFCCC, n.d.)

One of the most important Conventions of the past decade was held in Paris, France in 2015: the COP21 established the Paris Agreement. It was intended to improve the application and achievement of the Convention, and the Agreement reinforced the global action in face of climatic urgency, within the framework of sustainable development and alongside the efforts of poverty reduction (UNFCCC, 2015)[1]:

[1] Paris Agreement, United Nations Conference of the Parties (COP21) on Climate Change action.

> *Recognizing* that climate change represents an urgent and potentially irreversible threat to human societies and the planet and thus requires the widest possible cooperation by all countries, and their participation in an effective and appropriate international response, with a view to accelerating the reduction of global greenhouse gas emissions […]
>
> Decision 1/CP.21. Adoption of the Paris Agreement (UNFCCC, 2015)

The Paris Agreement was a turning point in how states developed their national environmental policies. In addition to providing policymakers with clear, measurable goals (i.e., limit global average temperature increase to 1,5ºC), it established a consensus between 194 parties on the urgency of climate action, the relevance of environmental policies and the reinforcement of a long-term view on economic growth. This also motivated discourses on energy transition, renewable energies, and self-efficiency to achieve sustainable development. This is directly related to convergence, "the process by which relatively poorer regions or countries grow faster than their rich counterparts." (Mathur, 2005, p. 185) This is because differences in growth rates across regions, over a long period of time, can have substantial impact on the standards of living of people. As Mathur points out, "Understanding the causes behind such inequalities is essential to formulate appropriate policies." (ibid.) Therefore, the Paris Agreement alongside the SDGs set a precedent for states to act on environmental issues and thus reduce poverty, inequalities and draw a path towards sustainable development.

iii. State of the art

Eckersley (1992) affirmed that achieving environmental sustainability requires not only a reconsideration of greener means, but also a review on the very purpose of modernisation, thus an analysis of the policy changes necessary for addressing risk. There has been a surge of academic strands focusing on environmental issues, their impact on IR, and the global challenges arising from these; green theory is an example of this trend, which results from growth and development theories. This theory claims that environmental degradation is a consequence of the dominant view on development equated to economic growth, which is based on the exploitation of natural resources while

neglecting planetary boundaries[2]. Therefore, it commentates on two concepts developed in the last decades: sustainable development and ecological modernisation (Pérez de Armiño, 2020).

Historically, economic growth has been at the core of modern societies in order to increase wealth, employment, and welfare. This is questioned by the idea of the limits to growth, which was developed by Robert Malthus in the late 18th century, and it gained relevance in the international sphere in the late 20th century with the publication of "Limits to Growth", written by Meadows and Randers. This approach suggests that the Earth has finite ecosystems in which there are fixed-volume resources, thus a continuous economic growth threatens to exceed at some point the limits of these systems (Dryzek, 2013). The view on the limits to growth considers environmental protection and economic growth to be exclusive. This view focuses on economic growth and its negative environmental impacts. Nevertheless, sustainable development provides a more optimistic view on how these two aspects can be complementary and has become a more popular policy choice at the academic and political level.

In 1983 the United Nations created the World Commission on Environment and Development (also known as Brundtland Commission) to follow up on the growing concern for the environment. In 1987, the Commission issued the report "Our Common Future" (or Brundtland Report), which introduced the notion of "sustainable development" into the policy discourse. The concept is based on the principle of not endangering the needs of future generations. Sustainable development is grounded on two ideas. On the one hand, there is the idea of needs and particularly the needs of the world's poor. On the other hand, there is the notion of limitations, and current development production models and consumption levels, metrics all equated to growth, in fact threaten the environment. Scholars have criticised the term as it does not transfer into the reality of development economics. Daly (1990) argues that it is an oxymoron[3] given that the evolution of development makes it difficult for it to be sustainable (providing long-term, positive impacts to present and future generations, considering needs and limitations). Redclift states that "the simplicity of this approach is deceptive, and obscures underlying

[2] This term will be explored in depth throughout the chapter on Green Theory. It is a conceptualization of the idea defended by the report "Limits to Growth", published in 1972.

[3] An oxymoron is a figure of speech that consists of combining two antithetical concepts.

complexities and contradictions." (2005, p. 213), given that it does not address the material manifestations of development, which should be focused on the fulfilment of capacities. To reach something that can be called sustainable development, international organisations and states would need to radically transform how the environment is exploited, and stop considering that the environment is at hand to satisfy human needs without taking into account the Earth's needs (ibid.)

Since the 80s, many countries (Finland, Norway, Japan, The Netherlands, and Germany, amongst others) have changed the discourse on sustainable development with a rhetoric based on ecological modernisation. Ecological modernisation justifies state intervention in the economy in order to face environmental challenges, under the assumption that it is possible for sustainable growth within planetary boundaries. State intervention is conceived through stricter environmental regulations, the use of substitutive resources instead of non-renewable, scarce resources, but especially by means of technological innovation. Technological innovation would increase growth while being environmentally efficient, by reducing resource and energy consumption (Pérez de Armiño, 2020; Jänicke & Jacob, 2006). The development of green energy is certainly a key element of technological innovation, as it can play an important role in the economic growth of states that are not as competitive in the global economy. This last point will be discussed in the course of this research. Nevertheless, ecological modernisation has been strongly criticized by radical environmental perspectives[4] as it aspires to combine the environment and economic growth; radical views argue that technological innovation has a contrary effect on the practice, as it increases resource consumption and waste production. In addition, ecological modernisation through technological progress is seen as a simplistic approach since it does not tackle the effects of environmental degradation across different regions (Garner, 2019; Eckersley, 1992).

For over a decade, international organisations have provided policymakers with optimistic, insightful definitions on green growth. International organisations have a direct impact on the development of green growth theory, and practice, because they have the means to provide state's all over the world with relevant data, a draft on future priorities and, recommendations. "Policies for reducing natural resource and

[4] These radical environmental perspectives are explored in the chapter covering Green Theory.

environmental degradation can achieve environmental sustainability without large sacrifices of economic growth and may even help stimulate growth." (Smulders et al., (2014, p. 424).

Each of these definitions portray different nuances and views on green growth. On the one hand, the OECD (2011) states that:

> Green growth means fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. To do this, it must catalyse investment and innovation which will underpin sustained growth and give rise to new economic opportunities. (p. 4)
>
> [Policy measures] will need to be introduced, particularly in emerging markets where some populations are most vulnerable to transition costs associated with greening growth. (p. 17)

On the other hand, the United Nations Environment Programme (UNEP, 2011) defines a *green economy* as:

> *One that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities*. In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive. […]
>
> The concept of a "green economy" does not *replace* sustainable development, but there is now a growing recognition that achieving sustainability rests almost entirely on getting the economy right. (p. 2)[…]
>
> As global economic growth bumps into planetary boundaries, decoupling the creation of economic value from natural resource use and environmental impacts becomes more urgent. (p. 16)

Smulders et al. (2014) label these two views as “weak green growth” and “strong green growth”, respectively. Weak green growth views, the one defended by the OECD, follow the neoclassical environmental economics perspective, arguing that “typically there are trade-offs between income growth and the environment, but that appropriate policies can soften this trade-off while taking advantage of those win-win opportunities that do exist.” (Smulders et al., (2014, p. 425) Other researchers emphasize the importance of a holistic approach to environmental policy, focusing on institutional capabilities, political economy, and cost-effectiveness in policy design, as well as addressing cost-sharing and growth prospects for developing countries (Sterner & Damon, 2011; 2012) It is also important to encourage innovation and develop technology-oriented approaches to achieve reduction of green-house gas emissions (ibid). This would materialise into incentives to consumers allowing them to actively participate in the journey towards a green economy. An improved institutional design makes it possible for consumers to understand and participate in green growth. Strong green growth views are based on positive spillovers rather than trade-offs; when environmental policies are well designed, the benefits in the economy are significant and increase economic growth. This is explained by the Porter Hypothesis, which argues that stricter and more prescriptive environmental regulation can also increase productivity and thus enhance growth (Porter & van der Linde, 1995);Smulders, et al., (2014)). That means well-designed environmental policies, complementary to a strict regulation system, can correct externalities that prevent overall well-being. As they point out, “the existence of any intertemporal externality implies that correction of that externality can increase overall well-being.” (Smulders, et al., (2014, p. 425) When governments and institutions address environmental externalities, and fix them, there is an increase in long-term wealth, as well as a contribution to the sustainable development of economies around the globe. Both weak and strong views on green growth focus on growth in conventional income, the opposite of adopting a broader perspective of consumption utility or overall economic welfare. This view reflects a “Realpolitik” about the importance of income growth: rather than focusing on trade-offs or even positive spillovers, the views on green growth focus on the negative economic impact that arises when responding to environmental and ecological concerns (ibid.). This has impeded the evolution of environmental policies over the last decades, as these concerns are addressed in the international arena, but loose relevance at the national level.

II. OBJECTIVES OF THE THESIS

i. Hypothesis

The following research questions have served as the motivation of the investigation, and are the basis of the hypothesis development:

Have green energies been included in the leading models of economic growth?

Can green energies drive sustainable economic growth? What is the difference between green growth and economic growth?

Do green energies boost economic convergence? Is there economic convergence between economic growth and green growth?

What is the role of international organisations in the development of green energies? Are there any policy implications?

The initial hypothesis of the research has been formulated as a result of the previously stated research questions and is intended to demonstrate how green growth can be pursued through green energies, without disregarding the role of international organisations. Therefore, the initial hypothesis is as follows:

Green energies can boost sustainable economic growth (also referred to as green growth); while the investment might have short-term negative effects in growth rates, the long-term effect results in convergence between green economic growth and "brown" economic growth.

To complete the research, complementary hypotheses have been developed:

Green energies can drive economic convergence between different regions.

International organisations and agreements act as a lead for states to make environmental policy decisions.

ii. Objectives of the thesis

The main objective of this research is to delve into how green energies can boost economic growth and observe the different effects of green economic growth versus the classical conception of economic growth amongst regions.

In order to see how green economic growth can be included in the International Relations' agenda, it is necessary to overview the main, classical IR theories, and follow with an exploration of the modern Green Theory, which focuses on environmental issues in IR from a critical perspective.

This research will also review the concept of green growth, which addresses the environmental concern from an economic perspective. In addition, key ideas retrieved from economic growth models will be considered.

To investigate the role of green energies in economic growth, it has been deemed pertinent to analyse and compare the economic growth of 4 signatory countries to the Paris Agreement, considering both "classical" economic growth and green economic growth. The analysis has been carried out by applying an economic model developed in a study outside the scope of the present research. The model is thoroughly described in the section "METHODOLOGY".

The aim of this project is to propose a series of recommendations on the inclusion of green energies in the policy arena, at the national and international level.

The present work serves first and foremost as a forerunner to other studies that build on the importance of green energy for economic growth and development studies.

III. METHODOLOGY

Initially, a review of the existing academic literature on environmental issues within IR theories' discipline, green energies and green economic growth was carried out, with a subsequent selection of the concepts and ideas that best assist in the understanding of green growth.

Thereafter, the methodology developed by an external study has been applied to this investigation. In 2019, researchers from Saudi Arabia, Turkey and Pakistan carried out a study examining "the role of cleaner energy, technological innovation, and militarization on green economic growth (GEG)." (Sohag, Taşkın, & Malik, 2019)The study examines GEG under different economic conditions in the context of Turkey, over the period 1980-2017. It provides insightful information on the role of cleaner energy in the economic development of Turkey[5]. The authors developed the study under the assumption that "replacing fossil fuels with cleaner energy in the production process can significantly lower the negative externality of the economic growth process." (ibid.) This relates to how cleaner energy can promote green growth in several ways.

The authors developed a model that defines GEG as follows:

> GEG [is defined] as positive sustainable economic growth that is realized by ensuring the efficient use of renewable resources after deducting the damage due to greenhouse gases, the exploitation of natural resources and other negative externalities. The formulation of green growth is as follows:

$$GEGt = GDPt + EEt - NRPt - NFDt - CO2t$$

Where GEG indicates green economic growth; GDP is gross domestic product; EE is education expenditure; NRP is the monetary value of depleted coal, crude oil, natural gas, and other minerals; NFD indicates the monetary value of forest depletion; CO2 is

[5] To read the full study, go to "Green economic growth, cleaner energy and militarization: Evidence from Turkey" (Sohag, Taşkın, & Malik, 2019).

the monetary value of carbon dioxide, particulate emissions damage; and *t* represents time. (Sohag, Taşkın, & Malik, 2019, p. 3)

The present investigation uses the formulation of GEG carried out in the aforementioned study to analyse the green economic growth of 4 signatory countries to the Paris Agreement and compare it to the "classical" economic growth (GDP growth). Specifically, the formulation of GEG adapted to the present research is as follows:

$$GEGt = GDPt + EEt - CRt - ORt - ANFDt - ACO2t$$

Where GEG indicates green economic growth; GDP is gross domestic product in current US$; EE is total government expenditure on education as a percentage of GDP; CR is coal rents as a percentage of GDP; OR is oil rents as a percentage of GDP; ANFD is the adjusted savings for net forest depletion in current US$; ACO2 is the adjusted savings for carbon dioxide damage in current US$; and *t* represents time.

Variable	Definition
Green Economic Growth (GEG)	Economic growth decoupled from negative externalities like carbon dioxide damage, natural resource depletion, net forest depletion and emission damage. (Sohag, Taşkın, & Malik, 2019)
Gross Domestic Product (GDP)	Gross Domestic Product in current US$, calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources
Government expenditure on education (EE)	Total government expenditure on education as a percentage of GDP. The percentage will be multiplied by GDP in current US$ and divided into 100.
Brown energy consumption of GDP (BEC)	Coal and Oil rents as a percentage of GDP. The percentage will be multiplied by GDP in current US$ and divided into 100.
Damage from brown energy use (BEDU)	Damage caused by the use of brown energies (Net Forest depletion and carbon dioxide damage) in current US$.
Population, total	Total population, accounts for all residents regardless of legal status or citizenship.

Table III:1. Data and their definition.

Source: own elaboration.

The variables used in the adapted formulation of GEG respond to the available data provided by the source, which is the World Bank Databank for World Development Indicators. Table III:1 shows a resume of the variables used in the analysis, and the long definition of each of the variables is available in the Annex II: GEG variables' long definition.

The data comprises the period 2006-2019, because of several reasons. Firstly, the data available for this period of time is sufficient to draw a growth path and induce conclusions. Secondly, this period of time allows comparison between the nations' economic growth before and after signing the Paris Agreement. Thirdly, the four selected countries have a substantial amount of data for that period, whereas other countries do not have enough data and would be inconclusive; posterior years to 2019 do not have complete data for all the necessary variables.

The countries selected for this investigation are Thailand, Ethiopia, Costa Rica, and Chile. All these countries are located in different regions of the world, providing the study with a representation of 3 out of 5 continents (Asia, Africa, and America, respectively), with different development profiles: Thailand is an upper-middle-income economy; Ethiopia is a low-income economy; Costa Rica is an upper-middle-income economy; and Chile is a high-income economy. The energy profiles of the 4 countries differ significantly, which will be addressed in the sections dedicated to each one of the countries. All these countries have signed and ratified the Paris Agreement, which means they are bound to comply with the provisions and decisions taken by the Agreement. It has been already mentioned in the present investigation that the Paris Agreement is a historical precedent for environmental policies, and even though there have been other posterior agreements, it is the latest Agreement with a timeframe that provides an adequate amount of data for the purposes of this investigation.

Therefore, the methodology of this investigation is a "case study" method, composed of both quantitative and qualitative analysis. For the quantitative analysis, the formulation of GEG will be applied to each case study. For the qualitative analysis, several aspects of each country will be included, these being: a brief country profile, energy profiles with special attention to renewable energy, and the latest version of the

submitted NDC. To enrich the qualitative analysis, complementary index will be included.

IV. THEORETICAL FRAMEWORK

i. International relations theories' framework

a. Realism

Reus-Smit (Grieco, et al., 2019, p. 83) states that the realist tradition within IR theories is characterized by six main features. First, realism as a tradition of thought claims a monopoly on the understanding of international politics, therefore antagonizing itself to notions such as idealism, utopianism, and wishful thinking. Second, realism is characterized by "a considerable degree of pessimism as regards the prospects of a more peaceful world" (ibid.), therefore there exists a strong sense of tragedy. Third, theorists within the tradition focus on the political aspect of international relations, excluding other disciplines such as economics, cultural studies, or the religious question. In addition, the political conception employed entails dynamics of maximizing one's own power, rather than cooperating (main contraposition to liberal theorists). Fourth, "the tradition is characterized by a clear-cut distinction between domestic and international politics [with the latter] being an almost exclusive priority." (ibid.). Fifth, theories within the realist tradition are based on conflict; when cooperation does exist, it is considered in the form of military alliances, or as a reflection of the balance of power (term that will be explored below). Finally, "power politics is considered to be an endless, repetitive form of social action to which there is no enduring solution" (ibid.), and since international relations from a realist perspective focus on the political aspect, these respond to a cyclical view of history.

The classical realist perspective relies heavily on rational choice theory, by which "politics can be understood in terms of the goal-directed behaviour of individuals, who act rationally in the minimal sense that the make ends-means calculations designed to maximize the benefits […] or minimize the losses." (Brown & Ainley, 2009, p. 40) It can be argued that politics will therefore try to minimize the losses that stem from climate change; nevertheless, realist stance towards environmental issues is inconclusive about this assessment.

Waltz's Theory of International Politics (Waltz, 1979) states that there are two kinds of systems possible: hierarchical or anarchical. In the former, different kinds of units are organized under a clear line of authority. In the latter, units that are similar in nature, even though they differ in capabilities, conduct relations with one another. Waltz argues that the current world operates under an anarchical system, for states are obliged to look after themselves, therefore they are concerned with their security and regard other states as potential threats. In view of this phenomenon, the international system operates within a balance of power. The notion of *balance of power* can be defined "in terms of the number of *poles* in the balance […], and the number of poles is defined by the number of states that are a serious threat to each other's basic survival." (Brown & Ainley, 2009, p. 43) Serious threats are determined by security, economic and social affairs. In the light of the existing balance of power, "states will likely take the necessary steps to not fall behind the international system and thus to not suffer harm. Other states with a favourable geographical position, or some other natural advantage, have the luxury of being able to belittle the demands of the international system without suffering serious harm. ((Waltz, 1979, p. 118; Brown & Ainley, 2009) "The rational choice version of the balance of power is that in which states are assumed to be self-interested egoists who determine their strategies by choosing what maximizes their welfare." (Brown & Ainley, 2009, p. 44) For the purpose of the present investigation, this might be choosing brown energies over green energies, without taking into consideration the externalities of the choice in other countries.

Another standpoint is the one developed by structural realist thought, which splits the discipline into *defensive realism* and *offensive realism*. The former holds that realist states "attain security by maintaining their position within the system, so their tendency is towards achieving an appropriate amount of power, in balance with other states." (Brown & Ainley, 2009, p. 44) The latter affirms that states aim to conserve as much power as possible, and reach hegemony at the global, or at least regional, level. This "leads them to pursue aggressive, expansionist policies, [which are] less costly and more rewarding." (ibid.) Brown & Ainley affirm that the international system does not reward offensive states, but rather those that maintain the status quo by maintaining their position. This relates to the fact that nations may well adopt offensive positions with regards to

energy and resource exploitation, as energetic hegemony increases power and influence over other states, hence improves security[6]. Hans Morgenthau, a realist academic, declared that "1973s oil crisis was historically unprecedented because it divorced military power from economic power based on raw materials", as pointed out by Nye (2003, p. 195) That is, crises can evoke energy crises, and fossil fuels evidenced the importance of *hegemony*.

b. Liberalism

Knud (Grieco, et al., 2019) points out liberalism as "a prominent political ideology [that has also been] heralded as perhaps the most important perspective within Western political philosophy […]. Some simply identify liberalism with Western civilization." In its origins, liberal thought advocated for individual liberties, free markets, and minimal political intervention in the sphere of economics. Knud (Grieco, et al., 2019) identifies five main characteristics to understand the liberal tradition in IR. First, liberal thought relies heavily on the reasoning human capacity. He writes, "human beings are capable of shaping their destiny, including shaping international relations and moulding the negative ramifications of the absence of a world government." (ibid.) This feature is rooted in John Locke's political philosophy (1632-1704). Second, liberalists deem possible a reform of international relations, based on a linear development of history that can experience progress thanks to social learning that comes from the capacity to reason. Third, "liberal theorists focus on state-society linkages and claim the existence of a close connection between on the one hand domestic institutions and politics and on the other hand international politics." (ibid.) Fourth, academics in the liberal spectrum claim that economic interdependence reduces the probability of conflict and war. David Ricardo (1772-1823) played an important role contributing with his theory of comparative advantages of trade. In addition, both liberalism and International Political Economy overlap when discussing economics and political interdependence. Fifth, liberal tradition stands for the institutionalization of international relations, which is directly related to cooperation as the basis, and tool, for the field. Some scholars emphasize the importance

[6] Security under Realism is understood as the capacity of states to protect themselves from external serious threats, and it is at the top of the priorities of domestic and international politics. This idea is inferred in the development of the section above and supported by the scholars from whom excerpts have been applied in the present investigation.

of agreements (that act as regimes), others point out the legalization and regulation of international relations.

Liberalism relates to this investigation because of the emphasis on cooperation and the establishment of regimes on the basis of common values shared by states; international agreements on environmental issues depict this understanding of international relations. “Human reason counters fatalism and makes progress possible […] and domestic institutions can be reformed and democratized and, in turn, contribute to an expansion of the international zones of peace.” (Grieco, et al., 2019, p. 111) Precisely, neoliberals assume that states are essentially concerned with the absolute gains made from cooperation; as long as they are happy with their own situation, they will not be too worried about how well other states are doing. “This is a clear parallel with liberal trade theory, where the fact that parties will gain unequally from trade that reflects comparative advantage is considered to be less important than the fact that they will all gain something.” (Brown & Ainley, 2009) How unequal are the effects of cooperation should be addressed in further investigations. For neoliberals, states cooperate because it is in their absolute interest to do so. Nevertheless, “states tend to cheat, to become *free riders*, and what is needed is some mechanism that prevents cheating. This would allow states to realize their true long-term interest in cooperation as opposed to falling prey to the temptation to settle for short-term gains.” (Brown & Ainley, 2009, p. 47) The mechanism needed to prevent cheating are institutions and international agreements; the large international institutional framework proves that states are willing to cooperate.

The concept of *free riders* needs to be clarified for the purpose of this investigation. It is a multidisciplinary concept, as it is present in many fields: psychology, philosophy, and political science amongst others. Free riders are individuals who benefit from a collective good without contributing to the costs of participating in its production (Hardin, Russel, & Cullity, 2020) In the case of international relations, states can act as free riders if one considers the international arena to be a group in which collective goods are produced.

Liberal thought argues some of these collective goods are collective security[7], institutions, shared norms and values and international agreements. Nordhaus (2018, p. 451) linked the free-riding problem to climate change by stating that "effective policies [on the protection of the environment] should have the highest possible participation […] Free-riding should be discourage." Free riding hinders international cooperation, especially with regards to environmental issues since global externalities are discarded for the national interest. That is, the benefit of effective environmental policies ,which tends to appear in the long-term, applied globally falls down in the list of priorities and preferences of states' interests . Short-term gains are more tentative than long-term gains, as it has already been stated in this investigation.

Liberalism assumes "the pattern of interdependence among state preferences shapes state behaviour." (Ayson, et al., 2008, p. 239) which explains the nature of the International System from a liberal perspective. The link between preferences and state behaviour is conceptualized as *policy interdependence*, which refers to "the extent to which the pursuit of state preferences necessarily imposes costs and benefits upon other states, independent of the 'transaction costs' imposed by the specific strategic means chosen to obtain them" (Ayson, et al., 2008, p. 239) Policy interdependence therefore explains that different states can have similar preferences towards a set of policies; when these policies are applied jointly, these will have distributional consequences (positive or negative). When the consequences impose costs on social groups in other countries, policy interdependence can lead to tension and conflict. This happens because of an asymmetrical interdependence amongst states, which is linked to the number of resources available that differs from one to another (Ayson, et al., 2008). This explains why some states might be more likely than others to agree on international environmental policies, given the impact these have on communities.

[7] According to Knud (Grieco, et al., 2019), collective security is a system that emerged under the foundation of the League of Nations - Paris Peace Conference, 1920 - , since traditional national security institutions were complemented by this new system which aim was to ensure common values and, ultimately, common security interests. Collective security is offered as an alternative to the realist balance of power, "claiming that historical experience had demonstrated that balance of power politics is a very difficult statecraft to conduct prudently; it often fails, in turn causing war." (ibid., p. 112). Nevertheless, collective security did not prevent states from going to war either, as shown by the League of Nations being succeeded by the First and Second World Wars, amongst other international conflicts.

c. International Political Economy

Economic interdependence

Interdependence and its effects in international relations has been explored in previous sections on this chapter; precisely, the understanding of policy interdependence from a liberal perspective. International Political Economy as a theory of IR is directly related to *economic interdependence.*

"Interdependence refers to situations in which actors or events in different parts of a system affect each other [which leads to] mutual dependence." (Nye, 2003) For better grasping of interdependence and its nuances, Nye (Nye, 2003, p. 205) states three assumptions on what complex interdependence means: (1) transnational actors working across state boundaries are major players in international relations, (2) economic manipulation and the use of international institutions are dominant instruments, (3) welfare is the dominant goal, to be achieved using dominant instruments.

Economic interdependence responds to these assumptions while also being dependant on other aspects such as pricing, economic sectors, economic power of countries, availability of resources and more. Economic interdependence in a globalized world is the result of different economies establishing relationships. Ayson et al. (2008) state economic interdependence was a result of several historical moments in global economy: the recovery of Western Europe and Japan from wartime devastation[8], a steep increase in Foreign Direct Investment, and the transformation from a historically dominant exchange of manufactures of raw materials to an intra-industry trade.

Nye (2003) exemplifies economic interdependence considering the oil crisis in 1972. He argues there was a shift of power by which oil producers were affecting the price, contrary to what had been happening up until that moment; richer countries, main consumers of oil, were determining the price of oil in their markets while that good was being produced in poorer countries. "This was a shift of power and wealth from rich to relatively poor countries." (ibid.)

[8] Wartime devastation refers not only to the economic environment but also to infrastructures, diplomatic relations, and societal changes.

Explaining International Political Economy

International Political Economy (IPE hereinafter) emerged as a theory and a field of study in the 1970s, to explain the growth of economic interdependence. It has been influenced by classical economists (such as Adam Smith, David Ricardo, John Stuart Mill), theorists of social change (Karl Marx, Émile Durkheim), and institutional economists and anthropologists (such as Thorstein Veblen and Karl Polanyi). IPE adopts a position that differs from realism and liberalism in its core values, since the former considers economic interactions to be significant in the study of IR, while the latter's focus on the role of state and its behaviour. Nonetheless, "many scholars agree [with liberalism] on the role of non-state actors when considering the relationship between politics and economics (same happens with the interaction between state and market." (Ayson, et al., 2008, p. 550). In addition, "despite the origins of IPE in a rejection of the state-centric ontology of realism, states continue to occupy the central place in most IPE analysis. [In fact], only a limited universe of states […]: less developed economies have rarely featured." (Ayson, et al., 2008, p. 351) As a result, "efforts to broaden IPE as a field of study have included work on the application of IPE theories to less developed economies and to development more generally." (Payne, 2005; Phillips, 2005). The impact of IPE and other classical IR theories on development will be addressed in following chapters of this investigation.

IPE is the field of study that aims to bridge economics, political science, and political economy in the international arena. Each of these fields have had different interpretations throughout history, mainly due to historical events that shaped academia.[9] As a field of study that "embraces all work for which international economic factors are an important cause or consequence" (Frieden & Martin, 2003, p. 118)

With regards to economics, IPE addresses the efficient allocation of resources, the role of public spending, economic growth related to investment and, ultimately, institutions as the actors influencing the aforementioned issues. With regards to political science, IPE also deals with the focus on power, the state, and the welfare of particular

[9] There are ongoing debates on the possibility of theories shaping reality, rather than only describing it. Constructivist theories address this issue in depth. For further reading on constructivist ideas, access Ayson et al. (The Oxford Handbook of International Relations, 2008) and Grieco et al. (International Cooperation in Europe and beyond, 2019).

communities[10]. With regards to political economy, IPE studies the interaction between economics and politics, and how these are deeply interrelated. Nevertheless, each IPE analysis is "based on a set of assumptions common to a specific paradigm [following] a particular theoretical perspective" (Grieco, et al., 2019, p. 251) The interpretations of every one of the fields within the IPE theory is subject to the complexity of the world, for "even what is in principle a holistic perspective cannot say everything and must necessarily prioritise." (Dunn, 2009, p. 318)

ii. Green Theory

Green Theory appeared as a critical current in the 90s decade, responding to socio-political discourses that sprouted in the late 80s to address environmental issues. The theory is a multidisciplinary approach in the International Relations Theory field, as it analyses natural and social concerns from a perspective that differs from the classical IR theories' approach. For this reason, it is complicated for academia to delimit with precision the contributions that green theory confines to international relations. In this manner, green theory appeared to expose the "ecological blindness" within the discipline, in which the natural world, environmental issues and its consequences were not being considered. Pérez de Armiño (2020) delves into how the classical IR theories neglected this concern. With regards to (neo)realism, "it ignored nature and has only been interested in resources and territory as a source of political and military power, in the service of national interests." (Pérez de Armiño, 2020, p. 340) In addition, (neo)liberalism has carried out studies on environmental cooperation since the 1970s, "but it has done so as a transnational issue rather than as a determining element of international policy, using existing frameworks and not formulating deep theoretical or political questions." (ibid.) Similarly, IPE has studied economic interdependence and how global cooperation in implementing policies enhance trade, efficiency, and sustainable development; yet, it has failed to treat the environmental issue as a central area of international politics. It does not take into account its relevance in the field as well as undermining its negative effects to the economic environment.

[10] As it has already been stated, IPE has dealt with economic growth and development in specific regions, leaving aside less developed countries. This idea will be present all throughout this investigation.

In dealing with this theoretical debate, green theory focuses on the gravity of the environmental threat. It argues that the ecological crisis is of such severity that it demands radical theoretical and political changes, which leads to a questioning of various ontological and epistemological foundations of the domain. There are two main ground-breaking contributions. First, it provides an alternative analysis of environmental challenges as a political problem. Second, it includes a discourse with innovative and highly transformative policy proposals to address the environmental challenge. On account of that, green theory deals with interdisciplinary topics such as the relationship between humanity and nature, the incapacity of states and the international system facing the environmental issues, development and modernisation , environmental justice, and security (Pérez de Armiño, 2020). One of the main theoretical perspectives to evidence the importance of the matter is the idea of the *Anthropocene*. Crutzen (Geology of Mankind, 2002) defines the term as an era in which humans have become geological agents due to the unprecedented impact on the planet, which is causing an irreversible alteration of ecological cycles that fall beyond reach. The idea is based on an apocalyptic discourse since it underlines a critical point at which life itself is in danger and which humankind must act quickly and appropriately. The contribution of the *Anthropocene* to the discipline of IR is significant on the grounds that it exposes a "need for major ontological and epistemological shifts in IR [as it is] a discipline traditionally concerned with security but lacking a framework for addressing the risk of human extinction." (Crutzen, 2002; Pérez de Armiño, 2020, p. 342)

a. Theoretical antecedents

There are two main theoretical antecedents of green theory, that explain the evolution of thought around environmental issues and help understand the relevance of green theory as a lens in IR theories.

Environmentalism is often a misunderstood concept, as it entails a discourse that addresses several issues related to the environment and the role of humankind in its preservation. Environmentalism is a reformist position with two main strands. On the one hand, this standpoint follows the neoliberal school, which studies international cooperation and the creation of international regimes to manage common resources and global ecological problems. It provides recommendations for improvement, yet it does not question international political or economic structures (Pérez de Armiño, 2020). On

the other hand, environmentalism is also based on a critical point of view, through which it points out the main cause of environmental degradation, competitiveness and inequality, result from global capitalism. Having this in consideration, the solution cannot be found in cooperation between states, but in the transformation of global capitalism and the way states interact with each other (ibid.). Both strands are characterized by two aspects. First, they deal with the environmental issue as an issue that needs to be addressed in the political system, but they do not deal with it as a central dimension demanding a profound change in the political or value system. In addition, this concern can be heard by different political sectors, as it does not belong to a one ideology (ibid.). Second, as pointed out by Dyer (2017) environmental perspectives study relations between humans, but they do not study interactions between humans and their natural surroundings.

The limitations and weakness of environmentalist approaches led to a more critical perspective, which in this investigation will be referred to as *radical environmentalism*[11]. Andrew Dobson (2007) defends radical environmentalism as a specific political ideology, or needs to be considered as such, since it has principles and values that clash with the existing system, and therefore there is a need for a radical social and political change. Radical environmentalism is based on green political theory, a political analysis about the relations between nature and humankind (Pérez de Armiño, 2020). Green political theory argues that global environmental problems have socio-political roots: the global free market economy and the growth-oriented development model, which encourages mass production and mass consumption, severely damage the environment. This model is not environmentally sustainable, therefore green political theory advocates for a radical change in the relationship between social, economic, and political structures (Hardt, 2018). Radical environmentalism then rejects some of the central claims of environmentalism: (1) the idea of the *Anthropocene* and how the preservation of the environment is in the interest of humans, (2) environmental preservation being ensured through science and technology, (3) environmentalism and its compatibility with economic growth and, (4) environmental preservation within the structures of modern industrial societies. (Pérez de Armiño, 2020)

[11] In Spanish, environmentalism refers to “medioambientalismo”, and what will be named as radical environmentalism refers to “ecologismo”. Other languages, such as French, also make this differentiation: “environnementalisme” and “écologisme”, respectively.

It can be stated that the dichotomy between the reformist and radical currents of environmentalism is a simplistic view of the foundations of green theory, notwithstanding it helps to understand the contributions of green theory to the discipline of international relations.

b. Addressing Green Theory

Green theory provides an analysis from a multidisciplinary, political angle, as an alternative to other interpretations coming from rationalist currents such as rational choice theory or liberal thought. It is characterized by four main standpoints, which are developed below.

It questions anthropocentrism, as it is based on a separation between nature and humans, as well as on the superiority of humans, whereby the value of nature depends on its utility to human activities. Accordingly, anthropocentrism exempts human beings from moral responsibility towards other living beings, as well as towards future generations (which prevents sustainable development). It also fails to consider that natural resources, such as fossil fuels, are finite (Garrido, 2007).

As an alternative to anthropocentrism, green theory formulates the idea of *Ecocentrism*: "a holistic vision that perceives Earth as a complex ecosystem in which every form of life is interdependent with the other." (Pérez de Armiño, 2020, p. 348) This concept requires political analysis to consider the existence of contradictory interests and values, amongst humankind and nature but also between different human generations (ibid.). This argument is motivated by the apocalyptic discourse on the environmental crisis. Eckersley (1992) stresses that green principles are emancipatory approaches to the system, whereby adopting new values towards the environment and the relationship between humans and its surroundings would be beneficial for our society. Because ecocentrism lacks political and intellectual impact, scholars have proposed concepts such as *intelligent anthropocentrism* (Garner, 2019), *reflexive anthropocentrism* (Mitchell, 2017), *self-reflexive anthropocentrism* (Barry, 1999), and *weak anthropocentrism* (Dobson, 2007). All these concepts assemble a discourse that keeps humans in the centre of the discussion, bearing in mind their role in the protection of the environment and aiming to change the way these relationships have evolved throughout history; this discourse diminishes the limitations of both anthropocentrism and ecocentrism. It does

not, however, undermine the complex ecosystem in which humans live. It challenges the perception of ethics, politics, and coexistence itself (Mitchell, 2017). In this sense, this proposal guarantees the protection of the environment that is supported by radical environmentalism, while allowing the participation of diverse social and political actors. Pérez de Armiño (2020, p. 350) argues that "this perspective implies nature's value is seen depending on its benefit for humans, but such benefits are precisely conceived in terms of protection of nature and the environment."

Green theory, given that it is influenced by Critical Theory[12], questions modernisation, progress and industrialisation as factors that might have been detrimental for the environment since their appearance during the Enlightenment. These three factors are present in capitalist and communist economic models and are based on two main assumptions. First, economic growth is a worthwhile objective that is achieved through dominance of natural resources, which tends to happen by way of scientific and technological progress. Second, the idea of natural resources being infinite (following an anthropocentric view), and that these resources have a carrying capacity suited for endless economic growth. (Pérez de Armiño, 2020)

As an alternative to the modernisation that deteriorates the environment, green theory proposes what is called *reflexive modernisation*. It is a critical attitude towards the means and ends of modernisation, with the objective of learning and avoiding its increasing ecological risks (Eckersley, 1992). Two of the most influential schools of thought in the development of critical theory in IR (Habermas and School of Frankfurt) already explored the sequels derived from the dominance of nature: the environmental risks that affect society and come from modernisation, science, and technological progress without regulation. In view of this, environmental sustainability depends not only on developing greener means ,such as green energies, but also on reassessing modernisation. It also includes these discussions in social and political discourses, with the ultimate goal of implementing the required political adjustments to manage the risk posed by environmental degradation (Eckersley, 1992).

[12] Critical Theory in IR is composed of several theorists who develop "a philosophy which questions modern social and political life through a method of immanent critique [… and explores] built-in pathologies and forms of domination [in contemporary societies]." (Grieco, et al., 2019, p. 164)

One of the main critiques of green theory towards the established literature on economic growth is the idea of development equated to economic growth, which is an idea based on the exploitation of nature, ignoring the environmental limits, and thus questioning both growth and development.

Many authors have studied the limits to growth: Robert Malthus developed the idea in the late 18th century, and it gained relevance in the international sphere with the publication of the report "Limits to Growth", written by Meadows' and Randers in the late 20th century. This approach suggests that the Earth has finite ecosystems in which there are fixed-volume resources, thus an endless or continuous economic growth necessarily threatens to exceed at some point the limits of these systems (Dryzek, 2013).

Pérez de Armiño (2020) remarks this approach has been nuanced with the concept of *planetary boundaries*. This approach asserts that environmental factors essential to life have limits and maximum thresholds that work according to the maximum carrying capacity of the Earth. Thus, crossing these limits would mean overflowing the safe operational spaces for humanity, which can have severe consequences. This idea is explored by Rockström (2009, p. 32), and it relates to how if levels of economic growth, production, and consumption are not reduced to sustainable levels, the crises derived from the overflowing of limits will have economic and environmental consequences at the big scale (Pérez de Armiño, 2020). Different views emerge from this approach. On the one hand, regional differences when it comes to development and environmental impact in development need to be taken into account. On the other hand, sustainable development must also be considered. The development needs to not threaten present and future generations. (ibid.)

Green theory grounds its analyses and proposals in values, ethics, and justice, focusing on dimensions that had been ignored in classical IR theories. The incorporation of these dimensions into the analysis demonstrates that ecological problems generate *environmental injustice*, given that the main causes of environmental problems transfer the damage to other humans, who normally have less decision-making power in regulatory processes and institutions (Pérez de Armiño, 2020). It also entails damage to

future generations and other forms of life that coexist in the complex ecosystem[13]. "The debate on environmental degradation, which crosses borders and has an unequal effect globally, [has contributed to] the development of theories on justice that go beyond the traditional view of justice." (Pérez de Armiño, 2020, p. 356)

These evolved theories on justice expand the range of existing objects of justice and thus also extend the responsibilities to be assumed, specifically in three areas. First, it addresses animal ethics, considering animals have moral value (Garner, 2019). Second, it develops the concept of *ecological footprint*[14]: countries of the global north consume the most resources and have the largest ecological footprint, yet it is the communities in the global south who suffer most from the effects of environmental degradation (for instance, global warming). This issue overlaps with other social concerns such as indigenous identity, gender, or territorial rights (Martínez-Alier, 2016). It can be stated that ecological footprint is therefore an add-on to other dimensions concerning inequality, both within countries and between countries.

Green theory advocates for a solution to the environmental problem that extends from a merely technical perspective, thus considering the transformation of global politics, which should be based on new behaviours and values. Following this ambition, it is necessary to focus on three aspects. First, a long-term perspective that includes communities who have been affected by ecological risks, which is ultimately a holistic vision of the environmental problem. Second, the reduction of GHG to decrease the detriment of the atmosphere, precisely reduces GHG in rich countries that have financial means to substitute high-polluting industries (powered by brown energies) with more environmentally friendly industries. This also reflects on the right to use natural resources within their carrying capacity. Third, to broaden the reach of responsibilities and obligations with regards to environmental deterioration, so as to not harm future generations with current environmental costs. This requires an institutionalisation of the environmental problem, in order to implement the necessary regulations and policies, based on the democratic participation of all countries involved (specially involving those most affected communities) (Eckersley, 1992; Pérez de Armiño, 2020)

[13] Based on the idea defended by green theory: every form of life coexists in a complex ecosystem with finite resources.
[14] Usually referred to as "Carbon footprint".

In summary, a change in the global political and economic model is needed, which advocates for economic and social models alternative to the current free market economy. These new models should assume the limits to growth and reducing inequalities while also improving long-term sustainability . This also requires a change in ethics and social behaviour, embracing shared ecological values such as non-violence, environmental justice, democratic governance and ownership and ecological responsibility.

iii. Green growth

Green growth is often argued to be a relatively new term, as it arises from current concerns on environmental sustainability, sustainable development, and the long-term impacts of economic growth. It can be understood as "a call for balancing longer-term investments in sustaining environmental wealth with nearer-term need for growth to reduce poverty" (Smulders et al., (2014, p. 423). Therefore, the term takes up on concepts that can be found throughout the existing literature on economic theory, growth economics and development economics. "The literature that looks at resource scarcity and the dynamics of environmental policy through the lens of economic growth theory is directly relevant to green growth." (Smulders et al., (2014, p. 424) This is why green growth is not as new as it can be seen; however, the relationship between growth economics and environmental policy has indeed gained relevance in the policy arena.

Neoclassical growth theories explain economic growth considering the relation between accumulation of capital and technical change, and consequently investment and innovation. These theories depend on three variables that are developed under various crucial assumptions: substitution of productive factors, the law of diminishing returns, and technological change. Substitution of productive factors is important because it can determine productivity, which is an indicator for "how effectively resources are being used for the production of various goods and services. The resources may be labour, capital, materials, energy […] or any combination of these." (Jurison, 2003, p. 517) The law of diminishing returns predicts that when an optimal level of capacity is reached, adding an additional factor of production can lead to smaller increases in output (the additional unit yields decreased per-unit incremental returns) (Hayes, 2022). Technological change can be defined as "an increase in the outputs possible with a given level of inputs trough the processes of invention, innovation, and diffusion." (Niggol Seo, 2017) That is technological change increases the efficiency of a process as it results in an

increase in output without an increase in input. The relationship between these three assumptions is that the substitution of factors can augment labour productivity and thus per capital income, all the while increasing capital accumulation; nevertheless, capital accumulation without technological change runs into diminishing returns. "Only if steady technical change continuously creates new investment opportunities, can *per capita* income growth be sustained." (Smulders et al., (2014, p. 426)

Technological change plays a key role in environmental policy:

> While new technologies can make cleaner production and more efficient resource use possible, markets are unlikely to provide proper incentives for the development of clean technologies, absent public policy. […] knowledge spillovers lead to underinvestment in R&D by private firms. […]
>
> By addressing the externality problem, environmental policy increases incentives for environmental R&D. [technological change focused on environmental issues] (Popp, Newell, & Jaffe, 2010, p. 926)

Growth theory and green growth are complementary when explaining the connection between environmental degradation and environmental policies on the one hand, and the sources of growth and the rates of return to investment on the other hand. While growth theory explains the trade-offs arising from growth and the environment, green growth shows how "different trade-offs are possibly connected, and it can derive through which processes and policies trade-odds might be mitigated." (Smulders et al., (2014, p. 426) Because of the nature of variables interacting in growth theory (capital accumulation, technological change, etc.), one can assume that environmental policies affect and interact as well with growth, investment, and innovation; they are expected to slow down capital accumulation and growth. Nonetheless, if environmental policies stimulate innovation, trade-offs can be softened and technological change boosted, therefore improving investment possibilities, thus reversing the cycle. This present investigation assumes that stimulated innovation arises from the needs of the market and the societies, which explains the surge of new forms of energy, i.e., green energies. A key consideration in the context of green growth is how different types of technology change

depend on substitutability between production factors. If production factors are high substitutable, it will be more efficient to increase the productivity of the substitute and increasingly substitute away from the depletable resource. This will increase incentives to innovate on technological change. This idea resonates with green energies, as technological change increases their substitutability from fossil fuels and other non-renewable energies (ibid.)

Green growth is feasible if production relies on renewable resources. This requires a large investment to adjust the market economy, while ensuring GDP growth, and protecting environmental quality. However, at the beginning of such a growth path the returns to investment will fall accordingly to the decrease in non-renewable energy inputs. Growth models suggest that this path, lacking increasing returns in capital investment on technological change, will lead investors and consumers to adopt a pessimistic view, given the consumption and production shrinking to zero; growing consumption is possible in the nearer term, but, as it has already been explored in this investigation, growth paths should focus on the long term for a feasible green growth (Smulders et al., (2014, p. 428). "When an economy starts from an unsustainably high level of extraction because of neglect of environmental issues in the past […] resource use necessarily has to be reduced and this implies a growth drag in the short run." (ibid.) Energy transition is a costly process, if rushed, in the short run, in spite of being beneficial and cost-efficient in the long run. The shift from an unsustainable extraction profile to more sustainable economic activities bring along trade-offs and externalities that will be offset in the long run; the investment needed in the short run is high but will eventually lead to diminishing returns in the short run. This explains why environmental policies focus on the long-term rather than the short-term.

iv. Growth models with an environmental perspective

The previous section of this research focuses on green growth as a study field and the considerations that need to be applied to economic growth models. Growth models serve to understand the economic reality of countries, predict growth paths and, consequently, to design and implement political economy. Economic growth theories are based on a set of assumptions and represent the reality of the moment when these are developed. This is why authors such as Schumpeter and Solow developed models that give a starting point to develop today's theories. Although these models can be adapted

to current needs of the global economy, proper models dealing with technological change, economic interdependence, and the interaction between markets and the environment need to be developed. Theories of endogenous growth answered to the question "where is technological progress coming from?"; in addition, endogenous growth models gave rise to the concept of *conditional convergence*, which deals with the increasing asymmetry between economies (Fernandez et al., (2021). With regards to the first question, endogenous economic growth models justify technological progress as a result of new forms of technology and efficient and effective means of production; this, which enhances a nation's human capital, will lead to economic growth (Liberto, 2020). Conditional convergence refers to how countries can defer in their growth rates depending on their structures and stationary states[15]. The current investigation focuses on the role of green energies – which result from technological progress, as defended throughout the investigation – within economic growth and how green growth can lead to economic convergence between countries. Therefore, economic models addressing technological progress and environmental issues are the cornerstone of the theoretical framework of this research. Precisely[16], Paul Romer's ideas on endogenous growth, and William Nordhaus' approaches to "environmental economics".

a. Romer

Romer introduced to growth economics the nature and importance of innovation. Technical progress being endogenous implies that innovation comes from within the model and the economic agents, thus strongly dependent on incentives; these incentives vary and can be enhanced or weakened by policies and regulations. One of the main contributions of Romer's model into growth economics is the concept of *non-rival ideas*, which developed in the 1990. Ideas serve to transform other objects into an output with more utility. Ideas are nonrival because they can be used simultaneously, that is one person using an idea does not preclude others' from using it. This generates knowledge spillovers, because ideas can move around the world allowing several regions to profit from the same information. This increases productivity, which will in turn be

[15] A stationary state is when economic growth in a country or region is neither positive nor negative; there is a constant stock of physical capital and a constant population size. For more about stationary state and its implications in growth models, go to "Solow model on economic growth" (Solow, 1956; 1957)

[16] Paul Romer's ideas on endogenous growth, and William Nordhaus' "environmental economic" where awarded in 2018 with a Nobel Prize in Economics; "it sends a powerful message [to the global economy]: we need economic growth, and we can, and we should make this growth sustainable." (Guriev, 2018)

characterized by increasing returns to scale. "Because of the nonrivalry of ideas […] each idea only needs to be invented once and then it is technologically feasible for the idea to be used by any number of people or firms simultaneously and repeatedly." (Jones, 2019, p. 866) If innovation is the source of growth, and incentives to innovation are needed for it to be constant, then the government plays an important role. Romer (2021) states that, in fact, governments have two roles in the process of innovation. The first one is that it can encourage the discovery of these fundamental insights from basic science, the second one is that it can structure the process of taking advantage of this insight. Romer (ibid.) exemplifies this by referring to fertilizers and how governments can regulate the use of these methods, for instance, to avoid chemicals to pollute waterways. "Innovation involves the creativity that the market [economic actors] can unleash and the creativity that the government is responsible for." (ibid.) These two forces make it possible for ideas to encourage economic growth and improve standards of living. This is also explained through capital externalities, which result from knowledge spillovers, and promote incentives from the government. Capital externalities that result from the development of cleaner energies can increase capital accumulation which can be reinvested into education (increasing human capital), environmental policies (protecting the environment), and health (promoting welfare states).

b. Nordhaus

Nordhaus (2018) explored the interaction between climate change – a result of ineffective environmental policies – and the economy. This interaction is the result of spillovers or externalities of economic growth, which have an impact on climate-change (its sources, its potential impacts, and the policy tools available to address it). Nordhaus deals with climate change as a global public good, as it is considered a global externality that differs from local or national public goods, "because the resist the control of both markets and national governments." (ibid.) Nordhaus argues that nations have had limited success with agreements dealing with global economic externalities because the benefits of the agreements did not outweigh the costs for states. Effective institutions fostering cooperation have played a significant role in shifting the balance, so that international agreements would be beneficial without decreasing welfare states ,even in the short run. This is why governance is at the core of global externalities; effective management requires major economies to be bound by international agreements, and cooperation is

needed to avoid free riding in managing global externalities. Global externalities refer to the harm that suffers the global economy because of inefficiencies in the system. "Global environmental concerns raise completely different governance issues from national environmental concerns." (ibid.) And because environmental concerns at the national level do not appear in the centre of the political agendas, "it is only by designing, implementing, and enforcing *cooperative multinational policies* that nations can ensure effective climate-change policies." (ibid.) This is how benefits return to the national level.

Nordhaus developed the DICE model[17], which explains how climate interacts with the economy. Figure IV:1 shows the circular flow of global warming science, impacts, and policy. The author indicates that the global warming issue starts at the upper-left box, where an increase in economic growth leads to rising emissions of CO2 and other GHG. The second box, in the upper right corner, shows how these emissions lead to major changes in the climate system. This changing climate impacts human and natural systems, affecting productivity (shown the lower-right box). Finally, governance and civil societies enter into science to respond to the threat of climate change. The arrows represent the linkages between the different phases of the "economy-climate-impacts-politics-economy" nexus (Nordhaus, 2018, p. 443) The question marks illustrate the inexistent linkages between the last two phases because, as defended by the author, "there are no effective international agreements as of 2019 to limit the emissions of carbon dioxide and other greenhouse gases." (ibid.) Whether existing agreements are effective or not is out of the scope of the present investigation. However, this model demonstrates that environmental policies that tackle climate change will directly increase productivity, although capital accumulation will be notable in the long run because the environment and climate change interact with the economy. The positive externalities from this interaction are only possible through effective policymaking.

[17] For more information on the basic structure of the DICE model and its evolution, go to "Evolution of Assessments of the Economics of Global Warming: Changes in the DICE Model, 1992-2017" (Nordhaus, 2018)

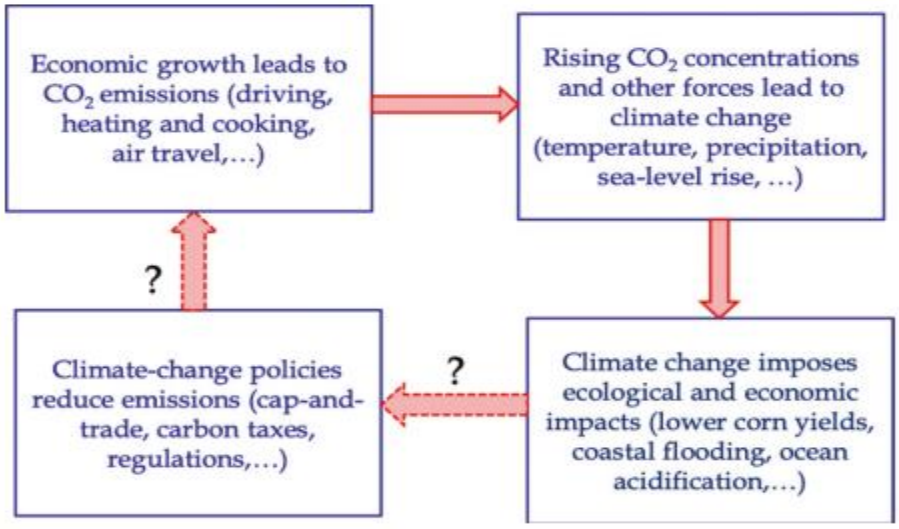

Figure IV:1. DICE model. The circular flow of global warming science, impacts, and policy.
Source: (Nordhaus, Climate change: The Ultimate Challenge for Economics, 2018)

V. ANALYSIS AND DEVELOPMENT OF THE INVESTIGATION

The countries studies in this investigation have different development profiles. According to the WB, as for the current 2023 fiscal year: low-income-economies are those with a GNI per capita of $1,085 or less; upper-middle-income economies are those with a GNI per capita between $4,256 and $13,205; high-income economies are those with a GNI per capita of $13,205 or more. (WB, 2023) Costa Rica is an upper-middle-income economy; Ethiopia is a low-income economy; Thailand is an upper-middle-income economy; and Chile is a high-income economy. The sections for each country provide a brief country and energy profile and overview the most recent and relevant policy implementation with regards to the energy sector and economic development. In addition, each section explores the NDC to the Paris Agreement of the country being analysed. The NDC is a required document stating long-term goals and the efforts adopted to reduce national emissions and adapt to climate change. Every party is required to elaborate a report in which they "shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions." (UNFCCC, n.d.) NDCs are submitted every five years to the UNFCCC secretariat and are intended to demonstrate a progression over the Paris Agreement' ambitions. The NDCs analysed in the present investigation can be consulted in Table V:1.

Party	NDC Title	Submission Date
Costa Rica	Costa Rica First NDC (updated submission)	December 29, 2020
Ethiopia	Ethiopia First NDC (updated submission)	July 23, 2021
Thailand	Thailand 2nd Updated NDC	November 2, 2022
Chile	Chile First NDC (updated submission)	April 9, 2020

Table V:1. NDCs according to each case study.
Source: own elaboration.

Complementary index will be included in each of the analysis in order to enrich the qualitative analysis, by providing data related to development in the different countries. The index included are the HDI and the GINI. The HDI is an index calculated from the average of three different index: life expectancy index, education index and GNI index. Therefore, the HDI measures the achievement in three key areas of human development, these being a long and healthy life, knowledge, and a decent standard of living. (UNDP, n.d.) The GINI coefficient calculates income inequality by comparing cumulative proportions of the population against cumulative proportions of the income they receive. GINI = 0, complete equality; GINI = 1, complete inequality. (OECD, n.d.)

As a preliminary analysis, the following map (has been drawn up using data sourced from the World Bank. The map indicates the GEG per capita; it illustrates the green production per capita for each country in 2019. It can be seen that countries that belong to the group of high-income economies tend to have a higher GEG/per capita (i.e., USA, Canada, Norway). These countries are the leads for the energy transition in the global economy. The study cases provided in this research will serve to determine if green growth through green production can lead to convergence in the GEG/per capita.

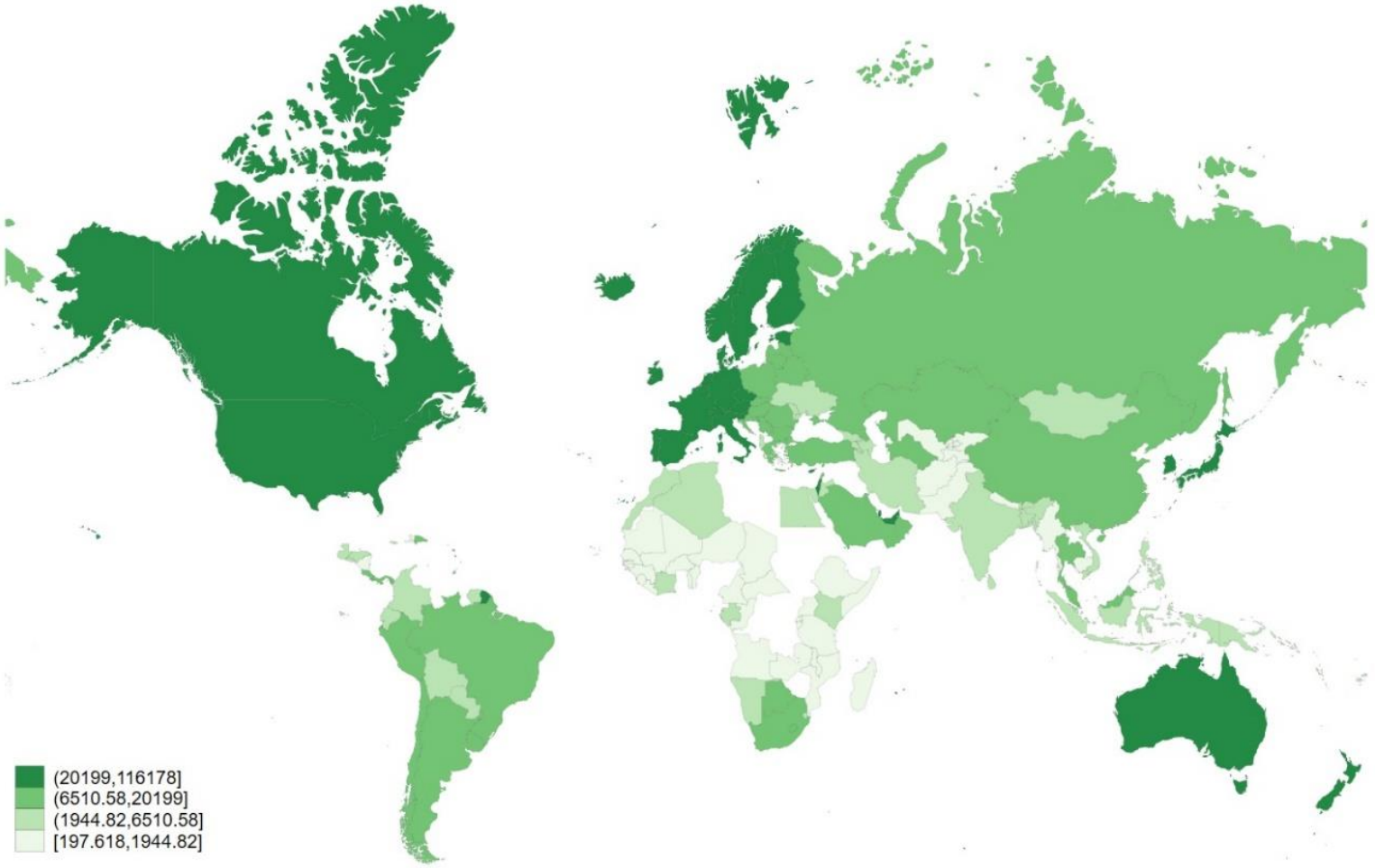

Figure V:1. GEG per capita.

Source: own elaboration with external data (WB, n.d.).

i. Costa Rica

The Republic of Costa Rica is considered a full democracy (rank 17) in the Democracy Index for 2022[18]. It is a presidential republic with a unicameral parliament, located in Central America, with an area of 51100 km2. It is bordered to the northeast by the Caribbean Sea, to the southwest by the Pacific Ocean, and is a country with a very mountainous terrain. Costa Rica's economy is characterised by a high fiscal deficit, which hovered around 7% of GDP in 2019, due to limited tax collection capacity and the burden of public wages. It is a trade-based upper middle-income economy, a green economy leader (the country has reversed deforestation, reaching 52% of forest coverage in 2019 versus 21% in the 80s) and is investing in blue economy infrastructure[19]. (MAEC, 2023; CIA, 2023)

With regards to the energy profile, the vast majority of the country's electricity is generated by renewable sources: 71% of the country's energy came from hydroelectricity in 2020. (CIA, 2023) Other green energies used for electrical generation are geothermal, wind and solar power. The country was supplied about 99,5% of the energy from renewable sources in 2017 (ITA, 2023)

Costa Rica has put in place numerous policies to decarbonize the economy. One of the latest milestones is the adoption of the National Decarbonisation Plan, which is aimed at having a decarbonised economy by 2050, and to this end they analyse and propose improvements in different sectors of the economy that are sources of emissions: energy, industry, and waste management (Gobierno de Costa Rica, 2018). With regards to the Paris Agreement more specifically, in the area of energy, Costa Rica stated in its NDC that "Costa Rica's contribution in energy is focused on accelerating the electrification of different sectors in the country, limiting and reducing the use of fossil fuels, promoting energy efficiency and innovating in energy sources". On the subject of energy, Costa Rica offers the following contributions: to achieve and maintain an

[18] The Democracy Index is a report elaborated by The Economist Intelligence Unit, which ranks the world's countries based on five categories: electoral process and pluralism, functioning of government, political participation, political culture, and civil liberties. With the given score, countries are classified as one of four types of regimes: "full democracy", "flawed democracy", "hybrid regime", or "authoritarian regime". (The Economist Intelligence, 2023)

[19] Blue economy infrastructure serves to the development of blue economies, which mitigate climate change by developing offshore renewable energy, as well as decarbonizing maritime transport and greening ports. (EC, n.d.)

electrical capacity 100% renewable by 2030; to develop in the meantime an integrated inter-sectoral planning of the process of electrification of the energy demand, which will incorporate the needs of sectors and the diversity of renewable energy source across the regions of the country. In addition, the report declares that by 2030, the country will have developed and updated energy efficiency standards and regulations for the end-use technologies, to ensure consistency with the country's decarbonisation trajectory to comply with the net zero emissions plan by 2050. During the implementation process of these contributions, the country will encourage the adoption of a moratorium on the exploration and exploitation of hydrocarbons in the national territory. (Gobierno de Costa Rica; MINAE; DCCC, 2020)

COSTA RICA	2006	2009	2012	2015	2019
HDI	0,747	0,769	0,786	0,798	0,819
GINI	49,3	50,6	48,4	48,4	48,2

Table V:2. Costa Rica HDI and GINI index.

Source: own elaboration with external data (UNDP, 2023; WB, n.d.)

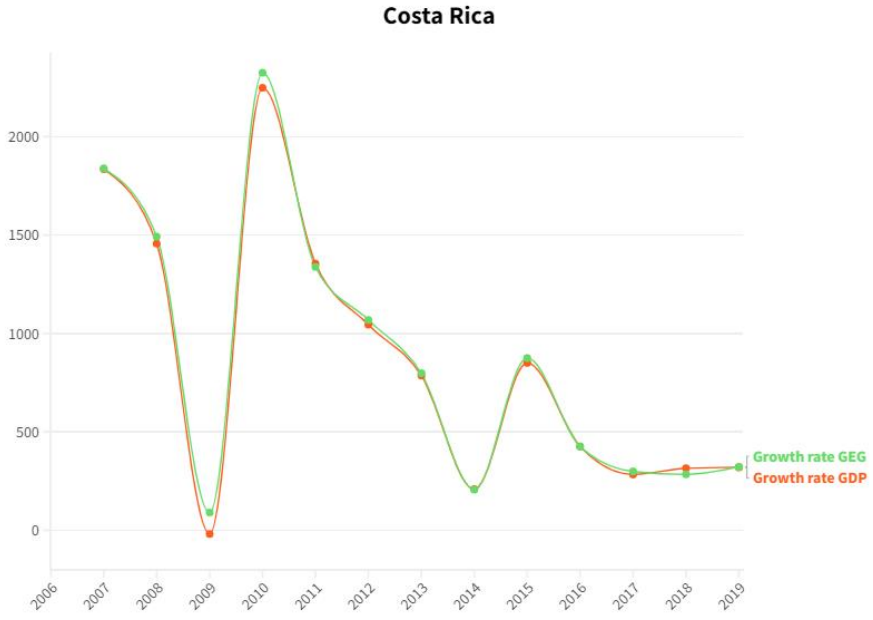

Figure V:2. Costa Rica GEG growth rate vs. GDP growth rate.

Source: own elaboration. Data in Annex III: Data per country; Costa Rica

Figure V:2 shows how Costa Rica's economy would not have been worse-off with green growth. From 2017 to 2019, the growth rate of GDP was higher than the growth rate of GEG; for the rest of the timeline, GEG growth rate has been higher than GDP growth rate. Therefore, it can be concluded that in Costa Rica there is convergence between GDP and GEG growth rates. However, as seen in Table V:2, inequality has not diminished considerably in the last decade. Therefore, policy implementation should also focus on wealth redistribution of green economic growth to reduce inequalities and achieve sustainable economic growth.

ii. Ethiopia

The Federal Democratic Republic of Ethiopia is considered an authoritarian regime (rank 122 alongside Jordan) in the Democracy Index for 2022 (The Economist Intelligence, 2023). It is a parliamentary federal republic, located in the Horn of Africa, with an area of 1,112 million km2. It is landlocked and is characterised by a large plateau divided by two broad mountain ranges crossed by the Rift Valley. The port access is situated in Djibouti and Eritrea. It is a low-income, growing economy of the region, based on construction and services. It is highly disrupted by global and neighbouring crises (COVID-19, Tigray crisis, etc.), therefore public investment has increased in recent years. It is the second larges African labour force, with widespread but declining poverty. (MAEC, 2022; CIA, 2023)

With regards to the energy profile, almost the total of the country's electricity comes from hydroelectricity (95.8% of total installed capacity as for 2020). (CIA, 2023) Hydro dominated systems have been severely affected by drought and other climate change consequences, therefore the country has diversified its power sources with sola, wind and geothermal power. Nevertheless, there is a lack of infrastructure and connectivity. (ITA, 2022)

In 2011, the government of Ethiopia established the Climate Resilience and Green Economy Strategy (CRGE), aimed at lowering GHG emissions and building climate resilience while working towards the middle-income status by 2025. This strategy stands on four pillars: agriculture, deforestation, green energies for power generation, and developing energy efficient technologies for different economic sectors. (LSE, 2011; IEA, 2022) In addition to this strategy, in 2012 the Ministry of Water and Energy (2012)

launched the Scaling-Up Renewable Energy Program (SREP), developed in collaboration with the African Development Bank, the World Bank, and other development partners alongside key Ethiopian stakeholders. This program aims to maximize the potential of renewable energy through different investment plans. (IEA, 2022) With regards to the Energy Sector contribution into the Paris Agreement, Ethiopia divides its policy interventions into four areas. Energy efficiency focuses on improving energy efficiency of appliances, machinery, and other capital assets. Transport electrification is based on shifting transport energy demand from brown energies to electricity (which comes from green energies). This will be complemented with the improvement of public transport networks, electrifying energy demand as well as upgrading infrastructures. Lastly, and closely related to the main economic drivers of the country, public sector will intervene to switch from industrial petroleum demand to electricity and sustainable biomass. (Federal Democratic Republic of Ethiopia, 2021)

ETHIOPIA	2006	2009	2012	2015	2019
HDI	0,363	0,402	0,430	0,460	0,498
GINI	NA	NA	NA	35	NA

Table V:3. Ethiopia HDI and GINI index.

Source: own elaboration with external data (UNDP, 2023; WB, n.d.)

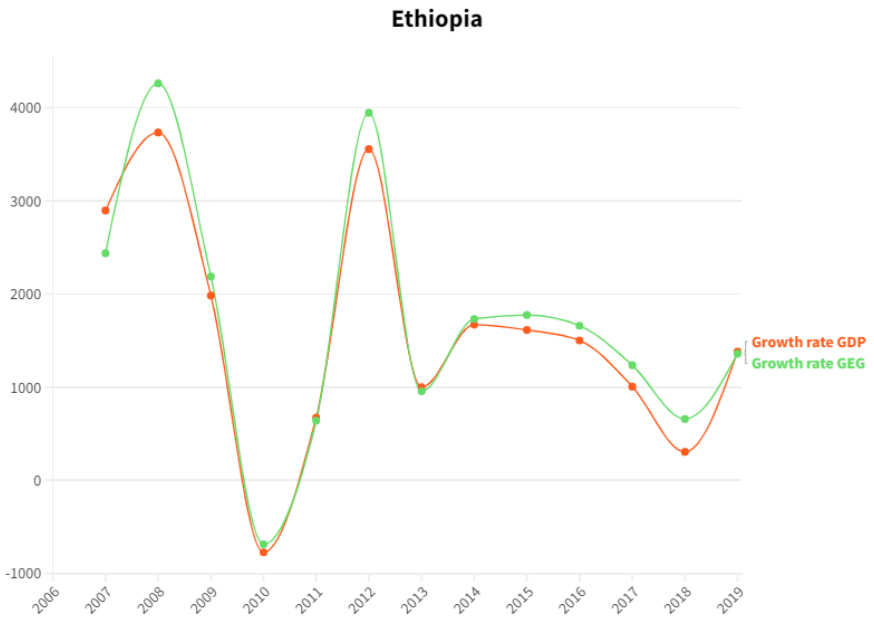

Figure V:3. Ethiopia GEG growth rate vs. GDP growth rate.

Source: own elaboration. Data in Annex III: Data per country; Ethiopia

As shown by Figure V:3, Ethiopia's GEG growth rate is considerably higher in almost all of the years analysed, specially since the signature of the Paris Agreement. As seen in Table V:3, wealth distribution cannot be analysed because of unavailable data, in addition to a low HDI value (because Ethiopia is a developing country). Therefore, it can be concluded that in Ethiopia there is convergence between GDP and GEG growth rates. Nevertheless, GEG does not contribute to the development of the country, and as a consequence the relationship between GEG and human development in developing countries remains inconclusive.

iii. Thailand

The Kingdom of Thailand is considered a flawed democracy (rank 55) in the Democracy Index for 2022 (The Economist Intelligence, 2023). It is a constitutional monarchy, located in Southeast Asia, with an area of 513120 km2. It is bordered to the east by the Gulf of Thailand and to the west by the Andaman Sea and has a tropical climate which varies considerably between the different regions. It is an upper-middle income economy, based on exports of electronics, food, and automobile components. It has low unemployment (0,72% unemployment rate in 2019) and is currently experiencing great economic development. (MAEC, 2023; CIA, 2023)

With regards to the energy profile, Thailand relies heavily on fossil fuels; electricity generation from fossil fuels accounts for 83% of total installed capacity (in 2020). (CIA, 2023) In 2019, renewable energies accounted for less than 25% of total energy supply; oil and gas accounted for almost 70% of total energy supply. 96% of the renewable energy supply in 2019 came from bioenergy. (IRENA, 2022)

In 2017, Thailand adopted the 12th National Economic and Social Development Plan 2017-2021, set within the principles of the "Sufficiency Economy Philosophy", aimed at preparing Thailand to achieve "Stability, Prosperity, and Sustainability" (LSE, 2017). The Plan establishes several objectives to adapt to climate change in different sectors which are of significant priority, through domestic mitigation mechanisms to provide support in finance technology and capacity building. The objectives are set to contribute to economic and social development: to preserve and restore natural resources and environmental quality in order to support green growth; to redistribute wealth across different regions through urban and regional development by improving existing

networks and developing new ones; and to increase efficiency of GHG emissions' reduction and improve the capacity for climate change adaptation. (Government of Thailand, 2017; LSE, 2017) With regards to the Paris Agreement more specifically, Thailand's contribution was formulated following several plans that had been adopted at the national level (such as the one previously explored). The main policy implementations cover the areas of climate resilience, GHG emission reduction, mitigation and adaptation mechanisms, and the development of educational and training programmes to raise awareness on climate change and NDC. One of the national adaptation priorities falls within the natural resources management sector, with the ultimate goal to "sustainably manage natural resources and biodiversity to respond to climate change impacts by enhancing the conservation, rehabilitation, and sustainable use of natural resources and biodiversity and strengthening public participation." (Government of Thailand, 2022)

THAILAND	2006	2009	2012	2015	2019
HDI	0,712	0,730	0,746	0,781	0,804
GINI	41,8	39,6	39,3	36	34,9

Table V:4. Thailand HDI and GINI index.

Source: own elaboration with external data (UNDP, 2023; WB, n.d.)

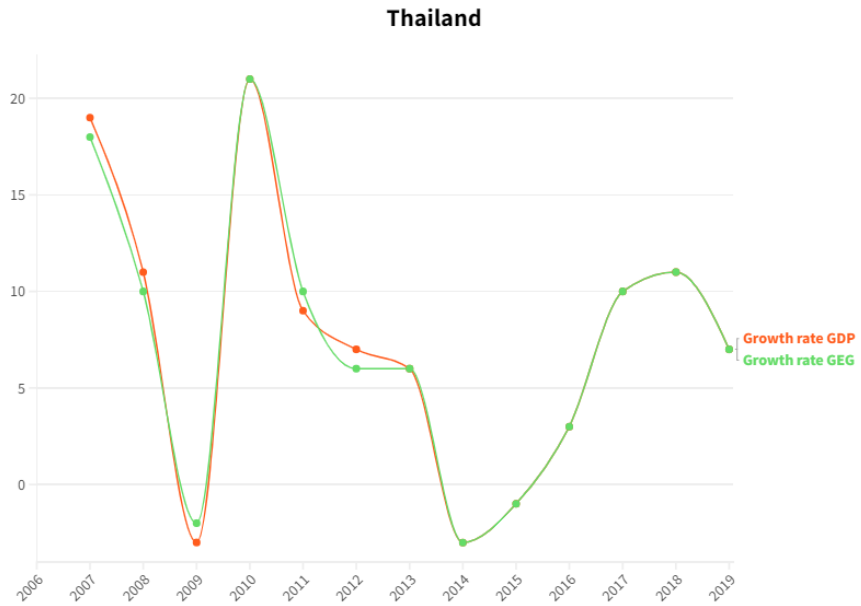

Figure V:4. Thailand GEG growth rate vs. GDP growth rate.

Source: own elaboration. Data in Annex III: Data per country; Thailand

Thailand's GEG growth rate reached convergence with GDP growth rate prior to the Paris Agreement, but the establishment of the international agreement has made it possible for GEG to be sustained over time (see Figure V:4). In addition, as shown by Table V:4, inequality has decreased considerably since the establishment of the Agreement, and HDI has also increased. Therefore, it can be concluded that the implementation of environmental policies in economies driven by brown energies do not drag GDP growth, and in fact can increase human development and decrease inequality.

iv. Chile

The Republic of Chile is considered a full democracy (rank 19) in the Democracy Index for 2022 (The Economist Intelligence, 2023). It is a presidential republic, located mainly in South America, with an area of 756945 km2. Chile is present in South America, Oceania, and Antarctica. It is bordered to the west by the Pacific Ocean and to the south by the Pacific Ocean and the Antarctic Territory. Its climate is very varied depending on the latitude of the region. The country is traversed by several short, low-flowing rivers that end in the Pacific Ocean. It is a high-income economy driven by exports, precisely copper exports as it is a leading cooper producer. It has decreasing poverty but significant levels of inequality, with rising public debt and an unemployment rate of 7.29% in 2019. (MAEC, 2022; CIA, 2023)

With regards to the energy profile, Chile's electricity generation sources are mainly fossil fuels (51,9% of total installed capacity), followed by hydroelectricity (26% of total installed capacity), solar and wind (9,5% and 6.9% of total installed capacity, respectively). (CIA, 2023)

In 2018, the government adopted the Energy Route 2018-2020, which consists of a long-term strategy on energy policy to achieve 10 different goals. These goals are based on 7 lines of action, which are the following ones: energy modernisation, energy and social development, energy development through progress-driven investment, low GHG emissions, efficient public transport, energy efficiency, and education and training to raise awareness on energy culture. (Gobierno de Chile, 2018; LSE, 2018) With regards to the Paris Agreement, Chile proposed a series of contributions with the ultimate goal of strengthening domestic resilience to the impacts of climate change, both at the national and subnational level. Chile's NDC is specific about contributions and mitigation efforts,

defining clear plans adjusted to a determined timeline. However, its NDC does not address the energy sector; instead, the strategy is defined under the scope of GHG emissions' reduction and the development of new renewable energies, which will allow Chile to respond to the climate action urgency. (Gobierno de Chile, 2020)

CHILE	2006	2009	2012	2015	2019
HDI	0,796	0,811	0,824	0,846	0,861
GINI	47,3	47	NA	44,4	NA

Table V:5. Chile HDI and GINI index.

Source: own elaboration with external data (UNDP, 2023; WB, n.d.)

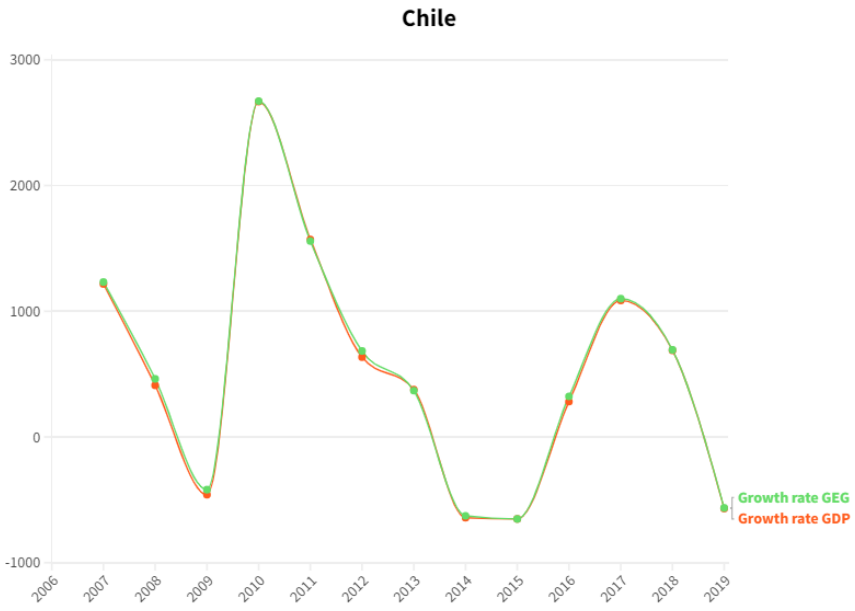

Figure V:5. Chile GEG growth rate vs. GDP growth rate.

Source: own elaboration. Data in Annex III: Data per country; Chile.

Chile has experienced a similar GDP and GEG growth rate over the past 10 years, accompanied by an increase in HDI, as shown by Figure V:5 and Table V:5, respectively. It can thus be concluded that there is convergence between GEG and GDP growth rate, but high-income economies need to better implement policies so that GEG has a significant impact in human development.

VI. DISCUSSION AND CONCLUSIONS

The present investigation has demonstrated that green energies have not been include in leading models of economic growth. However, technological progress has been included in growth economics as one of the main components of long-term economic growth, and green energies are an example of how innovation can boost sustainable growth. Because of the relationship between green energies, technological progress, and environmental policies, green energies can drive sustainable growth. The difference between green growth and economic growth relies on the production models; “classical” economic growth occurs in societies with an intensive industrial structure, which tends to depend on brown energies; green growth takes a step forward on the battle against climate change and invests in more efficient, less intensive industries than can be sourced with green energies.

The results regarding green energies and how they can boost economic convergence between regions are inconclusive, mainly due to the unavailability of data and the limited scope of the study. However, the four case studies have shown that there is economic convergence between economic growth (GDP growth rate) and green growth (GEG growth rate). Given this circumstance, policy implementation focused on human development is necessary to achieve sustainable economic growth. International organisations play an important role in the development of green energies, as they set the cornerstones of the agenda if international organisations encourage the development of new renewable sources, states will be less reluctant to participate in environmental policymaking. International organisations thus play a crucial role in green growth, which must encompass economic growth, poverty reduction, efficient redistribution of wealth, and sustainable development.

i. Policy recommendations

In order for countries to pursue green economic growth it is necessary to invest in infrastructure and new renewable energies that can meet the needs of the market. This investment should be both public and private, and this is why programs from international institutions (IMF, WB, OECD) can complement other financial sources such as FDI.

Policymaking at the national level should focus on maximizing the country's own energy potential, specially in developing countries. When it comes to countries with low energy potential, policymaking should focus on energy cooperation.

Energy efficiency needs to be at the heart of subnational, national, and international agendas, so as to develop less resource-intensive economies, improve capacity usage, and boost innovation, which will in turn motivate sustainable economic growth.

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VIII. APPENDIX

i. Annex I: The Sustainable Development Goals

No poverty: more than 700 million people still live in extreme poverty.

Zero hunger: a third of the world's food is wasted, yet 821 million people are undernourished.

Good health and well-being: vaccinations resulted in an 80% drop in measles deaths between 2000 and 2017.

Quality education: 617 million children and adolescents lack minimum proficiency in reading and mathematics.

Gender equality: 1 in 3 women has experienced physical and/or sexual violence.

Clean water and sanitation: water scarcity affects more than 40% of the world's population.

Affordable in clean energy: three billion people still lack clean cooking fuels and technologies.

Decent work and economic growth: one-fifth of young people are not in education, employment, or training.

Industry, innovation, and infrastructure: roads, water, sanitation, and electricity remain scarce in many developing countries.

Reduced inequalities: the poorest 40% of the population earn less than 25% of global income.

Sustainable cities and communities: 9 out of 10 urban residents breathe polluted air.

Responsible consumption and production: by 20150, the equivalent of almost three planets could be required to sustain current lifestyles.

Climate action: global emissions of carbon dioxide (CO2) have increased by almost 50% since 1990.

Life below water: over three billion people depend on marine and coastal biodiversity for their livelihoods.

Life on land: forests are home to more than 80% of all terrestrial species of animals, plants, and insects.

Peace, justice, and strong institutions: in 2018, the number of people fleeing war, persecution and conflict exceeded 70 million.

Partnerships: achieving the SDGs could open up 12USD trillion of market opportunities and create 38 million new jobs by 2030.

ii. Annex II: GEG variables' long definition

The long definitions provided in this document are retrieved from the official source of the data, which is the World Bank Databank for World Development Indicators, and their intellectual property belongs to The World Bank.

GDP is gross domestic product in current US$:

GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.

Source according to WB: World Bank national accounts data, and OECD National Accounts data files.

EE is total government expenditure on education as a percentage of GDP:

General government expenditure on education (current, capital, and transfers) is expressed as a percentage of GDP. It includes expenditure funded by transfers from international sources to government. General government usually refers to local, regional, and central governments.

Source according to WB: UNESCO Institute for Statistics (UIS). UIS.Stat Bulk Data Download Service. Accessed October 24, 2022. https://apiportal.uis.unesco.org/bdds.

CR is coal rents as a percentage of GDP:

Coal rents are the difference between the value of both hard and soft coal production at world prices and their total costs of production.

Source according to WB: World Bank staff estimates based on sources and methods described in the World Bank's The Changing Wealth of Nations.

OR is oil rents as a percentage of GDP:

Oil rents are the difference between the value of crude oil production at regional prices and total costs of production.

Source according to WB: World Bank staff estimates based on sources and methods described in the World Bank's The Changing Wealth of Nations.

ANFD is the adjusted savings for net forest depletion in current US$:

Net forest depletion is calculated as the product of unit resource rents and the excess of roundwood harvest over natural growth.

Source according to WB: World Bank staff estimates based on sources and methods in World Bank's "The Changing Wealth of Nations: Measuring Sustainable Development in the New Millennium" (2011).

ACO2 is the adjusted savings for carbon dioxide damage in current US$:

Cost of damage due to carbon dioxide emissions from fossil fuel use and the manufacture of cement, estimated to be US$40 per ton of CO2 (the unit damage in 2017 US dollars for CO2 emitted in 2020) times the number of tons of CO2 emitted.

Source according to WB: World Bank staff estimates based on sources and methods described in the World Bank's The Changing Wealth of Nations.

Population, total

Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values shown are midyear estimates.

Source according to WB: (1) United Nations Population Division. World Population Prospects: 2022 Revision. (2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) United Nations Statistical Division. Population and Vital Statistics Report (various years), (5) U.S.

Census Bureau: International Database, and (6) Secretariat of the Pacific Community: Statistics and Demography Programme.

iii. Annex III: Data per country

Costa Rica

Costa Rica (CRI)									
Year	GDP (current US$)	Government expenditure on education, total (% of GDP)	Coal rents (% of GDP)	Oil rents (% of GDP)	Adjusted savings: net forest depletion (current US$)	Adjusted savings: carbon dioxide damage (current US$)	GEG= GDP+EE-Coal-Oil-Forest-Carbon	Growth rate GDP	Growth rate GEG
2006	22715540324	4,616139889	0	0	9207629,716	161493664,9	23593420148		
2007	26884700345	4,63451004	0	0	0	197310344,2	27933364138	18,35%	18,39%
2008	30801744881	4,886970043	0	0	0	202379608,6	32104637317	14,57%	14,93%
2009	30745712007	6,010300159	0	0	0	198966683,8	32394654900	-0,18%	0,90%
2010	37658614803	6,565740108	0	0	0	204135750,4	39927045829	22,48%	23,25%
2011	42762617082	6,379889965	0	0	0	221320455,2	45269504542	13,55%	13,38%
2012	47231651863	6,582399845	0	0	0	232946950,9	50107681091	10,45%	10,69%
2013	50949672206	6,687399864	0	0	0	251987234,2	54104893282	7,87%	7,98%
2014	52016408951	6,67952013	0	0	0	264013190,4	55226842267	2,09%	2,07%
2015	56441917653	6,87349987	0	0	0	262926126,5	60058526663	8,51%	8,75%
2016	58847016045	6,893959999	0	0	0	289644800,9	62614260991	4,26%	4,26%
2017	60516043590	7,069809914	0	0	0	306071819,3	64488341020	2,84%	2,99%
2018	62420165100	6,769919872	0	0	0	323626103,2	66322334158	3,15%	2,84%
2019	64417670083	6,7958498	0	0	0	337146249,9	68458251936	3,20%	3,22%

Table VIII:1. Costa Rica data.

Source: own elaboration. Data from WB (World Bank Development Indicators).

Ethiopia

Ethiopia (ETH)									
Year	GDP (current US$)	Government expenditure on education, total (% of GDP)	Coal rents (% of GDP)	Oil rents (% of GDP)	Adjusted savings: net forest depletion (current US$)	Adjusted savings: carbon dioxide damage (current US$)	GEG= GDP+EE-Coal-Oil-Forest-Carbon	Growth rate GDP	Growth rate GEG
2006	15280861835	5,490960121	0	0	2855173450	132936858,3	13131817556		
2007	19707616773	5,451129913	0	0	4290946886	157588656,5	16333369023	28,97%	24,38%
2008	27066912635	5,408199787	0	0	5052051921	185155812,1	23293537613	37,34%	42,61%
2009	32437389116	4,422070026	0,0018377	0	5289715527	191505433,2	28389976116	19,84%	21,88%
2010	29933790334	4,496590137	0,00724499	0	4647249162	185760661,7	26444611674	-7,72%	-6,85%
2011	31952763089	5,485760212	0,0050128	0	5339352929	224597070,2	28140063327	6,74%	6,41%
2012	43310721414	5,56678009	0	0	6215812586	264527678,4	39241393767	35,55%	39,45%
2013	47648211133	4,498549938	0	0	6463843204	332959995,8	42994886506	10,01%	9,57%
2014	55612228234	4,602019787	0	0	7312178902	415744909	50443590169	16,71%	17,32%
2015	64589334979	4,737919807	0	0	7801227499	449136407,1	59399161968	16,14%	17,75%
2016	74296618481	5,061510086	6,368E-05	0	8255983403	535914575,8	69265204029	15,03%	16,61%
2017	81770791971	5,64951992	7,7249E-05	0	7985508062	578468255	77826409668	10,06%	12,36%
2018	84269348327	5,06867981	9,428E-05	0	4944994854	637849026,6	82957768442	3,06%	6,59%
2019	95912590628	4,480868816	5,679E-05	0	5242735639	732591177,3	94234926707	13,82%	13,59%

Table VIII:2. Ethiopia data.

Source: own elaboration. Data from WB (World Bank Development Indicators).

Thailand

Thailand (THA)									
Year	GDP (current US$)	Government expenditure on education, total (% of GDP)	Coal rents (% of GDP)	Oil rents (% of GDP)	Adjusted savings: net forest depletion (current US$)	Adjusted savings: carbon dioxide damage (current US$)	GEG= GDP+EE-Coal-Oil-Forest-Carbon	Growth rate GDP	Growth rate GEG
2006	2,21758E+11	4,05038023	0,086358152	1,55392407	0	5368925821	2,21734E+11		
2007	2,62942E+11	3,603149891	0,111303969	1,43433156	0	5819357060	2,62533E+11	19%	18%
2008	2,91383E+11	3,508500099	0,24740913	1,9273341	0	6144320272	2,89125E+11	11%	10%
2009	2,8171E+11	3,861939907	0,091508292	1,07562861	0	6115462102	2,83186E+11	-3%	-2%
2010	3,41105E+11	3,508440018	0,132405644	1,31658953	0	6762032619	3,41368E+11	21%	21%
2011	3,70819E+11	4,805550098	0,181793713	1,70978648	0	6988722098	3,74636E+11	9%	10%
2012	3,97558E+11	3,596918344	0,081689562	1,63629537	0	7881736631	3,97146E+11	7%	6%
2013	4,20333E+11	3,824398518	0,05273878	1,4441991	0	8500844407	4,21615E+11	6%	6%
2014	4,07339E+11	3,919177532	0,039691125	1,27014521	0	8721539186	4,09247E+11	-3%	-3%
2015	4,01296E+11	3,86397624	0,021089783	0,5349108	0	9173820341	4,05397E+11	-1%	-1%
2016	4,13366E+11	3,767617464	0,025706388	0,44652106	0	9346063426	4,17642E+11	3%	3%
2017	4,56357E+11	3,465321541	0,029634675	0,55894299	0	9753139415	4,59732E+11	10%	10%
2018	5,06755E+11	3,198600054	0,028719312	0,71455934	0	10102933047	5,09094E+11	11%	11%
2019	5,44081E+11	3,020620108	0,018429374	0,59890761	0	10564352393	5,46593E+11	7%	7%

Table VIII:3. Thailand data.

Source: own elaboration. Data from WB (World Bank Development Indicators).

Chile

Chile (CHL)									
Year	GDP (current US$)	Government expenditure on education, total (% of GDP)	Coal rents (% of GDP)	Oil rents (% of GDP)	Adjusted savings: net forest depletion (current US$)	Adjusted savings: carbon dioxide damage (current US$)	GEG= GDP+EE-Coal-Oil-Forest-Carbon	Growth rate GDP	Growth rate GEG
2006	1,5384E+11	3,021529913	0,003251125	0,031122915	0	1404453290	1,57031E+11		
2007	1,72566E+11	3,21378994	0,002328884	0,024359229	0	1680772590	1,76385E+11	12,17%	12,32%
2008	1,79663E+11	3,792429924	0,016825912	0,038941132	0	1836756421	1,8454E+11	4,11%	4,62%
2009	1,71413E+11	4,230649948	0,003523206	0,02416922	0	1806451684	1,76811E+11	-4,59%	-4,19%
2010	2,17105E+11	4,162089825	0,007420237	0,030681258	0	2001736219	2,24057E+11	26,66%	26,72%
2011	2,51225E+11	4,045189857	0,008912129	0,045040527	0	2277843231	2,58974E+11	15,72%	15,58%
2012	2,67176E+11	4,541704178	0,006204674	0,054737069	0	2454229017	2,76693E+11	6,35%	6,84%
2013	2,77239E+11	4,529429913	0,018806135	0,054342692	0	2686352340	2,86908E+11	3,77%	3,69%
2014	2,59405E+11	4,730949879	0,021304497	0,051292069	0	2575730219	2,68913E+11	-6,43%	-6,27%
2015	2,42497E+11	4,875309944	0,013264709	0,020413638	0	2858362678	2,51379E+11	-6,52%	-6,52%
2016	2,49299E+11	5,342010021	0,011698323	0,010381695	0	3088588619	2,59473E+11	2,81%	3,22%
2017	2,76365E+11	5,419660091	0,013653886	0,010527469	0	3256783759	2,88019E+11	10,86%	11,00%
2018	2,95403E+11	5,433169842	0,01370683	0,015064772	0	3393764293	3,07974E+11	6,89%	6,93%
2019	2,78585E+11	5,618120193	0,007631501	0,014456901	0	3559618233	2,90615E+11	-5,69%	-5,64%

Table VIII:4. Chile data.

Source: own elaboration. Data from WB (World Bank Development Indicators).