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A CRITICAL COMPARISON OF ENVIRONMENTAL ECONOMICS AND ECOLOGICAL ECONOMICS, COMBINED WITH THE CREATIVE VALUE SYSTEM OF DEGROWTH, FOR A MACROECONOMICALLY EFFICIENT AND EQUITABLE SUSTAINABLE DEVELOPMENT

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Abstract

The intersection of the fields of environmental economics and of ecological economics has called for more research in recent literature. Both fields represent turning points from previously held neoclassical approaches which center on rational decision-making of free market forces and value-neutrality, resulting in growth as the principal macroeconomic development goal. On that basis, natural resources were considered subsidiary to man-made ones, as well as substitutable, commensurable and monetizable, with internalizable externalities, provided appropriate pricing within cost-benefit analyses. Environmental economics and ecological economics both resist those tenets, but with different concepts and methods, especially regarding the notions of sustainability and growth. This research investigates them in more depth, by giving a concise yet comprehensive overview of their origins, principles, and differences. Critiques of neoclassical environmental economics and of weak sustainability are listed and analyzed in a way that does not yet exist in the literature. Methodologically, ecological economics is shown to go beyond environmental economics, by conceptually embracing the complex interconnectivity of macroeconomics, socioeconomics and development economics, and by methodologically encouraging a framework of pluralist research approaches and multidisciplinary collaboration. The research then analyses six macroeconomic solution models as to whether these can be recommended for macroeconomic global sustainable development. A special focus will be on the concept of de-growth. The six solution models are divided into two groups, one called "macroeconomic compensation solutions" and a more progressive one "macroeconomic transformation solutions". The conceptual contribution of this research lies in a unique synthesis and formulation of environmental and ecological economics models. Its methodological contribution is a concise combination of three research paradigms that are particularly suited to ecological economics. Its overall contribution offers conceptually sound, methodologically fruitful and practically viable solutions for macroeconomic policy options, to address worldwide economic, ecological and social challenges.

Keywords: Environmental Economics, Ecological Economics, Development Economics, Macroeconomic Development, Strong Sustainability, De-Growth.

JEL Classification: O11, O44, Q01, Q56, Q57.

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1. Introduction and Overview

1.1. Research Calls for Conceptual Clarity and Methodological Mindfulness

Macroeconomic literature has reacted to the increasing global awareness of sustainability issues by discussing the crossroads of the four broad fields, namely 1) macroeconomics, 2) environmental studies, 3) sustainability concerns, and 4) development studies form a variety of disciplinary angles, such as from those of economics, ecology, the physical sciences (especially biology and geography) and the social sciences (especially sociology, politics, philosophy and ethics). Following calls of recent literature, this research unites and clarifies that discussion from conceptual and methodological aspects with a macroeconomic focus, and with methodological considerations of multidisciplinarity. One entire macroeconomic field and one full concept have attracted special attention in the recent literature, namely ecological economics and de-growth (or post-growth). Within macroeconomics, ecological economics is still a dynamically evolving field. The concept of de-growth or post-growth has started to diversify in academic research only in the second decade of the new millennium. This research differentiates them and then advances their understanding to provide a solid conceptual and methodological foundation for the final macroeconomic solution suggestions to the question of how progress and development should be theoretically framed, and practically considered in policy decision making.

1.2. Crossroads of Macroeconomics, Environment, Sustainability and Growth

Environmental economics and ecological economics have different views on sustainability and development, based on different relationships to some basic principles of neoclassical economics. This caused a rift between them that only recently has begun to be reconciled. Hence after briefly outlining the locus and role of the concept of sustainability in macroeconomics and development economics, the evolution of environmental and ecological economics is traced along these stages: neoclassical economics before the rise of the concept of sustainability, the position of neoclassical economics on natural resource management, the shift from neoclassical to environmental economics, the position of environmental economics on sustainability, and the resulting concept of weak sustainability. Criticism of environmental economics and weak sustainability is analyzed in concise yet comprehensive form in a way that does not yet exist in the literature, before outlining the contributions of ecological economics, its differentiation from environmental economics, and its connection to development economics and the notion of growth.

Environmental and ecological economics will be differentiated in a concise yet complete way hitherto not found in the literature, as one of the conceptual contributions of this research. The methodology section will unite the three paradigms of multidisciplinarity, post-normality and co-evolution in a compact yet operationalizable fashion as the methodological contribution. The analysis and discussion section then synthesizes, compares and analyzes altogether six solution suggestions in literature and policy practice, and evaluates them from a macroeconomic perspective, with a special focus on the concept of growth, and with a view to global sustainable development policy and practice. In the conclusions, recommendations are made, and opinions given on how the

rift between environmental and ecological economics could be overcome from a macroeconomic viewpoint, and for worldwide sustainable development.

2. Literature Review

2.1. Sustainability in Macroeconomics and Development Economics

Sustainability considerations have started to play a key role in macroeconomic theory and practice, especially in economic development. The literature provides reasons in form of sociopolitical issues (such as the fast global population growth or unequal wealth distribution), environmental challenges (such as depletion of the earth's ozone layer, acid rain, loss of biodiversity in form of species extinction, toxic pollution, or the depletion of non-renewable energy resources), or climate change (such as the greenhouse effect or global warming) (see Costanza, 1989, p. 1; Munda, 1997, p. 213). Especially the two invasive processes of extraction and waste disposal, with the usually following environmental degradation, gave rise to the concept of "sustainable development" (Munda, 1997, pp. 213-214).

Sustainable development was first officially, politically and internationally defined on a high level in the 1987 *Brundtland Report* (World Commission, 1987, pp. 43-44) as "the development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (see also Dwyer and Edwards, 2013, p. 246; Gowdy and Walton, 2010, pp. 396-397; Romeiro, 2012, p. 70). In the wake of that report, several United Nations conferences reiterated and detailed that principle on a macroeconomic and worldwide level, such as the two famous Rio de Janeiro Conferences ("Earth Summits") on Environment and Development (UNCED) in 1992 and 2012 (see De Lara and Thöny, 2011, pp. 148-149). Another way to phrase the concept of sustainability would be to maximize, at the same time, the biological, economic and social system goals, such as biodiversity, satisfaction of needs and increase of goods and services, as well as cultural diversity or social justice and participation (Munda, 1997, p. 215). This makes sustainability a multidimensional concept. According to multidimensional criteria analysis, different objectives are hard or impossible to maximize at the same time (Munda, 1997, p. 215). Both macroeconomics and development economics have tried to optimize those broad parameters of economic and environmental concerns, even if they often seem to adhere to diametrically opposed interests. Under the umbrella of the concept of sustainability, the fields of environmental economics and of ecological economics differentiated themselves according to some basic tenets of neoclassical economics, discussed below as far as they are referred to in the analysis and the conclusions.

2.2. Neoclassical Economics before Sustainability: Open and Eco-Systems

Some define neoclassical economics as a "closed system" in both ontology and epistemology (Berger, 2016, p. 36). Others differentiate, and define it as an inconsistent system between orthodox economics (with a supposedly closed-systems approach in ontology and methodology) and heterodox economics (with an open-system approach in both), involving an open-systems ontology and a closed-systems methodology (Dow, 2016, p. 103; Martins, 2014, p. 326). Some of the most notable classical economists of the late 18th to mid-19th centuries (Malthus, 1798, p. 5; Mill, 1848, pp. 7-10; Marx,

1867, p. 168; Ricardo, 1817, pp. 264, 273) held that all economic activity is taking place within an open system of environmental conditions and limitations, an insight that reached neoclassical theory for good in the 1970s, when the economy was put forward as an open system, with resources extracted and returned into the environment in different form, such as waste or pollution (Beder, 2011, p. 141; Kneese, Ayres and D'Arge, 1970, pp. 43, 84, 115-118). Nowadays, the economy is mostly recognized as an open system. One decisive differentiation between neoclassical and ecological economics concerns the question whether the economy is a whole, with the environment being merely part of the macro-economy (as conventional economics sees it), or whether the macro-economy is itself part of a larger, enveloping and sustaining whole, namely the entire Earth as an ecosystem, with the economy thus being an open subsystem of the larger "Earthsystem" [sic] (Daley and Farley, 2011, p. 15). "Ecosystem" in this sense would be defined as the entirety of "population dynamics, food webs, energy flows, interactive behaviors, biogeochemical cycles, spatial organization across landscapes, and co-evolutionary processes" (Beder, 2011, p. 148).

2.3. Neoclassical Economics and Natural Resources: Neutrality, Substitutability

Even as an open system, neoclassical economics upholds scientific objectivity and value-neutrality (Dequech, 2007, pp. 280, 300). Based on Newtonian scientific paradigms, rational decisions lead to optimal results, for instance in terms of monetary calculability (Hamstead and Quinn, 2005, p. 145; Venkatachalam, 2007, 550-551). Based on utility theory and the notion of *homo economicus*, human behavior is explained within well-defined free markets, where individuals ensure the best possible allocation of resources by pursuing their own interests, free from government regulations (Hermann-Pillath, 2015, p. 440; Romeiro, 2012, p. 76; Spash, 2013b, pp. 356-357). In this view, natural resources do not constrain economic activity, since technological progress and reproducible human-made (manufactured) capital can replace natural resources. Even if the available natural resources decline per capita over time, technological progress, if high enough, can raise the productivity output per worker indefinitely, thus offsetting their decline. In short, natural resources can be substituted with man-made capital and technological progress (Gowdy and Walton, 2010, p. 397-398; Hamstead and Quinn, 2005, p. 145; Hermann-Pillath, 2015, p. 433; Romeiro, 2012, pp. 66, 73).

2.4. From Neoclassical to Environmental Economics: Subsidiarity, Monetization

Neoclassical economics approaches began considering issues of the environment and of sustainability by founding "environmental and resource economics" as sub-fields of economics after World War II; those two become an independent field in the 1960s (Beder, 2011, p. 140). Yet those environmental and sustainability considerations continued to be subsidiary to the notion of economic growth, defined as the expansion of the social basket of goods and services (Ghosh, 2017, pp. 13-15; Kallis, Martinez-Alier and Norgaard, 2009, p. 18). Hence environmental economics concerned itself with the intersection of neoclassical economic approaches and social sciences, but still using an evaluation system based on a single denominator, mostly monetary value (Cavalcanti, 2010, p. 61). "Value" would relate purely to commodity exchanges following supply and demand curves, not including wider political, moral, ethical, aesthetic, or spiritual

dimensions (Romeiro, 2012, p. 66). Consequently, sustainability was considered a merely economic concept fully explainable with technological progress and consumer behavior (Gowdy and Walton, 2010, p. 397-398, 403).

2.5. Environmental Economics and Sustainability: Internalizing Externalities

Environmental economics incorporated the notion of sustainability, based on internalizing external costs, or externalities (economic effects not market priced, such as environmental degradation or pollution) into the economic calculus by adjusting prices so that the person who buys or uses goods or services and causes external costs must pay for them, making those costs part of the buying or using decision (Beder, 2011, p. 143). Hence environmental economics also relies on the power of the market, by concentrating firstly on the problem of internalizing environmental externalities after pricing them properly, and then on the efficient management and allocation of natural resources. Consequently, environmental degradation results mainly from the failure of markets to evaluate and price the environment efficiently (Romeiro, 2012, pp. 66-67, 74, 76, 81; Spash, 2013b, p. 357). As an example, the problem of global warming was just a failure of adequately pricing the ecosystem service of climate regulation, which would have mitigated the problem by motivating technological solutions reducing the cost of greenhouse gas emissions (Romeiro, 2012, p. 77).

Environmental economics incorporates environmental factors, cost and benefits into its analysis and appraisals of private or public projects, by including them in a traditional cost-benefit-analysis (CBA), and comparing the resulting aggregate benefits and costs; an example for the latter are environmental externalities. These factors can be included in a CBA after having been converted into monetary measures, with environmental and human-made goods being interchangeable and substitutable (Beder, 2011, p. 141). In a rather radical logical furtherance of this argument, the sustainability concept could itself be done away with, since in a perfectly functioning and competitive market economy, with all externalities internalized, the right price signals will ensure Pareto optimal production and allocation of resources, including environmental ones, which would then just be commodities as all other market goods or inputs (Gowdy and Walton, 2010, p. 399). These considerations played a role in the rise to the so-called concept of "weak sustainability".

2.6. Weak Sustainability: Offsetting Economic and Environmental Capital

A combination of neoclassical and environmental economics approaches led to what became known as "the standard economic view of sustainability" (Gowdy and Walton, 2010, p. 397). Called "weak sustainability", it postulates that an economy is sustainable if it saves or maintains for future generations more than the depreciation of human capital (skills, knowledge and technology) and human-made capital (such as buildings, roads, factories or machinery) plus the depletion of natural capital (environmental goods, such as wetlands or woodlands) (Beder, 2011, p. 143; Munda, 1997, pp. 217-218, 228;). Hence development is considered sustainable if the loss of environmental goods is offset by man-made capital. Importantly to note, this offsetting works both ways: on the one hand, losses of environmental capital can be offset by human capital gains; on the other hand, losses of human capital can equally be offset by environmental capital gains

(Gowdy and Walton, 2010, pp. 397-398; Hamstead and Quinn, 2005, p. 145; Romeiro, 2012, pp. 73-74).

Consequently, proponents of the concept of weak sustainability classify human influence on the environment as an exclusively economic problem. Sustainability then merely means a constant or even growing economic output over time, or the maintenance of economic value measured by market prices (Gowdy and Walton, 2010, p. 396-398; Hamstead and Quinn, 2005, p. 145). To ensure that market prices can always be assigned to all forms of capital and types of resources, sustainability itself must be calculated precisely, which can happen provided two conditions are met: first, there must be complete substitutability between the different forms of capital (for example, between natural products and man-made or recycled ones). Second, there must likewise be a complete commensurability of all types of resources, meaning their overall comparability and measurability, which in practice usually happens the in the one-dimensional form of money (Gowdy and Walton, 2010, p. 401; Munda, 1997, pp. 217-218). Sustainability would then be less a biological or physical resource problem but rather one of correct portfolio management (Gowdy and Walton, 2010, p. 399; Hamstead and Quinn, 2005, p. 145).

2.7. Criticism of Environmental Economics: Substitutability

Neoclassical environmental economics and the concept of weak sustainability have been criticized in many ways: neoclassical environmental economics mostly concerning the aspect of substitutability, and the concept of weak sustainability mostly against the aspects of commensurability and monetization. Under this and the next heading, this criticism is listed and analyzed in a way that does not yet exist in the literature in its concise yet complete form. First follow the arguments why natural capital cannot be fully substituted with man-made capital:

1) Natural capital is essential to produce man-made goods: even presupposing technological progress, any increase in capital will always be limited by the available natural resources.
2) Assuming depreciation of capital over time (the degradation of production means, or monetary inflation), natural resources are indispensable to uphold progress (Munda, 1997, p. 218).
3) If natural capital were completely substitutable by human-made capital, there would be no need to transform natural into man-made capital in the first place (Beder, 2011, p. 143);
4) Natural capital complements man-made capital, thus is indispensable (Romeiro, 2012, p. 78);
5) Unlike man-made capital, natural capital is multifunctional in its support of all life functions (Munda, 1997, p. 218);
6) We simply do not know enough about substitutability, or, in the words of most recent research: “There is considerable debate among economists whether technology can mitigate scarcities through development of substitutes” (Korhonen, 2018, p. 115);

7) According to the physical laws of thermodynamics and entropy, energy cannot be fully conserved, conversed or substituted (Hermann-Pillath, 2015, pp. 434, 436);

8) The law of diminishing returns means that weak sustainability is bound to break down as soon as all the available substitutes are exhausted (Beder, 2011, p. 143);

9) Substitutability might work out on paper and in theory, but can lead to obvious negative trade-offs. As an example, a community could continue using up its natural resources and degrading its natural environment, if it increases its wealth and infrastructure by an equivalent amount of economic or monetary value. If it becomes a sterile and dangerous place to live in, its residents are supposedly compensated by their new material comforts and entertainments (Beder, 2011, p. 143).

2.8. Criticism of Weak Sustainability: Commensurability and Monetization

Below follow the arguments why natural resources should not be commensurable or monetizable:

1) As the substitutability discussion has shown natural and man-made resources not being alike, hence they cannot be commensurable, and thus should not be measured by the same standards, or expressed in traditional and common values and units such as money (Müller 2001, p. 415).

2) An exclusive focus on the gross domestic product (GDP) ignores environmental destruction or degradation, does not value natural resources, and counts repairs and remedies as positive GDP contributions, since they involve economic expenses. All this serves to hide rather than to help the social, environmental and distributive costs of economic expansion (Munda, 1997, p. 214).

3) A main reason for the nowadays widely perceived failure of purely neoclassical methodology has been its methodological limitation to quantification and monetization of environmental and sustainability values (Müller 2001, p. 415).

4) A focus on allocation efficiency for environmental policy decisions tends to ignore wider socioeconomic and sociopolitical issues such as equity (Beder, 2011, p. 141; Common and Stagl, 2005, p. 11).

5) The full value of natural resources only becomes clear only after they have disappeared, which is known as the "compositional" or "transparency problem" (Gowdy and Walton, 2010, pp. 396, 398, 401). An example is that of putting monetary value on a species, such as blue whales: this still does not guarantee their survival, and from a purely monetary viewpoint it seems preferable to exterminate them and invest the profit in growth industries rather than in their well-being. In another example, the Amazon rainforest could be removed if the resulting profit is reinvested into other, man-made capital (Beder, 2011, p. 142-143).

6) Cost-benefit analyses are unsuitable to account for cumulate losses over time, such as a slow but steady environmental degradation within a community, which may pass unperceived for a long time, yet can lead to a sudden and complete ecosystem breakdown once a critical threshold is crossed (Beder, 2011, p. 142).

2.9. Ecological Economics and Sustainability: Many Sciences and Denominators

As a reaction to this criticism, in the late 1980s the field of "ecological economics" was established, for broad, ecological, interdisciplinary, and holistic approaches to the study and management of the world. Before settling on its name, the literature discussed these alternatives: "ecology and economics", "economic ecology", "eco-economics", "natural economics", "sustainability economics", "socio-environmental economics", "eco-development", and even "ecolnomics" or "econology" [sic] (Cavalcanti, 2010, pp. 60-61; Costanza, 1989, p. 1; Romeiro, 2012, pp. 65, 67; Spash, 2013b, pp. 352, 359). Hence ecological economics includes natural sciences (biology and ecology) and is based on a multiple-denominator evaluation (including carrying capacity, environmental degradation, or socioeconomic aspects of consumption and destruction) (Dzeraviaha 2018, pp. 15-16; Munda, 1997, pp. 216, 220). Ecological economics was thus defined as "a new approach to both ecology and economics…to make economics more cognizant of ecological impacts and dependencies… [and] ecology more sensitive to economic forces, incentives, and constraints" (Costanza, 1989, p. 1; similarly Dzeraviaha 2018, p. 15). Later it was defined as "a new transdisciplinary field of study that addresses the relationships between ecosystems and economic systems in the broadest sense… differ[ing] from both conventional economics and conventional ecology in terms of breadth of its perceptions of the problem, and the importance it attaches to environment-economy connections" (Costanza, Daly and Bartholomew, 1991, p. 3; Dzeraviaha 2018, p. 15; Munda, 1997, p. 220).

2.10. Differentiation between Environmental and Ecological Economics

Some suggest environmental and ecological economics to be seen on a continuum between pure economy and pure ecology: environmental economics would be situated close to pure economics, while ecological economics would be situated around the halfway mark, and slightly closer to ecology (Cavalcanti, 2010, p. 61). Others imagine environmental economics in the intersection between economy and ecology from an economic perspective, including the field of environmental impact analysis, whereas ecological economics deals with that intersection also from an ecological viewpoint, including resource economics. In addition, ecological economics includes issues mainly ecological issues such as waste heat management, or environmentally friendly technologies such as solar energy (Costanza, Daly and Bartholomew, 1991, p. 4). While the macroeconomic goal of environmental economics is the growth of the national economy, that of ecological economics is the sustainability of the global economic and ecological system. Finally, environmental economics focuses mainly on the human species, while ecological economics contemplates the whole ecosystem, including non-human elements (flora, fauna, and climate) (Beder, 2011, p. 146; Costanza, Daly and Bartholomew, 1991, pp. 5-6).

2.11. Ecological Economics: Economic Subsystem and Development Economics

Ecological economics sees economic and ecological concerns as mutually constitutive and co-evolving. Investigating the interactions between the economy and the environment, it sees the local and national economy as a subsystem of the larger global

and local ecosystem (Romeiro, 2012, p. 78); Venkatachalam, 2007, p. 551). It thus considers the relationship between three systems:

1) the economic system that comprises the economic activities of humans, such as production, exchange, and consumption;
2) the human system that includes all the activities of human beings on earth, such as biological life processes, culture, aesthetics, and morality;
3) the natural system, which in turn encompasses both the economic and human systems (Munda, 1997, pp. 225, 228).

As the economic system cannot comprise all human activities, it must be a subsystem of the human system, and its expansion limited by the size of the global ecosystem. Hence any harmful activities or effects done within or caused by the economic system affect the bigger human system and determine and limit the economic system itself (Munda, 1997, pp. 225, 228). In a wider socioeconomic context, ecological economics holds that development economics should not be framed as a continuously rising, linear process within a Western or Euro-centric understanding of progress. Instead, it should be considered as an evolutionary negotiation of cultural, social, political, economic and ecological debates. Rather than posing the supremacy of either economics or ecology, both are indispensable branches of human development (Munda, 1997, p. 223). Finally, and based on a holistic understanding of development, the concern with growth is only one aspect of many, and is part of the larger notion of sustainability, meaning a preservation of the resources that enable that very growth (Ghosh, 2017, pp. 13-15; Müller 2001, p. 420-423).

2.12. Ecological Economics: From the Limits of Growth to Zero Growth

With the economic subsystem limited by the size of the global ecosystem, the term "scale" is used to describe "the physical scale or size of the human presence in the ecosystem, as measured by population times per capita resource use", and the limits of scale are defined as "the regenerative or absorptive capacity of the ecosystem" (Munda, 1997, p. 225, citing Daly). This begs the question whether there is an "optimal scale" for an economy (Munda, 1997, p. 225; Romeiro, 2012, p. 80-81), as "the scale of the economy compatible with its ecological base", if one is mindful of the concept of carrying capacity, defined by "thresholds of ecosystem resilience" (Romeiro, 2012, p. 78). A widely used images is that of a boat which, surpassing its load limits, will sink (Cavalcanti, 2010, p. 57-58). Another widely used metaphor is that of "spaceship earth" floating in space, and as the largest available economic and environmental system, cannot receive or dispose of material, and thus must survive with the available resources, which are limited in quantity and finite in duration (Mithukrishnan, 2015, pp. 95-96; Spash, 2013a, p. 348; Romeiro, 2012, p. 78). In a "cowboy versus spaceship economy" metaphor, the economic system is either represented by a cowboy on vast and mostly empty frontier plains, who does not have enough critical mass to cause irreversible ecosystem damage, even if subscribing to the slogan "bigger is better". Or, the economic system is represented by a spaceship crew, which can endanger its own survival if it does not handle available resources properly, and hence is mostly concerned with the maintenance and enhancement of the natural capital stock, minimizing material

production and consumption, and measuring success not just in growth or quantitative economic expansion criteria such as the GDP, but in the quality, resilience, coherence and complexity of human, natural, man-made, social and financial capital products and stocks, such as quality of life, well-being and longevity, community stability, or cultural diversity (Hamstead and Quinn, 2005, pp. 144, 150; Romeiro, 2012, p. 78).

Furthering that metaphor, some suggest pursuing and implement "zero growth", before growth inevitably will stop by itself (Romeiro, 2012, pp. 70, 79-80). Based on Meadow et al.'s pioneering work, commissioned by the Club of Rome, *Limits to Growth* (1972, updated 2004), they argue that growth is limited by energy and resource limits. Unlike proponents of "technological optimism", who see such limits to be overcome by human ingenuity, technological development and progress (see Romeiro, 2012, pp. 66-68), "technological pessimism" holds that basic energy and resource constraints will sooner or later stop economic growth. In an analogy from life sciences, natural systems all stop at a certain size due to resource constraints to maintain a healthy level (Costanza, 1989, pp. 2-3). It is pointed out that an ever-increasing average world income and consumption per capita ultimately threatens the entire planetary ecosystem. Besides, economic growth is more relevant for poorer, but less for richer economies (Belinga et al., 2018, pp. 304, 306; Common and Stagl, 2005, p. 194), but even the poorer ones are recommended to avoid the richer ones' mistakes of heavy environmental impacts and footprints (Romeiro, 2012, p. 69).

3. Methodology

3.1. Multidisciplinary Paradigm

In contrast to the traditional evaluation methods of neoclassical economics and environmental economics (consisting mainly of monistic, mathematical and monetary cost-benefit analyses, based on market philosophies linked to consumer behavior), ecological economics recommends a plurality of methodological perspectives for macroeconomic decision-making. Considering value conflicts inevitable, it asks scientists and decision makers to contribute to collaborative frameworks for the interdisciplinary intersection between economic and ecological issues (Beder, 2011, pp. 146, 149; Hamstead and Quinn, 2005, p. 151; Munda, 1997, pp. 228-229). They called that innovation "treat[ing] integrated economic-ecologic systems with a common (but diverse) set of conceptual and analytical tools" (Costanza, 1989, p. 1), and later widened that innovative viewpoint to "a new transdisciplinary field of study…in terms of breadth of its perceptions of…environment-economy connections" (Costanza, Daly and Bartholomew, 1991, p. 3; Munda, 1997, p. 220).

Thus equipped, ecological economists focus on salient recent problems (Beder, 2011, p. 148; Costanza, Daly and Bartholomew, 1991, p. 5). They explicitly include economics, ecology, biology, geography, sociology, politics, philosophy, ethics, and psychology (Herrmann-Pillath, 2015, p. 432; Spash, 2013b, p. 358) in what they call a "multidimensional paradigm" (Munda, 1997, pp. 228-229). On this basis, they propose a "transdisciplinary" methodology for ecological economics (Cavalcanti, 2010, p. 60), in which a "methodological pluralism" allows for a "multiplicity of approaches" that

"transcend the boundaries of the discipline in seeking understanding… [of] new concepts and mental structures which subsume and extend the approaches of even an interdisciplinary approach" (Spash, 2013b, p. 358; Venkatachalam, 2007, p. 551). This enables them for instance to account for complex individual motivations beyond self-interest: people can decide and vote not just as resource-using consumers, but also as environmentally and ecologically concerned citizens, to preserve those resources better (Beder, 2011, p. 142). Multidimensionality and multidisciplinarity are finally also suitable to ensure a not overly anthropocentric view, and to care also for non-human interests, such as other living creatures and collectives, such as animals, plants, and entire ecosystems (Beder, 2011, pp. 142, 146; Common and Stagl, 2005, p. 9).

However, ecological economics acknowledges two downsides of this inter- or transdisciplinarity: first, it might make it harder to achieve methodological unanimity (Dzeraviaha, 2018, pp. 15, 18). Second, it might be unable to overcome political or social barriers to collaboration in solving environmental challenges, and in turning its insights into widespread implementations of effective environmental measures. For instance, the working areas and tasks of government ministries, departments or agencies are often split to deal with stakeholders from different economic sectors, who all have vested interests in avoiding costs imposed on them by their governments, even if they are the ones who impose environmental burdens on the rest of the community (Beder, 2011, p. 149).

3.2. Post-Normal Paradigm

Ecological economics also employs a "post-normal" paradigm, in recognition that in our time of complex globalized issues and challenges, it so happens that most values, stakes, decisions and even facts are interpretable, therefore ambiguous and uncertain, and as a result, often highly contested (Costanza, 1989, p. 3; Munda, 1997, pp. 221-222; Cavalcanti, 2010, p. 58; Hamstead and Quinn, 2005, p. 144; Romeiro, 2012, p. 66). Consequently, values and ethics cannot remain neutral or indifferent either, but instead require conscious and deliberate decisions by all stakeholders, and are flexible to grow or change according to constantly evolving and ramifying scientific progresses and insights. "Optimal" outcomes are thus illusionary; in their place, the best we can do, but indeed should do is to render decision-making processes as fair and transparent as possible.

3.3. Co-Evolutionary Paradigm

Finally, recognizing the interconnected influence of economic, environmental and social issues, ecological economics also postulates a "co-evolutionary paradigm". It was taken from co-evolutionary biology, according to which two closely interacting species can change their genetic traits as a reaction to the dominant genetic traits (and thus the selective pressures) of the other one. In application, economic, social and the entire natural and human development can be considered as a process of adaptation to a constantly changing environment, or as being subject to change, while at the same time this development is itself a source of change (Munda, 1997, p. 223). The co-evolutionary paradigm can be considered as complementing both the multidisciplinary and the post-normal paradigms: depending on the concrete case (such as the cultural or national

locality, the involved stakeholders, their economic pressures, and their ecological preferences), different methodological approaches (multidisciplinary paradigm) might be applied in a flexible way (post-normal paradigm) and can then be adapted over time according to any changed circumstances (co-evolutionary paradigm).

Based on these conceptual and methodological insights, the below analysis and discussion section is divided in two parts, namely in what I call "macroeconomic compensation models" and "macroeconomic transformation models" for sustainable development. As those names indicate, I consider the latter to be the most progressive and recommendable measures for current and future policy and practice. The conclusion evaluates how feasible and recommendable they are from a macroeconomic viewpoint, for efficient and equitable sustainable development.

4. Analysis and Discussion

4.1. Macroeconomic Compensation Solutions for Sustainable Development

4.1.1. Compensation Solution 1: Internalization into Ecological Accounts

Some ecological economists suggest an economic-ecological integration, such as of resource use and pollution emissions (Munda, 1997, p. 216): externalities are not so much accounting problems as processes of shifting costs between individual and institutional participants of unequal power and influence, which traditionally made economic values count for more than ecological ones (Kallis, Martinez-Alier and Norgaard, 2009, pp. 14-17). Hence they internalize externalities (such as environmental damages or reparations) into ecological accounts. Others recommend protecting the environment by internalizing its value concerns, but not into the economic system, but instead into an ecological one (Müller 2001, p. 415). Finally, some consider complementary measures and multi-criteria decision-making processes (Beder, 2011, p. 147).

Internalizing externalities is criticized for mistakenly assuming that the originally inflicted damage is equal to the compensation. In the earlier example of a company polluting a community, the community might also spend the income on something that for them is equally worthwhile than correcting the pollution, so the sufferers from the original pollution would remain disadvantaged. Hence the argument of internalizing costs rests on the assumption that compensation is as good as, or better than avoiding damage from the beginning, and that substitutions are equal to the damage. Yet reality is different: polluters or environmental wrongdoers simply continue their misdeeds if they can financially afford it. They might be forced to reduce costs, but not necessarily in the area where they are charged. In other words, charges are rarely equivalent to the damages they mean to prevent or compensate (Beder, 2011, p. 143). Besides, paying for damages, even if those are alleviated, can still turn out to be the more shortsighted solution. For example, companies might opt for end-of-pipe emission measures (such as installing filters) that are less effective than remodeling their entire plant with cleaner technology, or opt for alternative and displacement actions (such as planting trees in developing nations) instead of reducing their original emissions (Beder, 2011, pp. 144-145). One way to ensure or enforce the internalization of externalities is via rights such as laws and regulations, discussed below.

4.1.2. Compensation Solution 2: Right-based Economic Instruments

Proponents of rights-based economic instruments invoke the "tragedy of the commons", namely that the lack of ownership of public goods and some natural resources (such as the atmosphere, waterways and some land areas) make them especially vulnerable to exploitation or extermination. Measures to protect them can either be laws, regulations, sanctions or charges, or the creation of artificial property rights to ensure their responsible treatment and management. For example, laws can force polluters to heed external costs by imposing limits to what can be discharged or emitted. An example for the internalizing effect of such taxes or charges is that of a firm discharging waste into a river: it could be charged a fee to cover the cost of lost recreational amenities and fish life. Hence the optimal level of pollution is the level at which the cost to the company of cleaning up the pollution equals the cost of environmental damage caused by that pollution. The company will clean up its pollution until any further reduction in pollution would cost more than the remaining charge, or until it is cheaper to pay the charge than reduce the pollution. The he polluter is better off for being able to continue to pollute, and the community is better off for receiving compensation as a Pigouvian tax or punitive charge, which can be used to correct the environmental damage. Practical experiences have revealed a preference for taxation over legislation, but also of free market consumer choices over taxation (Beder, 2011, p. 143-144).

As another rights-based instrument, damages caused can be traded in the "cap-and-trade system" within emission trading schemes, under which rights and permits, for instance to pollution, are allocated to firms which can either use or swap them, depending on their willingness to comply or to pay (Beder, 2011, p. 144). Yet an argument against rights-based instruments is that they are still market-based environmental policies, and thus indirect methods of achieving environmental goals. Rules that change decision-making conditions instead of directly prescribing remedial actions cannot ensure that the changed conditions will cause the desired decisions. In practice, emissions trading is generally preferred to taxation (Herrmann-Pillath, 2015, p. 440); yet emissions trading has so far failed to show significant environmental quality improvements (Beder, 2011, p. 144).

4.1.3. Compensation Solution 3: Ecosystem Services

Ecosystem services are defined as "including provisioning services (such as food, water, fibre and fuel), regulating services (such as carbon sinks, flood mitigation and waste treatment), cultural services (for example spiritual values, aesthetic pleasure and recreation) and support services (for example soil formation and nutrient recycling)" (Beder, 2011, p. 147; similarly Ballet, Marchand, Pelenc and Vos, 2018, p. 21). Hence ecosystem services provide natural capital in form of services to the economy. To be maintained, they must be paid for, usually by governmental institutions, in form of payments for ecosystem services (PES) to landowners and managers to conserve their own properties' ecosystems. Markets for ecosystem services (MES) include for example emissions trading or wetland mitigation banking (Jespersen and Gallemore, 2018, pp. 507, 510; Vatn, 2018, p. 170; Liua and Kontoleon, 2018, pp. 48-49). Some view ecosystem services positively, namely as an interdisciplinary integration of economic and ecological knowledge bases (Beder, 2011, p. 148).

Critics call ecosystem services yet another commodification of natural goods and resources, but now on the level of entire ecosystems. Hence they invoke the arguments against neoclassical and environmental economics (trust in market regulation, individual self-interest, substitutability, commensurability, allocation efficiency, and lack of moral-ethical frameworks) also against ecosystem services. Due to the complexity of ecosystems, such services might even reduce our scientific understanding of them. Also, such services favor a project-by-project approaches that tend to ignore the interconnectivity and interdependence of ecosystems, and foster overly obsequious attitude to those governmental or local institutions that are supposed to support them (Chan et al., 2017, pp. 110, 115; Ishihara, Pascal and Hodge, 2017, pp. 45-46, 50-51). As an example, wetland mitigation banks often assume that the value of a given wetland can be estimated in terms of acreage, and that a wetland in one watershed is equivalent to a wetland in another one, even though wetlands perform specific and different functions for their surrounding ecosystem. In another example, the view of forests as ecosystem service providers in form of carbon sinks has led to the growth of plantations without regard to their impact on local water supplies, biodiversity and people's livelihoods (Beder, 2011, p. 148).

4.2. Macroeconomic Transformation Solutions for Sustainable Development

4.2.1. Transformation Solution 1: Distributional Equity

Distributional equity is suggested as intra-generational equity (within the same generation, such as trying to overcome the global North-South divide) as well as inter-generational equity (between different generation, for instance regarding the use of non-renewable resources) (Hamstead and Quinn, 2005, pp. 148, 152-153; Kashwan, 2017, pp. 139-140, 144-145). An example for intra-generational inequality is *spatial ecological distribution*, such as CO2 (carbon dioxide) or SO2 (sulfur dioxide) emissions and their burdens of breathing problems or acid rain. Examples for inter-generational inequality are *temporal ecological inequality* brought about by the nuclear energy in form of radioactive waste, or the socio-ecological inequality of "environmental racism", when polluting or waste disposal industries are located in, or are transferred to areas of socially disadvantaged population groups (Munda, 1997, p. 216). In such cases, the perpetrators are usually socioeconomically different from the victims. Policy suggestions are appropriate allocation via full-cost accounting (including an economic, social and environmental calculation) and distribution in form of welfare economics. This includes considering not just which resources can be consumed, but also which ones should remain in the ecosystem untouched (Hamstead and Quinn, 2005, p. 148).

4.2. Transformation Solution 2: Strong Sustainability

Part of the literature postulates the concept of "strong sustainability", defined as "sustaining the life support systems of the planet including the evolutionary potential of the biosphere" (Gowdy and Walton, 2010, p. 397). It stresses the retention, improvement and maintenance of existing and future capital, as opposed to economic expansion, and defines "development" as overall qualitative improvement of all capital, rather than the quantitative expansion of just one type (Hamstead and Quinn, 2005, p. 145).

Specifically, it considers certain types of natural capital as essential, unique, non-reproducible and thus not readily substitutable by man-made, manufactured capital. Examples are the radiation protection effect of the ozone layer, the climate-regulating functions of ocean phytoplankton, the watershed protection functions of tropical forests, or the pollution-cleaning and nutrient-trap functions of wetlands, or genetic biodiversity (Beder, 2011, pp. 143, 147). These types of natural capital should be protected and sustained over time in holistic and physical terms, and not just in economic terms (Gowdy and Walton, 2010, p. 398). Their stocks should be monitored and measured, but not just with monetary indicators (Cavalcanti, 2010, p. 58; Gowdy and Walton, 2010, p. 406), and instead directly and physically, for instance in so-called "satellite accounts" (Munda, 1997, p. 226). Advocates of strong sustainability also hold that the current global ecological and social crises require fundamentally different ways to interact with our surrounding ecosystems, instead of the more incremental approaches favored by weak sustainability approaches (Hamstead and Quinn, 2005, p. 145).

4.3. Transformation Solution 3: Sustainable De-Growth

The limits-to-growth argument is taken to the last level with the concept of "sustainable economic de-growth", also called "post-growth", which has started to diversify in academic research only since 2012 (Gerber and Gerber, 2017, pp. 551-552; Weiss and Cattaneo, 2017, p. 220). Sustainable de-growth is not about discarding or decreasing the GDP, since negative externalities (such as loss of biodiversity, environmental degradation, climate change, or cultural erosion) could still be deducted from it, depending on the applied accounting principles. Rather, sustainable de-growth is about creating values and systems of an alternative, smaller-scaled economy, adapted to the physical needs of ecosystems and humans (Belinga et al., 2018, pp. 304, 307; Hamstead and Quinn, 2005, p. 151; Kallis, Martinez-Alier and Norgaard, 2009, pp. 14-17). Interestingly, the global economic crisis of 2008 was considered a special chance to implement such strategies, and such strategies were argued to have been used better in Europe, the USA and Japan than elsewhere. Furthering this insight, some argue that socio-ecological transitions of such type and magnitude should be used to move capital to smaller economies in a socially fair and equitable manner, thus progressively burdening the more privileged social strata, which would be consistent with their responsibility for, and profit gained from the previous pattern of unbalanced wealth buildup (Kallis, Martinez-Alier and Norgaard, 2009, pp. 22-25).

Critics point out that limiting growth and restricting choices of present generations for the sake of future ones are hard to argue for and to achieve in societies built upon economic surplus (Belinga et al., 2018, pp. 309-310; Drews, Antal and van den Bergh, 2018, pp. 265, 267; Gowdy and Walton, 2010, p. 404; Kish and Quilley, 2017, p. 306; Romeiro, 2012, pp. 69, 72; 82). For some, the concept and term of "sustainable growth" is "totally inappropriate", as any growth as well as sustainability considerations are a priori limited by ecological carrying capacities (Cavalcanti, 2010, p. 58). Finally, many are mindful that zero growth or de-growth would have to stop growth without triggering macroeconomic meltdowns or consumer shockwaves. The former can be prevented by formulating and implementing sound macroeconomic policies (which would constitute a form of "environmental macroeconomics") against problems such as unemployment or inequality, or as incentives to technological innovation. People would need some

altruism to accept restrictions for the sake of the environment or wider ecology, especially if those go hand in hand with zero growth. Yet such altruism may be fostered by two realizations: that the alternative would be a macroeconomic collapse of even greater proportions, and that the current level and degree of material comfort could already more than enough for all, so that further growth would be counter-productive and even harmful (Romeiro, 2012, p. 82).

5. Conclusions

If we unite our methodological contributions (the combination of multidimensional, post-normal and co-evolutionary paradigms) with some solution suggestions by the literature (such as strong sustainability), unique models can evolve, or new impulses can be given to existing models, while they can now be holistically evaluated, all of which adds to the overall contribution of this research. To start with, the solution of internalizing externalities is admittedly, a step beyond environmental economics based on neoclassical principles, in that externalities are now internalized specifically into ecological accounts. However, it attracts the same critique as environmental economics based on neoclassical approaches: that it upholds the principles of substitutability and commensurability between economic and environmental resources, whose rejection was one of the basic motivations for founding the field of ecological economics. The weightiest argument seems to be that their practical efficiency remains highly questionable, or even disproven by reality, hence it can be rejected.

Ecosystem services seem to differ in form, but not in effect: rather than internalizing externalities, they keep the externalities external, but the environmental improvement brought by their suggested services seems to be firstly only a matter of degree or shading, and secondly addressing symptoms (servicing a damage done) rather than their causes (avoiding damaging behavior in the first place). Rights-based economic instruments almost by definition concede an economic inequality between environmental perpetrators and the ecological systems or victims which they are supposed to protect. In practice, every company or individual with enough financial means can essentially do any desired harm to the environment, provided they are able to offer the legally stipulated amount of compensation. This might even completely counteract and thwart the purpose of those regulations, since the more economically affluent perpetrators are, the more severe the damage they are able to inflict to the environment and the society, whereas those who are on the opposite end of the socioeconomic scale (victims and ecosystems) are usually the ones most suffering from the consequences.

Distributional equity and strong sustainability both depart from a clear awareness of the differences between environmental and ecological economics. Their holistic approaches mean that their suggestions have no economic or social side effects that would cancel out their positive ecological intentions. Provided real equity, distributional equity would also ensure a population's widespread motivation to design, implement and control measures for maintaining environmental standards, since easy financial release as under rights-based economic instruments would not be possible.

As for strong sustainability, we could demand that all bio-physical indicators or satellite accounts, even if not integrated in monetary terms in national income accounting, should

be explicitly welcome to contentious scientific research and sociopolitical opinion and controversy about their value and place, both in the macroeconomic and in the wider social system. Such transparency would have a similarly motivating effect as in the instrument of distributional equity, as now public access and monitoring would ensure a wide following and support of strong and far-reaching sustainability measures.

Finally, the concept of de-growth is often misunderstood of meaning re-growth or down-growth, that is, as a loss of already available levels of progress and material consumption. As outlined earlier, instead it asks merely for a re-orientation and re-design of our value systems, so that the already available levels of material comfort could be considered as sufficient, contributing to enhanced personal and societal health and thus sustainability of individual, intra-generational inter-generational and international levels of community and cooperation. Hence "growth" as such could still be pursued and achieved by all and for all. It would merely be a different kind of growth, and maybe one that economic philosophers have recommended for ages, for instance inner growth, work-life balance, personal satisfaction and ultimately happiness. There would then be a clear link between de-growth and distributional equity, since a reorientation of our values, where growth can still be pursued, would be based on an equitable allocation and distribution of available natural resources. Such a form of growth might even be considered by many as increasingly fulfilling.

Maybe a final quote from American conservationist John Sawhill, professor and 12th president of New York University (NYU), as well as president and CEO of the global charitable environmental organization *The Nature Conservancy*, best encapsulates these reflections and directions in a nutshell: "A society is defined not only by what it creates, but also by what it refuses to destroy" (quoted in Menon, 2014, p. 18; Swing, 2017, p. 111; and UNESCO and UNEP, 2015, p. 10).

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