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Environmental Sustainability and the Economic Complexity: Policy Implications for a New Developmentalism Strategy

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ENVIRONMENTAL SUSTAINABILITY AND THE ECONOMIC COMPLEXITY: POLICY IMPLICATIONS FOR A NEW DEVELOPMENTALISM STRATEGY[*]

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Abstract: For most of human history, the economic system has operated according to the environment's support capacity, but this relationship changed radically after the Industrial Revolution. Since then, the economy has achieved sufficiently great scale and scope to make the rate of natural resource and energy consumption as well as waste generation rival the environment's support capacity. Hence, sustainable development requires the economy to expand at diminishing rates of natural resource consumption and pollutant emissions, including GHGs, as well as allow the long-term restoration of natural capital stocks. This purpose is only achieved through an Ecological Structural Change, which doesn't occur spontaneously due to several market failures and risks involved in investments in cleaner technologies and innovations, requiring a set of public policies. Therefore, this paper discusses the relationship between environmental sustainability, ecological structural change, economic complexity, and the implications for environmental policies in an eco-developmental (and broader) strategy. The insights obtained point out that it is the State's role to coordinate and provide information during policy management, acting as an identifier of opportunities for diversification of the economy that contribute to environmental sustainability. Besides that, to avoid corruption and rent-seeking processes, it is important to establish a proper institutional framework for effective interaction between the market and public sectors, mechanisms for transparency and accountability as well as the national eco-developmental strategy must have a high status in the governmental agenda.

Keywords: Green New Developmentalism; Climate Change; Forest Change; Economic Complexity; Policy Coordination.

Jel Codes: Q01; Q32; Q55; Q56.

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1 Introduction

All economic activities take place in a context given by the relationships between society and the biophysical world (Colby, 1991). It means that the production and consumption processes influence and, simultaneously, are influenced by the environment (Mueller, 2012). From the late 19th century, a broad set of innovations, such as electricity and combustion engines by fossil fuels (Gordon, 2016), provided an unprecedented pace of economic growth that radically changed the relationship between society and the environment. Progressively, the economic system has achieved sufficiently great scale and scope that has made the rate of natural resources and energy usage as the waste emanation rival the capacity of the ecosystems (Colby, 1991; Mueller, 2012).

As a result, problems arising from the increasing environmental degradation, with the most significant being the intensification of the *greenhouse effect* through greenhouse gases (GHGs). This scenario raises concerns about the well-being of present and future generations. Hence, sustainable development requires the economy to expand at diminishing rates of natural resource consumption and pollution emissions, including GHGs. Additionally, it mandates the long-term restoration of natural capital stocks (OECD, 2009), especially the *tropical forest coverage*.

The relation between the economic scale (in terms of GDP) and environmental degradation is not linear and stable among economies, and also over time, so the same scale generates a higher or lower environmental degradation, depending on the composition of production and technologies adopted (Mueller, 2012). Because of that, it is important that the share of segments that adopt *clean or green technologies* be expanded in comparison to the natural resource and carbon-intensive or brown ones. This will allow economic growth with constant, or even decreasing, rates of environmental degradation.

Thus, production sophistication (measured by the economic complexity) is a mandatory condition to find ways for creating and adopting environmentally friendly technologies through ecological structural change (Guarini and Oreiro, 2022; Romero and Gramkow, 2021). However, the investments needed to enable this process do not happen spontaneously due to a set of market failures and risks so it is necessary to formulate public policies that overcome these barriers and provide adequate stimulus to the accumulation of physical and human capital by the most sustainable, inclusive and innovative economic activities (Guarini, 2020; Guarini and Oreiro, 2022; Sterner and Coria, 2012).

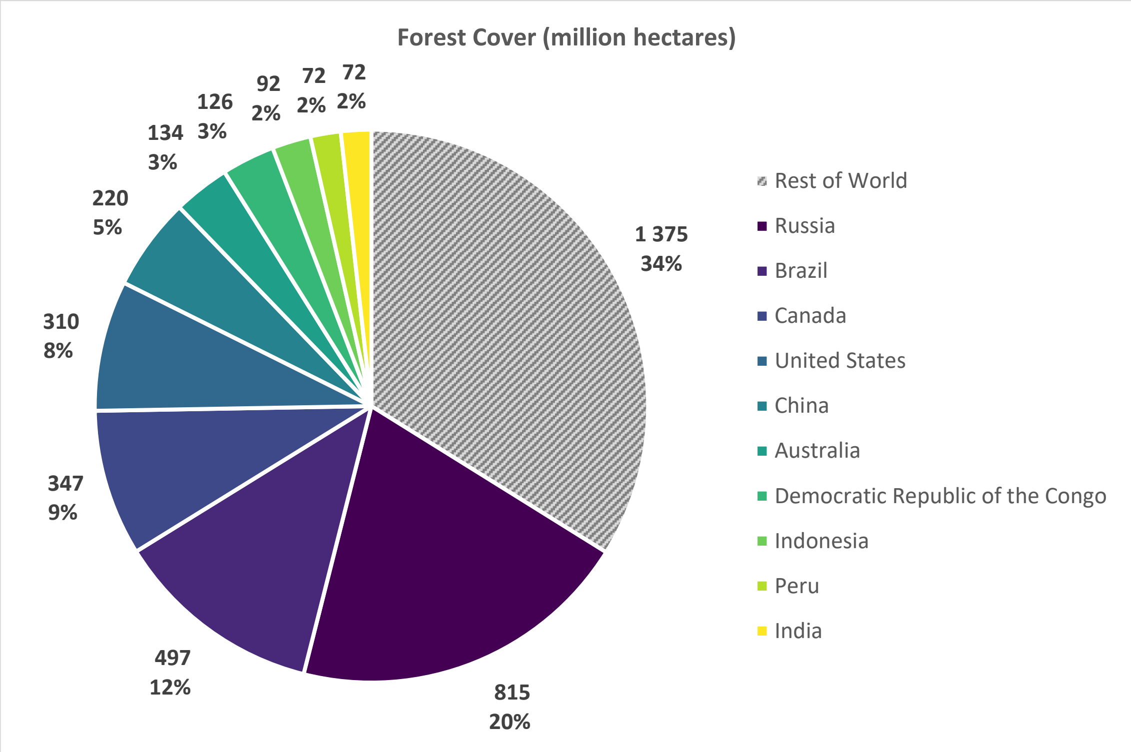
The new branch of developmental literature recommends the use of a public policies mix that combines fiscal, industrial, trade and regulatory policies in a *national eco-developmental strategy*, considering the accumulated knowledge on structural change, and natural resources management (Guarini, 2020; Guarini and Oreiro, 2022). Therefore, this article aims to discuss theoretically the policy implications, in terms of coordination and governance, for a new developmentalism strategy of forest transition; i.e. a reversal or thurnround in long-run trends fro a country or a region for a period of net forest area loss to net gain (Barbier, Delacote and Wolfsersbeerger, 2017). For that, it will be brought the main elements from the forest's role in climate change, the fundaments of environmental sustainability and ecological structural change, and economic complexity.

2 Forests and Climate Change

Regarding climate change, forest ecosystems constitute the largest terrestrial carbon sink, absorbing roughly 2 billion tons of CO_2 each year (UN, 2021). In this process, the atmospheric carbon is captured to compose the tree biomass, and over time, it turns into dead wood and litter, and later it is incorporated as organic matter in the soil. When deforestation or degradation of forests occurs, the carbon previously stored in the biomass and soil is released back into the atmosphere, contributing to the greenhouse effect deepening (IPCC, 2020; Klemperer, 2003; UN, 2021). Thus, net forest carbon emissions are based on changes in carbon stores from forests and soil, in which afforestation and reforestation (including through natural regeneration) activities represent *negative emissions* whereas deforestation, *positive emissions* (Ritchie, 2020).

Currently, the world has a forest area of 4.06 billion hectares, corresponding to 30.8% of the global land area, of which two-thirds are distributed in a strict group of ten countries, as shown in Figure 1 (FAO, 2020; FAO and UNEP, 2020). This amount represents less than half of the original forestlands due to deforestation during the 20th century (Dauvergne and Lister, 2011), particularly in tropical forests.

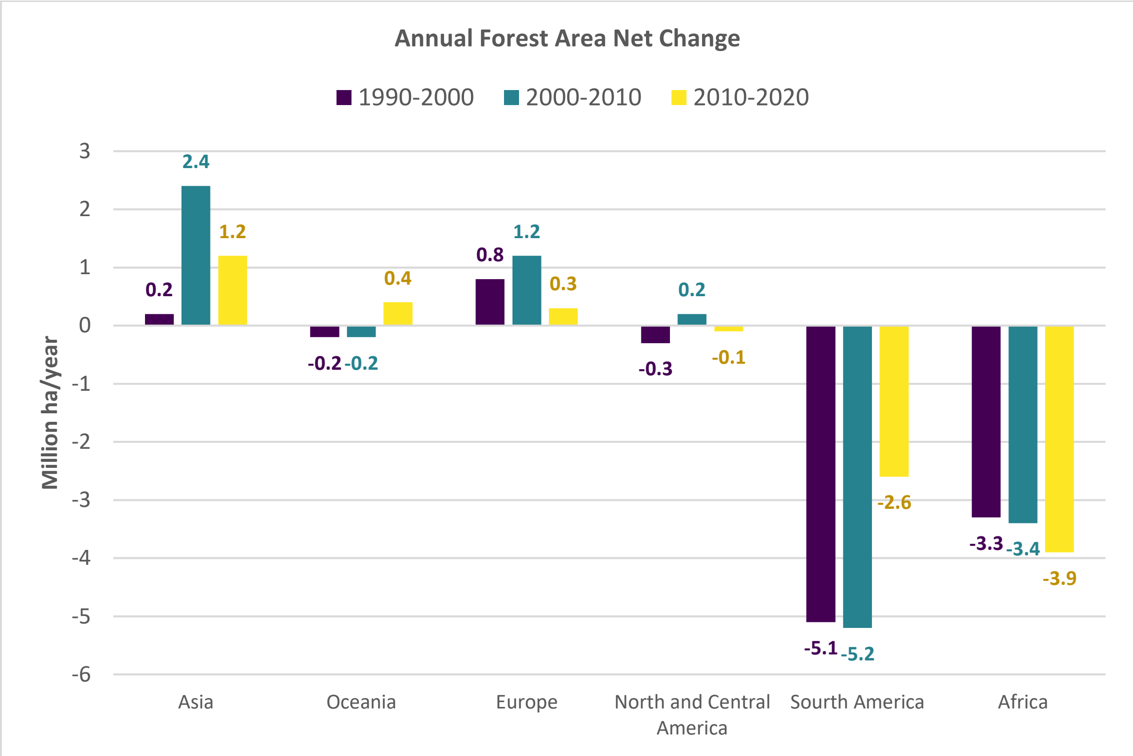
Figure 1. Forest Cover Distribution in the World



Source: FAO and UNEP (2020).

The loss of tropical forests falls from a rate of 13 million hectares per year in the 2000s to 9.3 million hectares per year in the 2010s, predominantly occurring in Sub-Saharan Africa, Latin America, and the Caribbean (FAO, 2020). The reasons for that cannot be separated from the particularities of land use changes for each region or country (Barbier et al., 2010), but it is possible to point out the expansion of croplands such as oil palm plantations as the common reason (FAO, 2022). So, the final result is a negative annual forest area net change (land use change) whereas other regions experienced an increase (Figure 2).

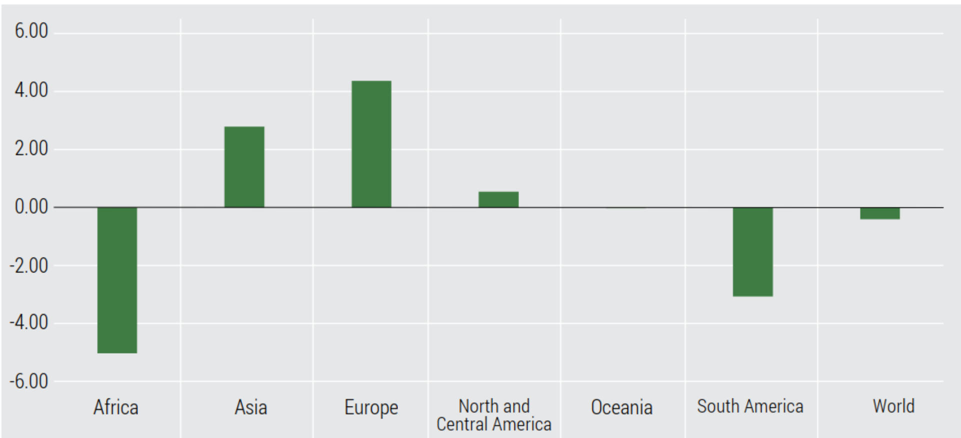
Figure 2. Annual Forest Area Net Change, by Decade and Region, 1990-2020



Source: FAO (2020).

As a consequence of that scenario, the global carbon stock fell from 668 to 662 gigatons of CO_2 between 1990 and 2010, mainly due to a loss of forest area. In 2020, it stayed at 662 gigatons, with Europe, North and Central America, and South America housing two-thirds of this total (UN, 2021). Figure 3 illustrates changes in carbon stock by region, revealing that increases in carbon stock in Asia, Europe, and North and Central America offset reductions in Africa and South America. It is important to highlight that this offset is not valid for other relevant services provided by forests, such as biodiversity.

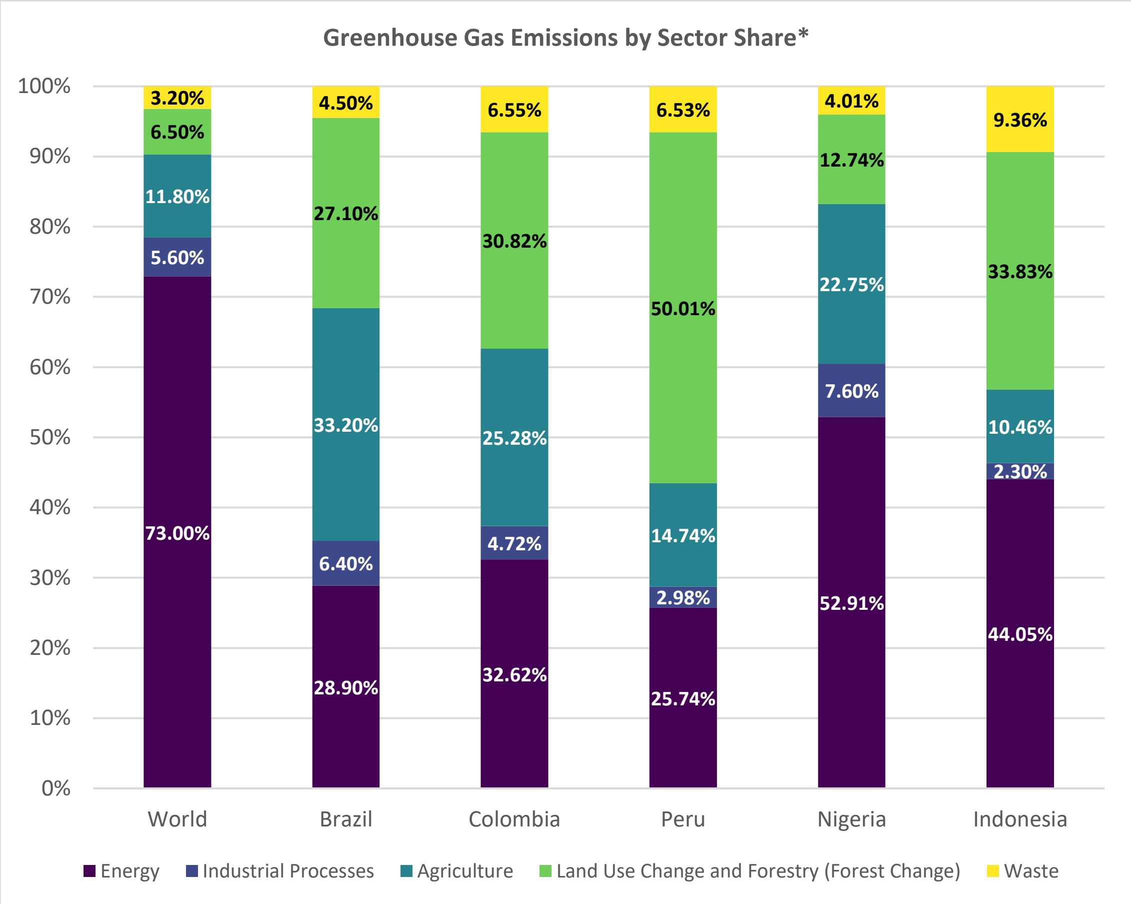
Figure 3. Change in Forest Carbon Stock, 2010-2020, Gt of CO_2



Source: UN (2021).

In terms of carbon emissions, forest change (embracing deforestation, burning, and land use change) represents 6.5% of global emissions, reaching 18% when added to emissions from agriculture (Climate Watch, 2022). In countries where it is seen larger losses of forest carbon stocks for expanding the agricultural frontier, as presented previously, the carbon emissions by forest change can be even higher. In this sense, Figure 4 shows that the profile emissions of some important economies with the largest tropical forestlands are more related mainly to deforestation and land use change, and less to the energy sector, in comparison with the global average.

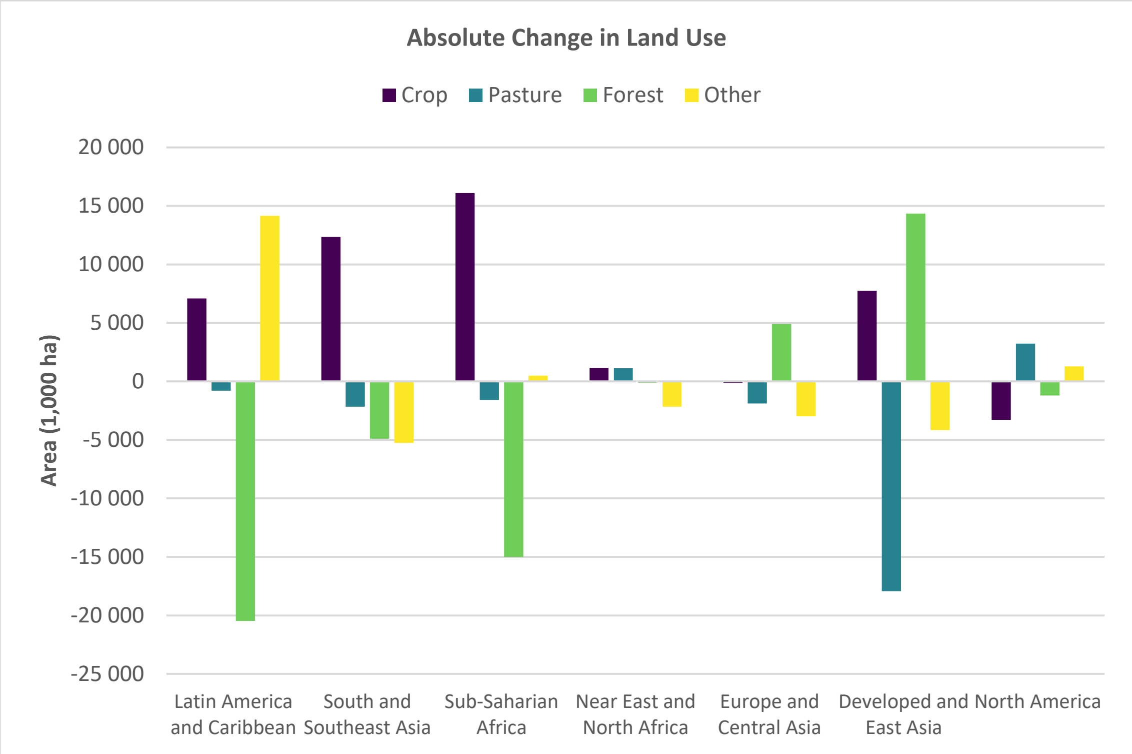
Figure 4. Global Green House Emissions by Sector Share



***This is shown for the year 2016 – Global greenhouse gas emissions were 49.4 billion tons CO2eq.**
Source: own elaboration from Climate Watch (2022), and MCTI (2021).

According to projections by OECD and FAO (2023), the trend of specialization in primary products is expected to get further along this current decade to 2032 for tropical regions as a result of the increase in global food consumption in calories and feed for livestock and aquaculture. As illustrated in Figure 5, during this period, more forestlands are going to be converted into agricultural lands in tropical regions despite gains in productivity. Hence, global agricultural carbon emissions are likely to grow by 7.6% (OECD/FAO, 2023), contributing to the severity of climate risks as well as losses of important environmental services to this sector, ranging from nutrient recycling to the protection of watersheds, soil quality, water resources, biodiversity, and climate stability (Dauvergne and Lister, 2011; Sterner and Coria, 2012).

Figure 5. Absolute Change in Land Use, 2020-22 to 2032



Source: OECD and FAO (2023).

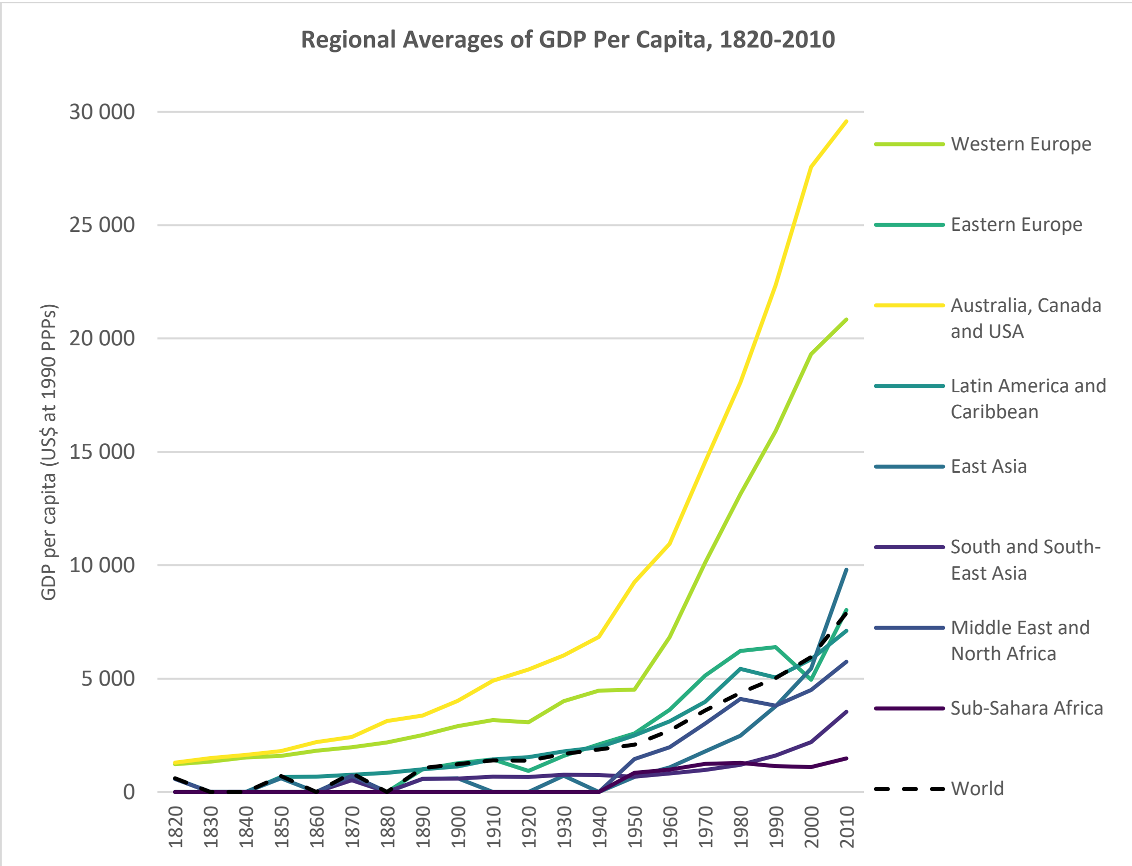
Therefore, sustainable development requires the adoption of several large-scale actions toward low-carbon practices, based on more environmentally efficient technologies, that reconcile increased productivity without expanding cultivated areas while expanding forest stocks and their services. For this, it is important to promote the sustainable use of forestlands in order to increase the perception of their economic value to society as a whole in comparison with alternative land uses. This is only possible through an *ecological structural change* in the economy, which will be discussed in the following section.

3 Environmental Sustainability and Ecological Structural Change

The operation of economic system involves natural resource extraction in the form of high-quality energy and matter, which are transformed by the production process into goods and services demanded by society. Along this path, waste (pollution) is generated and thrown into the environment to be neutralized through several natural mechanisms, such as biogeochemical cycles and ecosystem structures (Arrow et al., 1995; Mueller, 2012). For most part of human history, the economic system has operated in line with the environment's support capacity.

However, this relationship has changed radically after the *Industrial Revolution* when a set of technological innovations (such as electricity, and combustion engines by fossil fuels), combined with agricultural revolution and deepening of trade integration between countries provided an unprecedented pace of economic growth (Gordon, 2016; Mueller, 2012), according to Figure 6. Progressively, the economic system has achieved sufficiently great scale and scope to make the rate of natural resource and energy consumption as well as waste generation rival the environment's support capacity, causing several kinds of degradation that have been threatening the welfare of the present and future generations (Colby, 1991; Gramkow, 2019; Mueller, 2012; Sterner and Coria, 2012).

Figure 6. Regional Averages of GDP Per Capita, 1820-2010



Source: own elaboration from OECD (2014).

In general terms, the economic system's scale for a specific period can be expressed by the Gross Domestic Product (GDP) and has two basic components: the population size, and the average level of per capita income[1] (or level of value added per capita). It is important to highlight that both contribute to environmental degradation although the types of impacts are different. According to Mueller (2012), this relationship can be expressed algebraically by the equations (1) and (2):

$$Y = \left(\frac{Y}{P}\right)P \tag{1}$$

$$ED = \Omega(Y) \tag{2}$$

Y: GDP (the total real output)
P: population size;
ED: environmental degradation
$\left(\frac{Y}{P}\right)$ GDP per-capita

The relationship between the economy's scale (Y) and environmental degradation (ED) is not linear and unstable which means that it may differ across economies and over time; that is, the same scale may generate a higher or lower degradation, depending on the composition of production and technologies[2] adopted (Ω). In this way, *clean or green* technologies have the effect of decreasing Ω which indicates a clear reduction in natural resource consumption and/or waste emission, softening the environmental consequences for a given scale of economic system (Mueller, 2012). This is called the *decoupling* of economic growth from environmental degradation (UNEP, 2011).

This argument is easily illustrated by the eco-Keynesian cross, a model developed by Guarini et al. (2023) to insert environmental issues in a macroeconomic traditional Keynesian framework, composed of two different graphs: (i) the conventional AD-Y with the Aggregate Demand Curve (equation 3), and the 45° line that reflects the market equilibrium between the aggregate demand and real income (AD=Y); and (ii) the sustainability identity coming from the equation (2) in our case. Note that technological progress toward higher environmental efficiency, represented by Ω_1 to Ω_2 change, shifts

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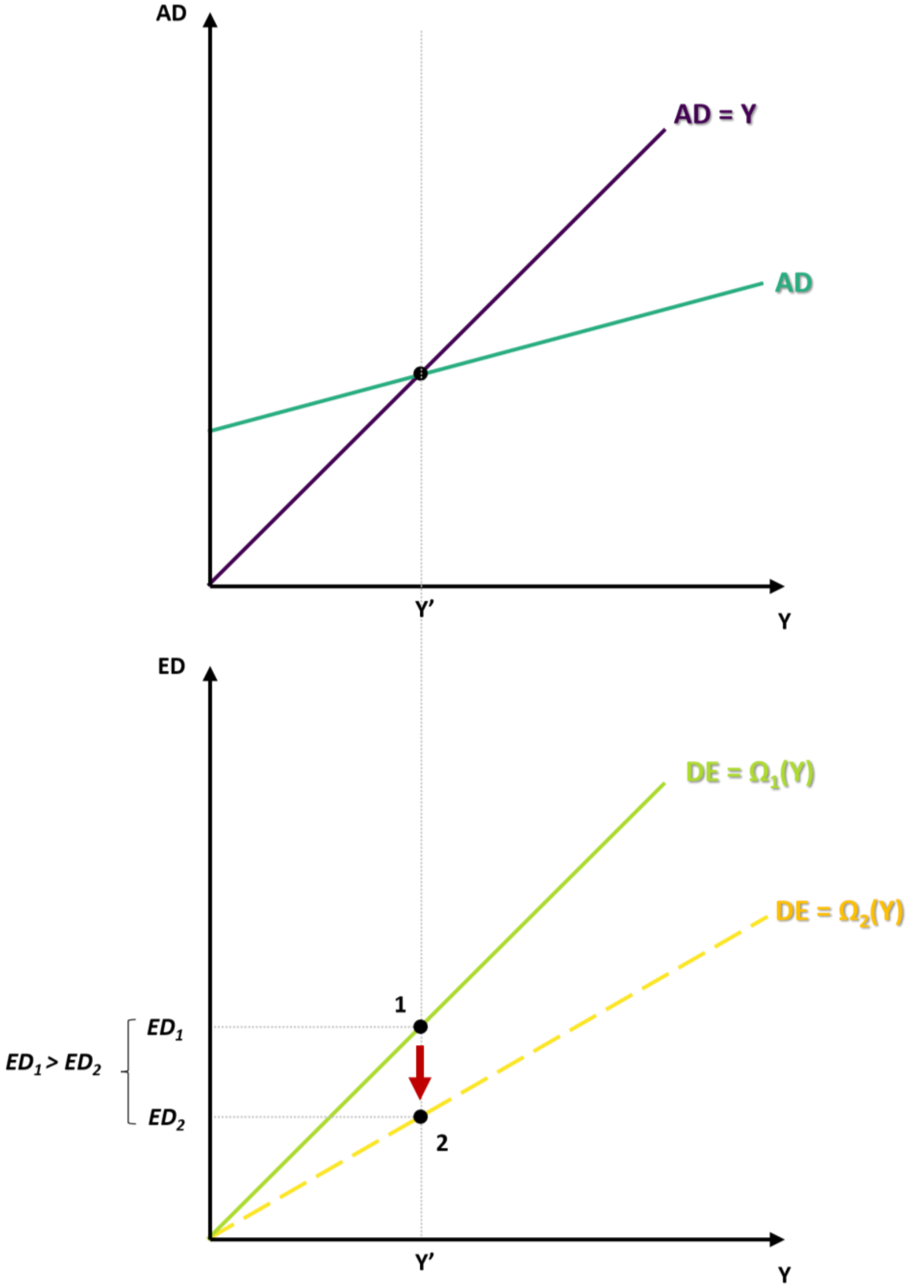
[1] The per capita income, measured by GPD per capita, is an important indicator for economic performance of countries because it translates the ability of residents to buy a larger amount of goods and services as well as non-material components of well-being, such as education, health and environment (OECD, 2014).

[2] Technology is a set of methods, practices, or processes, including the entire collection of available engineering devices to fulfill a purpose (Arthur, 2009).

the ED line, indicating a decrease in the environmental degradation for the same level of Y (Figure 7).

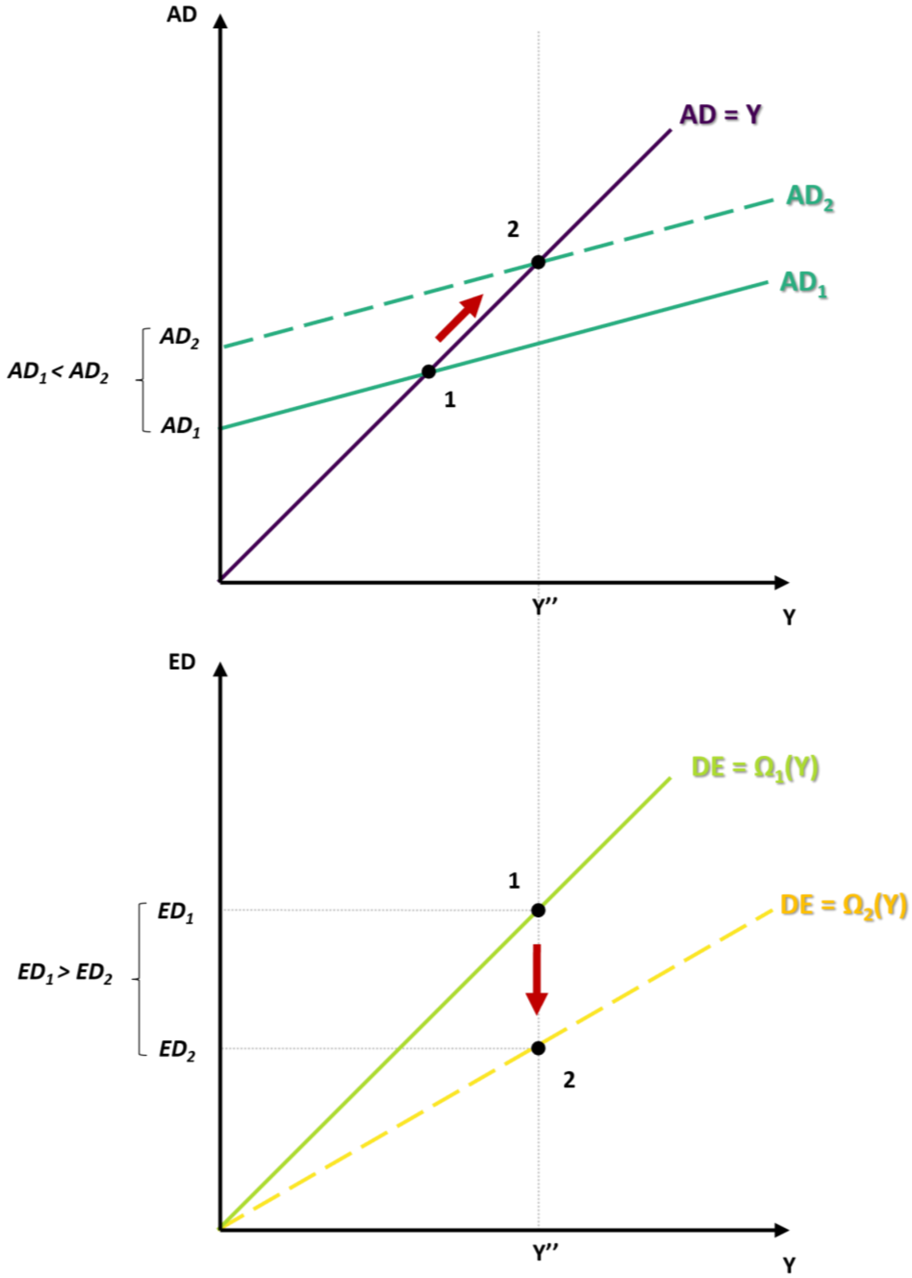
Figure 7. The Eco-Keynesian Cross with Eco-Technological Progress



Source: Adapted from Guarini et al. (2023).

A similar analysis can be done to demonstrate if an income increase (generated by population growth or per capita income increase) is combined with the same technological progress toward environmental efficiency, the environmental degradation can decrease per unit of economic output (relative decoupling), or even be zero (absolute decoupling), during this process, depending on the slope of ED line (Figure 8).

Figure 8. Eco-Keynesian Cross with an Income Increase Combined with Technological Progress in the Eco-Keynesian Cross



Source: adapted from Guarini et al. (2023).

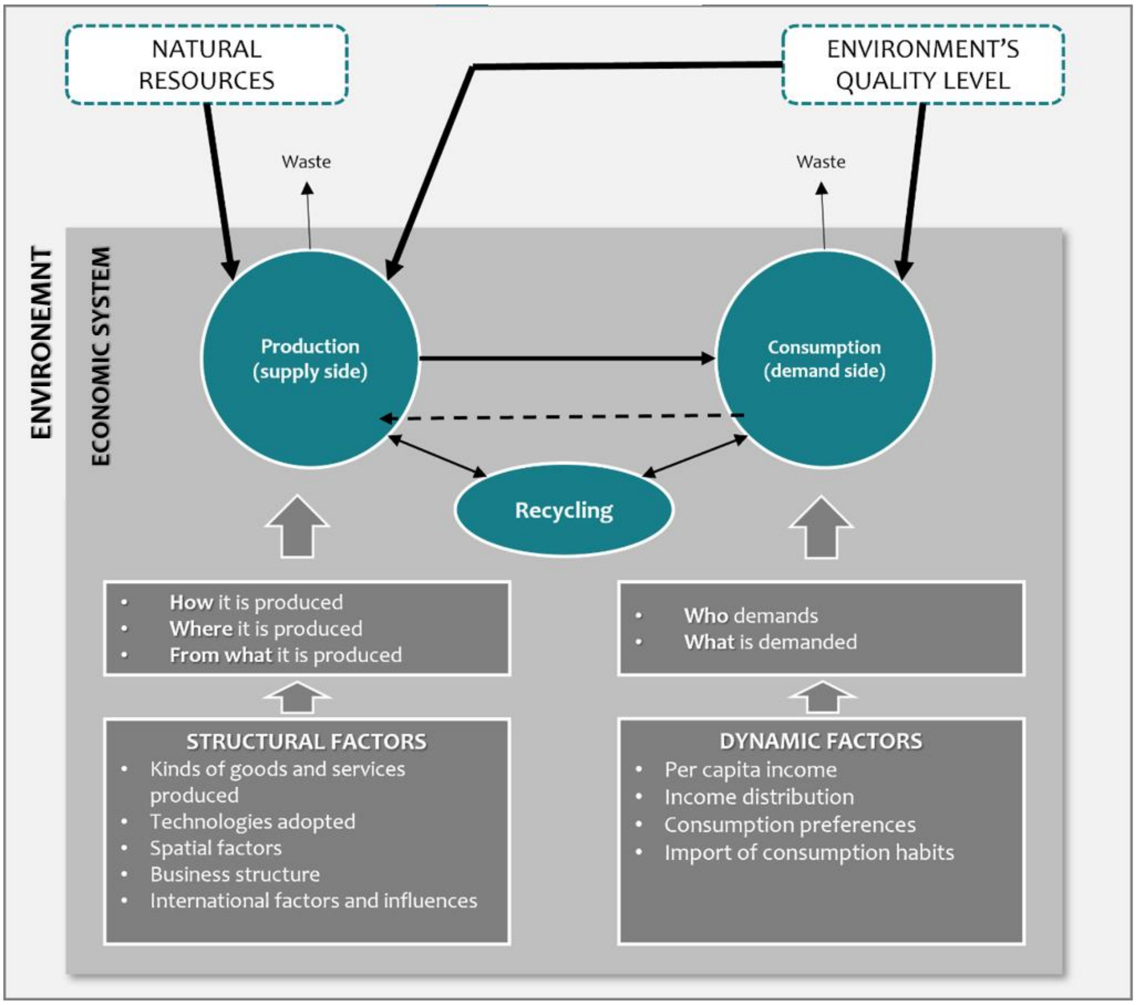
Furthermore, given the fundamental uncertainty surrounding the welfare of future generations (even those that will come a long time from now) and their preferences and needs, the way of abstaining from economic growth in the present to reduce the use of natural resources and pollution emissions involves active participation in the research and development of technologies that mitigate the environmental impact arising from the growth of economic system operation (Jones and Vollarth, 2015; Mueller, 2012).

Thus, achieving environmental sustainability requires a transition towards *clean and green technologies* called *Ecologically Efficient Technological Progress*. According to Guarini and Oreiro (2022), this is made possible only through *Ecological Structural Change* in which the sectors that adopt more environmentally efficient[3] technologies increase their share of the GDP in comparison with the other less environmentally efficient. During this process, the supply side embraces input movement (such as capital, labor, natural resources, and energy) from fewer to more efficient activities. In contrast, the demand side is related to the reorientation of aggregate demand components toward goods produced by the most efficient sectors in environmental terms.

Figure 9 shows how the supply and demand sides influence the economic system operation and consequently also the environmental degradation. Once it is established who demands, the economic system plays the role of organizing the activities and allocating the resources to produce what goods and services are required by the several social groups. Thus, it is determined how, where and from which inputs the production will be carried out (Mueller, 2012). The result of all those decisions will affect the intensity of natural resource usage and waste generation, demonstrating that the economic impacts are not caused by chance, but a reflection of a multidimensional context shaped by the relationships between demand, supply, and the environment.

[3] It is defined as the amount of energy, natural resource, or waste needed to produce a unit of added value (Guarini and Oreiro, 2022).

Figure 9. How the Supply and Demand Sides Influence the Economic System



Source: Adapted from Mueller (2012).

Still, the supply-side characteristics are defined by structural factors, such as the kinds of goods and services produced, technologies adopted, business structure, spatial factors, and international influences due to globalization. In turn, the demand side is determined by the dynamic factors, which include per capita income, income distribution, preferences from those groups that have more wealth, and imported habits of consumption. Both factors impact each other mutually so that, when the production is defined by the demand side, the latter is also influenced by changes in the new production structure. It occurs because different productive configurations provide distinct ways of appropriating the income generated and the balance between groups in society (Mueller, 2012). In short, *ecological structural change* has impacts on income distribution, modifying the dynamic factors of demand, and such changes tend to have feedback on the supply side through its structural factors.

Therefore, the ecological structural change concept represents a dynamic vision of ecological problems and economic development by bringing an alignment to (i) the Schumpeterian study on the continuous expansion of human capacity as well as on the continuous restructuration of production systems from (green) innovations with lights and shadows; (ii) the Georgescu-Roegen statements about *entropy law* and the necessary normative perspective for orienting the development processes to the sustainability; (iii) the positive relation to the economic complexity since the productive sophistication is an essential condition for that environmentally efficient technologies be created and adopted (Guarini and Oreiro, 2022; Romero and Gramkow, 2021).

3.1 Economic Complexity and Product Space

Since Adam Smith's pin factory, wealth has been intricately tied to the division of knowledge and labor (Hidalgo, 2021). The rationale behind this assertion lies in the fact that the advancements witnessed since the Industrial Revolution were made possible through the expansion of productive knowledge (or capability), a collective phenomenon resulting from the combination of each individual's knowledge (Hausmann et al., 2013).

When organized within networks, encompassing firms, markets, supply chains, and institutions, individuals gain the capacity to generate and disseminate more information than they could individually. This is fundamental to reducing the transactional costs associated with technological progress (Hidalgo, 2015). As networks become larger, more diverse, and increasingly sophisticated, they store more productive knowledge for their members. This, in turn, fuels the production of a broader spectrum of goods and catalyzes the birth of novel productive knowledge. This dynamic underpins a process characterized by increasing returns and path dependence (Gala, 2017).

Furthermore, productive knowledge is not readily reproducible or shareable due to its tacit nature, highly specific to an economic task or activity (Gala, 2017; Hidalgo, 2021). Consequently, the productive configuration of an economy, shaped by the networks within it, reflects its information about productive knowledge over time, defining its diversification trajectories and framing its possibilities for economic development (Romero and Gramkow, 2021). The study of the network interactions and hence the amount of knowledge embedded in the productive structure is called *economic complexity* (Hausmann et al., 2013; Hidalgo, 2021; Romero and Gramkow, 2021).

The economic complexity can be measured from metrics of relatedness[4], which measure the overall affinity between a specific activity or location, as well as explain path dependences and predict which activities will grow or decline in a location (Hidalgo, 2021). It is based on the assumption that similar goods tend to need similar infrastructure, institutions, technologies, and other properties to be produced together while for those that differ in requirements, joint production is less likely (Hidalgo et al., 2007). From trade databases, like UN Comtrade, it is possible to calculate the proximity between goods as the probability of a country exporting a good p with *Revealed Comparative Advantage* (RCA, hereafter) given that it exports product k with RCA as well (Romero and Gramkow, 2021). The set of all proximity linkages between products is called Product Space. Countries from the product space periphery tend to produce goods with a limited number of linkages, hindering changes in their production structure needed to produce new and more sophisticated goods (Hausmann et al., 2013; Hidalgo et al., 2007; Romero and Gramkow, 2021).

The *Method of Reflection* also measures the complexity of a particular good and the economy as a whole. From the country's list of exports, it is observed the diversification and ubiquity criteria, where the first one considers the number of goods that have the RCA, and the second one refers to the number of countries that export a given good. If a country is more diversified, it will have more capabilities whereas, if a product is less ubiquitous, it will require more specific capabilities. Thus, a country will be more complex as more diversified its exports while a product will be more complex if

[4] The similarity measure between products i and j is based on the conditional probability of having a Revealed Comparative Advantage (RCA) which quantifies whether a country or region is an effective exporter of a product i (RCA > 1), or not (RCA < 1), considering that there is a comparative advantage in the good j at time t, and vice versa (Hidalgo et al., 2007). This index has been developed by Balassa (1965), and compares the exports from a region of interest in comparison to a reference country so that the index value for a given product is calculated from the division between (i) exports of the good from the region of interest related to its total exports; and (ii) exports of the good from the reference country in relation to its total exports. More details can be found in Hausmann et al. (2013, p. 25).

there are not so many countries exporting it[5] (Hidalgo et al., 2007). Further details about how to calculate the economic complexity measures can be found in Hausmann et al. (2013, p. 24).

Felipe et al. (2012) found out that the 10 most complex products (such as machinery, chemicals, etc.) are mostly exported by high-income economies and that the 10 least complex ones (like wood, agricultural products, etc.) are predominantly exported by middle or low-income countries. Hausmann and Hidalgo (2011) also show that there is a non-linear relationship between the number of capabilities of a country and the products made by it. In addition, they point out that countries with few capabilities tend to have few incentives to develop new ones, a situation that could leave them in a kind of trap of lower economic development.

Another problem is that knowledge is concentrated in a few highly industrialized countries which are constantly improving technologies. Meanwhile, other countries lag despite greater possibilities for technology transfers through increased trade, communications, foreign direct investment, and public policies for cooperation, among other channels (Archibugi and Coco, 2004). In other words, few countries are trading more complex products due to the difficult conditions necessary for a favorable environment for those goods, such as good infrastructure, qualified and specialized labor, good quality institutions, and a fully developed national innovation system (NIS)[6]. These issues are part of the discussion of non-price competitiveness between economies, which is also necessary as countries advance in their economic development process (Dávila-Fernández et al., 2018).

Several studies have linked economic complexity with environmental issues. For example, Lapatinas et al. (2019) analyzed 88 countries among emerging and developing

[5] There are goods that are scarce for natural reasons, such as diamonds, so that the producers of these kinds of good do not have their economic complexity overestimated, there is the concept of diversification. Besides that, if a given country has a diversified exports, but with very ubiquitous products, it will have low economic complexity.

[6] A National Innovation System is an articulated group of public and private sector institutions (development and financing agencies, financial institutions, public and private companies, teaching and research institutions, etc.) whose activities and interactions generate, adopt, import, modify and disseminate new technologies, with innovation and learning being the crucial aspects. It is the articulation level between the different actors that make up a NIS that determines the ability to generate innovation.

between 2002 and 2012. These authors point out that the increase in economic complexity is associated with better environmental performance in the sample, except for air quality. These results are robust for several econometric specifications with different control variables. Also, it was possible to see an increase in the willingness of the population from countries with greater complexity to adopt environmentally friendly practices, that is economic complexity can be a good predictor for this culture.

Neagu and Teodoru (2019) also indicate through econometric exercises that countries of the European Union that have superior economic complexity reduce pollution activities more quickly due to their greater efficiency concerning energy usage. Nonetheless, these authors highlight that a country that wishes to increase its complexity must modify its energy profile, otherwise, it would increase the emission of polluting gases, besides promoting better environmental practices and investments in return.

Therefore, complexity metrics help to estimate the sophistication of specialization patterns, and to predict future economic growth, which makes them useful in efforts of structural upgrading through industry policies, especially when complemented with other metrics focused on environmental issues (Hidalgo, 2023). In the case of forest net change, this approach can help to identify patterns of specialization in primary production (*Dutch disease*) as well as directions for an industrial policy to improve the value of forest products through forest-based industry consolidation. At the same time, carbon pricing instruments, like carbon emission markets or taxes, would provide a way of financing this transition.

4 Environmental Policies for a New Developmentalism Strategy

As discussed in the previous section, the sophistication of the production structure through the ecological structural change is an essential condition for the creation and introduction of more environmentally efficient technologies over less sustainable ones. However, this process is not spontaneous because of the existence of several market failures and higher risks that hinder the private sector from internalizing all the benefits and costs involved, which makes free markets unable to efficiently allocate resources for this purpose (Alternburg and Rodrik, 2017; Rodrik, 2014). In other words, if the markets worked well in the absence of any kind of regulation, then the natural resources and pollution would be priced at the level of their social marginal cost, and the benefits from the efficient technologies adoption would be fully captured by their developers so that investment decisions of private agents would always converge toward the optimal alternatives (Rodrik, 2014).

In the case of investments in sustainable technologies, the literature points out three main kinds of market failures (i) positive technological externalities (known as spillovers) not fully captured by investors in the form of collective learning, skill development, or crowding effects which have a highly experimental nature and substantial risks involved; (ii) difficulty in establishing a price for carbon due to subsides on the production and consumption of fossil fuels, and failures in the application of taxes or controls that internalize the risks of climate change, resulting in a private cost of carbon substantially below the social cost; and (iii) the global public good nature of carbon reduction, encouraging the emergence of free-riders (Guttmann, 2018; Rodrik, 2014).

The solution to the market failures problem requires an institutional framework suitable for effective interaction between the market and public sectors as well as public policy implementation that induces the private agents to internalize social benefits and costs of investments in sustainable technologies, enabling the *green creative destruction* with the growth of the sustainable sector over the dirtier or brown ones (Alternburg and Rodrik, 2017; Gala, 2017; Guarini, 2020; Guarini and Oreiro, 2022; Sterner and Coria, 2012). Due to the complexity involved in the ecological structural change, it is recommended the use of a public policies mix that combines fiscal, industrial, trade and regulatory policies in a national eco-developmental strategy, considering the accumulated knowledge on structural change, and natural resources management (Guarini, 2020; Guarini and Oreiro, 2022). Currently, this kind of strategy is known as the "Green New Deal" package.

In the forest context, the eco-developmental strategy must unlock investments in sustainable forest management to enhance the engagement of this sector in supplying forest resources (fibers, fuels, foods, pharmaceuticals, among others) with the potential to replace fossil resources, while also capturing and storing carbon, among other already mentioned relevant environmental services (Verkerk et al., 2021; WBCSD, 2019; Wolfslehner et al., 2016). It is also noteworthy that there is potential for the development of new technologically advanced products through advancements in native species forest research, such as biofuels and biomaterials for industries including construction, cosmetics, pharmaceuticals, chemicals, and textiles (WBCSD, 2019). As a result, it is expected that forest activities will become economically competitive with other less sustainable land uses, such as low-productivity agriculture and extensive livestock farming.

Furthermore, a national eco-developmental strategy must anticipate long-term technological trends, market consolidation, and incentives provision to adapt the structure of the economy in such a way that it can take some advantage of structural change toward a greater level of environmental sustainability by establishing a future pattern of technological development through the pioneer firms, or first movers (Alternburg and Rodrik, 2017). These companies earn significant head-starting commercial advantages over their competitors (who will continue to employ traditional production methods), market dominance, technology ownership, production scale, and so on (Gala, 2017; Rodrik, 2014; Sterner and Coria, 2012). It is worth mentioning that cleaner technologies can reduce social costs during the ecological structural change by generating positive technological externalities and helping to combat carbon underpricing, in the case of climate change (Rodrik, 2014).

4.1 The Policy Coordination and Governance Role

By obtaining knowledge about structural change, technological spillovers, market failures, and barriers to investment in cleaner technologies, it is the State's role to coordinate and provide information during policy management, acting as an identifier of opportunities for diversification of the economy that contributes to the environmental sustainability (Gala, 2017; Rodrik, 2014). Specifically about the forest change, it is necessary to increase the understanding of the opportunities for alignment among climate, economic, and social development policies in rural areas, as well as their potential trade-offs, for the country to effectively meet its environmental targets throughout the process of economic development (Chiavari and Antonaccio, 2023).

According to Guarini and Oreiro (2022), the *Ecological Structural Change* effectiveness depends on the prevailing conventions regarding the *reasonable levels* of profit rate for both less environmentally efficient sectors (such as extensive livestock) and more efficient ones (forest management). Due to the uncertainties regarding investment in the latter sector, it is reasonable to assume that the profit rate considered *competitive* will be higher than the profit rate for the former. This is because green investments require a *positive liquidity premium* dur higher K-uncertainty (Vercelli, 1991, pp.72-79). So, policy coordination plays a key role in instituting strategies that foster competitiveness in sustainable investments, such as a competitive exchange rate and/or low interest rates. However, simultaneously, it can also prevent new investments in less sustainable activities, like the establishment of a regulated carbon market or carbon tax.

Also, Policy coordination is essential for avoiding possible green rebound effects as a consequence of the output increase caused by the income multiplier jointly with higher environmental efficiency (Guarini et al., 2023). For example, this situation might lead to a net increase in degradation, like the case of an increase in land use change resulting from a rise in meat demand surpassing productivity gains. Or when the rise in investment costs in agriculture within one region leads to the expansion of this activity in other regions. This is the case with the *Brazilian cerrado* being more vulnerable to agricultural activities due to land use restrictions being more stringent in the Atlantic Forest and the Amazon.

The need for coordination between public and private sectors may result in an excessive proximity between policymakers and businessmen. Consequently, this elevates the risk of corruption and the initiation of rent-seeking practices by corporations and lobbyists, which distorts the coordination role (Gala, 2017; Guttmann, 2018; Rodrik, 2014). To avoid this situation, it is necessary to keep the bureaucrats at a safe distance from entrepreneurs who are the object of regulation by creating councils and coordination forums between public and private sectors as well as development agencies, non-profit organizations, and class representation bodies; in these instances, knowledge exchange between the actors flows better. There also needs to establish mechanisms for transparency and accountability as well the *national eco-developmental strategy* must have a high status in the governmental agenda (Gala, 2017; Rodrik, 2014).

5 Concluding Remarks

According to what was discussed in this article, achieving environmental sustainability requires a transition towards *clean or green technologies* called Ecologically Efficient Technological Progress which is possible through Ecological Structural Change. It requires a continuous process of production sophistication in terms of economic complexity which doesn't occur spontaneously due to several market failures and risks involved in investments in cleaner technologies and innovations. So, it becomes necessary for the State to assume its organizational role, and not only normative, by formulating a mix of public policies that combines fiscal, industrial, trade and regulatory policies in a national eco-developmental strategy (green new deal package). Besides that, to avoid corruption and rent-seeking processes, it is important to establish a proper institutional framework for effective interaction between the market and public sectors, mechanisms for transparency and accountability as well as the national eco-developmental strategy must have a high status in the governmental agenda.

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