An Overview of the Debates and Research on Ecologically Unequal Exchange

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Resumo

Troca desigual ecológica é um conceito associado com a economia ecológica e a sociologia ambiental que construí acima do conceito de troca desigual. Esse último conceito relaciona as transferências de riqueza principalmente entre o centro e a periferia. O trabalho começa com uma avaliação breve do conceito de troca desigual que foi apresentado primeiro por Emmanuel (1972). Esse conceito procurou encarar as inequidades associadas com os valores monetários dos fluxos de comercio, em contradistinção a troca desigual ecológica, associada com as transferências físicas subjacentes dos materiais e energia, e também com o resultante degradação ambiental.

Em décadas recentes, tinha uma extensão da discussão da troca desigual às áreas de ecologia, geografia, economia ecológica e sociologia ambiental, mudando a incluir estoques e fluxos de materiais e energia, no somente analisando estoques e fluxos monetários. Esse trabalho primeiro considera várias medidas biofísicas, como capacidade de suporte e pegada ecológica antes de avançar avaliando pesquisa teórica e empírica relacionado a troca desigual ecológica. Ademais também tem uma discussão sobre debates teóricas relacionado com as diferentes teorias de valor e a ecologia dos sistemas, entre outros temas. Mais além do assunto de troca desigual dos recursos naturais são as preocupações sobre deterioração ambiental e crises ecológicas potenciais e degradação no Sul Global, como no caso da Amazonia Brasileira. Muitos desses problemas são causadas como resultado da produção das mercadorias particulares, frequentemente do setor primário, necessário pela acumulação capitalista no Norte Global.

Palavras-chaves: Troca Desigual Ecológica, Troca Desigual, a Amazônia Brasileira, Economia Ecológica, Desigualdades Globais

Abstract

Ecologically unequal exchange is a concept associated with ecological economics and environmental sociology which builds upon the concept of unequal exchange. The latter concept relates to transfers of wealth primarily between the center and the periphery. The paper begins with a brief assessment of the concept of unequal exchange which was first presented by Emmanuel (1972). This concept sought to address the inequities associated with the monetary value of trade flows, which is in contrast to ecologically unequal exchange, associated with the underlying physical transfer of materials and energy, and also with the resulting environmental degradation.

In recent decades there has been the extension of the discussion of unequal exchange to the realms of ecology, geography, ecological economics and environmental sociology, moving to include material and energy stocks and flows, not just analyzing monetary stocks and flows. This paper first considers several biophysical measures, such as carrying capacity and ecological footprints before moving on to evaluating theoretical and empirical research related to ecologically unequal exchange. Moreover, there is also discussion of theoretical debates related to different theories of value and systems ecology, among other topics. Beyond the issue of unequal exchange of natural resources are the concerns over environmental deterioration and potential ecological crises and degradation in the Global South, as in the case of the Brazilian Amazon. Many of these problems are brought about as a result of the production of particular commodities, often from the primary sector, necessary for capitalist accumulation in the Global North.

Keywords: Ecologically Unequal Exchange, Unequal Exchange, Brazilian Amazon, Ecological Economics, Global Inequalities

SESSÕES ORDINÁRIAS: 6. AGRICULTURA, ESPAÇO E MEIO AMBIENTE NO DESENVOLVIMENTO CAPITALISTA

1. INTRODUCTION

Ecologically unequal exchange is a concept associated with ecological economics which builds upon the concept of unequal exchange. The latter concept is associated with the debate around wealth or value transfers was first presented by Emmanuel (1972) and further developed by Amin (1974), Mandel (1975) and others in the 1970s. The earlier concept sought to address the inequities associated with the monetary value of trade flows or quantities of labor, while in contrast, ecologically unequal exchange is associated with the underlying physical transfer of materials, energy, water, etc. and also the resulting environmental degradation. This paper presents the development of both concepts though emphasizing the debates around ecologically unequal exchange in recent decades and also to consider the use of this primarily between the center and the periphery. The original concept of unequal exchange category for analyzing the Brazilian Amazon.

In the next section of this paper the topic of Unequal Exchange is presented, initially with a background discussion and addressing a range of key authors, such as Emmanuel, Amin and Mandel. The third section of this paper presents the development of the concept of Ecological Unequal Exchange, considering precursors and related measurements, such as carrying capacity and ecological footprints. In addition, the trailblazing work of Bunker (1985) rooted in his work on the extraction of natural resources from the Brazilian Amazon is presented, followed by an evaluation of empirical studies and theoretical debates around the concept of ecological unequal exchange. The paper concludes with some final considerations.

In recent decades there has been the extension of the discussion of unequal exchange to the realms of ecology, geography, ecological economics and environmental sociology, as it moved beyond only analyzing monetary stocks and flows by incorporating an analysis of material and energy stocks and flows. The associated discussions include proposals of different theories of value, and seek to address the problem of unequal flows of embodied land, energy, water, etc., rather than just labor. The concerns over the deterioration of a range of natural resources, required for the production of particular commodities, especially for the consumption in the center, has led to major advances including the concepts of biocapacity and ecological footprints, crucial for analyzing ecological inequalities between regions.

There are a range of concepts and several approaches that have achieved important advances in conceiving of these asymmetric flows, without compensatory remuneration, but rather with very serious and notable ecological consequences. Authors that have made major contributions in this

debate and which will be presented include: Bunker (1985); Hornborg (1998, 2014a, 2014b); Rice (2009); Foster and Holleman (2014); Jorgenson (2006, 2009) and Odum (1996), among others. In order to understand the concept of Ecologically Unequal Exchange, which emphasizes physical material and energy flows and stocks, it is relevant to first review the history of the concept of Unequal Exchange; this former concept being strictly economic and in general limited to monetary exchanges of wealth or surplus value.

2. ISSUES AND DEBATES REGARDING UNEQUAL EXCHANGE

In order to consider the concept of unequal exchange and how this led to the concept of ecologically unequal exchange one needs to first consider the earlier discussion by Prebisch (1950), and others associated with ECLA, such as Celso Furtado. Prebisch, argued that terms of trade between the center and the periphery were biased based on a study of terms of trade from the 1880s through the 1930s, showing how for every 100 hours of labor from the periphery they were only getting back roughly 70% of labor hours from the center. These arguments became the basis for the correctly perceived injustice with regards to international trade. Prebisch presented this work in the 1940s and 50s and beyond and became associated with the `third world` strategy and advances via Import Substitution Industrialization (ISI),[ii] in Latin America from the 1930s through the 1970s. As a result, many countries, such as Argentina, Mexico, and Brazil, were able to industrialize and break from just being primary good suppliers to the center. In present day jargon this corresponds to the Global North robbing the Global South in terms of resources and labor. This economic discussion by Prebisch, Furtado and others of ECLA was extended by more radical approaches, such as marxist theories of imperialism and the dependency school, the latter rooted in Brazil, including authors such as Marini, Dos Santos, and Cardoso, among many others.

Before presenting the category of ecologically unequal exchange, a discussion of some of the key points and debates around unequal exchange is first considered. There is a continuity in the argument, whether it be terms of trade, unequal exchange or ecologically unequal exchange, reflecting a perceived and real injustice between the Global North (center) and the Global South (periphery) which contribute to global inequality overall, extending from at least the 18th century into the present 21st century.

2.1 Key Authors for Unequal Exchange: Emmanuel, Amin, Mandel

The discussion on unjust terms of trade constitutes the background to the development of research associated with the concept of unequal exchange, usually defined as unequal transfers of quantities of labor time embodied in the commodities that were traded between countries (see

Emmanuel, 1972). Much of this debate was rooted in primarily marxist discussions of different forms and categories of values and prices, and thus connected to the debate over the transformation of values into prices of production, etc. This reflected discussions and interpretations of Marx's analysis of competition in his three volumes of *Capital,* especially the two moments of competition, as argued by Shaikh (1979, 1980) and others: competition between industries and competition within industries. In spite of the interesting debate, the present section will concentrate on only a couple key points, related to the causes and effects of underdevelopment and the importance of understanding a few key concepts, such as transfers of value, in general, and that which is relevant for the exposition of ecologically unequal exchange. The distinction between use value and exchange value is especially relevant given the fact that unequal exchange concentrates on an imbalance of transfers of surplus value, which is quantitatively based upon exchange values, while ecologically unequal exchange concentrates on the physical quantities, more strongly associated with use values, not monetary categories.

One of the major points of contention in the debates on unequal exchange was that Emmanuel sought to demonstrate that the problem of unequal exchange derived from wage disparities between the center and periphery, rather than unequal development being the primary cause of wage disparities. There was much debate around this point, Mandel (1975) who is critical of Emmanuel's discussion of unequal exchange and argues that he confused cause and effect, when describing low wages in the periphery as the basis for underdevelopment, rather than the result of the uneven development of capitalism. The important issue is really to understand the historical processes producing and worsening the unprecedented levels of wealth inequality that the world experiences today in the 21st century, not a reduction or convergence as many mainstream economists argued would take place (e.g., Solow)**.**

There were two main types of transfers of surplus value: (1) one between industries based on differences in organic compositions of capital: basically, related to the differences between capital-intensive and labor-intensive industries; and (2) the other within industries, based on different levels of productivity between firms, in the same industry. In the discussion of unequal exchange, the transfers associated with trade were being considered, not transfers in general. There are at least two other important transfers of surplus value: (1) associated with foreign direct investment (FDI), and repatriation of profits, royalties and rents and (2) bank loans and external debt primarily via the IMF and the World Bank (see Cooney, 2004). FDI is also very relevant when looking at ecologically unequal exchange, not just consumption of traded goods, given the extraction of resources and the ecological impact of foreign transnational corporations from the center operating within countries of the periphery.

3. ECOLOGICALLY UNEQUAL EXCHANGE: PRECURSORS, EMPIRICAL ANALYSIS AND THEORETICAL DEBATES

As argued above, the development of the category of ecologically unequal exchange, originally linked to the discussion of unequal exchange but subsequently extended to a broader field than just radical political economy, has moved into a terrain involving new questions and debates. These include proposals of different theories of value, demands to address the problem of unequal flows of embodied land, energy, water, etc., rather than just labor; and seeking to critically evaluate the consumption of the Global North and the concern for environmental degradation and loss of resources in the Global South.

Prior to examining various attempts at empirical analysis related to ecologically unequal exchange, other measures are presented, namely ecological footprints and carrying capacity in sub-section 3.1; in particular, the authors, Borgström, Wackernagel and Rees are considered. Then sub-section 3.2 presents the original trailblazing work of Stephen Bunker (1985), where he developed the concept of ecologically unequal exchange in analyzing the extractive activities dominating the economy of the Brazilian Amazon. This is followed by sub-section 3.3 which evaluates empirical analyses of Ecologically Unequal Exchange, in the context of international trade, such as Jorgenson, Rice, and the work in systems ecology by Odum. The final sub-section is 3.4, Theoretical Debates around the concept of Ecologically Unequal Exchange, where the following authors are considered: Foster and Holleman, Hornborg, and Odum, among others. Lastly, is Section 4, Final Considerations.

The growing scholarship and accompanying documentation of the disproportionate flow of energy and materials from the Global South to the Global North, via ecologically unequal exchange relationships, could potentially strengthen the claim by developing countries that they are owed an ‘ecological debt’. In the chain of commodity production, extraction of resources and energy constitutes some of the most environmentally damaging activities and they are often located in the Global South. Furthermore, the North appropriates much more than its share of environmental space, such as the oceans and atmosphere, for the deposit of its wastes, such as carbon dioxide, among many others. As global negotiations to tackle climate change continue, the developing world could potentially employ these concepts of ecologically unequal exchange and ecological debt to produce measurements and try to levy influence. They should demand that the majority of the burden and responsibility of addressing environmental degradation must fall on the Global North. This can be argued, given the long history of global inequalities and the role of TNCs from the North operating in the Global South, usurping and removing materials and energy and causing incredible levels of ecological degradation. It has become increasingly evident that climate justice and human well-being

are directly tied to material ecological exchanges within the structure of the global economy.

3.1. Carrying Capacity, Ecological Footprints and Ghost Acreage

Besides ecologically unequal exchange, there have been other attempts at measuring the biological capacity or usage by different populations, in particular, carrying capacity and ecological footprints. According to Rees, "Ecologists define 'carrying capacity' as the population of a given species that can be supported indefinitely in a given habitat without permanently damaging the ecosystem upon which it depends. …, carrying capacity can be interpreted as the maximum rate of resource consumption and waste discharge that can be sustained indefinitely in a given region without progressively impairing the functional integrity and productivity of relevant ecosystems." Rees (2017: 5). In discussing carrying capacity, from the Global North perspective, Rees argues that "In the absence of negative feedback from the land on their economy or life-styles, there is no direct incentive for such populations to maintain adequate local stocks of productive natural capital." (Rees, 2017: 6). Given the degree to which the Global North imports carrying capacity, and also exports ecological degradation to the Global South, Rice argues that "the importing of sustainability by wealthy industrialized countries may equate to exporting ecological and social malaise to the Third World." (Rees, 2017: 6).

The development of the ecological footprint was seen as a breakthrough, and it was an empirical measure developed by Mathis Wackernagel and William Rees (1996). The ecological footprint was devised as the inverse of the old carrying capacity notion of ecology. Foster and Holleman point out that "Instead of asking, as in the analysis of carrying capacity, how much population or environmental load a particular unit of land would support, the ecological footprint inverted the question, asking how much land was required to support a particular environmental load, or a given population with a given per capita consumption." (Foster and Holleman, 2014: 209).

The most common definition for ecological footprints is a quantity of biologically productive land required to support the consumption of renewable natural resources and assimilation of waste products, including carbon dioxide of a given population. Ecological footprints tend to be measured in global hectares and according to Jorgenson (2009), "national footprints are measures of societal demand on domestic as well as global natural resources, and they allow for comparisons of a nation's environmental demand relative to available domestic and global natural capital". (Jorgenson, 2009: 25). In recent years, sociologists have tested a variety of propositions derived from political-economic theorization in cross-national analyses of per-capita ecological footprints (e.g., Jorgenson, 2003, 2005; Jorgenson and Burns, 2007; Jorgenson and Rice, 2005; Rice, 2007), as well as propositions derived from structural human ecology in studies of the total footprints of nations (e.g., York et al.,

2003).” (Jorgenson, 2009: 24).

Foster and Holleman, argued that the approach of Borgström, was a forerunner of ecological footprint analysis, employing the category ‘ghost acreage’ (Foster and Holleman, 2014: 208). Back in 1965, Borgström, a food scientist, published the book *The Hungry Planet*, and argued that “What allowed some countries to overshoot their available land or ecological base was the import of food from elsewhere– other countries or the sea. Such ‘ghost acres’ permitted wealthy countries, like the Netherlands, to develop population density and industrialized production while having an inadequate agricultural base. In the poorer countries, meanwhile, committing this ‘ghost acreage’ to production for export to the rich countries decreased the food acreage available for local subsistence.” (Borgström, 1965: 74–90). All of the categories considered in this sub-section have contributed to an awareness and understanding of ecological imbalances and international inequalities which deserve global attention. Due to space limitations, this paper cannot carry out a comprehensive comparative analysis of these different measures, although such an analysis would prove very useful.

Critical Points

As referred to in several definitions considered above, it is necessary to critically evaluate the definitions of ecological footprints and the use of “natural capital.” The concept of “natural capital,” just like human capital, does not exist, assuming one employs the concept of capital from a marxist perspective. Such categories are neoclassical distortions, not based on scientific analysis. Instead, we can refer to the flows and stocks of natural resources, independent of whether they constitute capital in the marxist economic sense or not. Therefore, a more adequate definition of ecological footprints is the sum of stocks and flows of natural resources, such as water, air, soil and forest resources, necessary for generating a flow of goods and services derived from resources for societies and the assimilation of waste products. If we consider a national park, which could be purchased by a transnational profit-making corporation, such natural resources could be considered potential capital, but to just refer to any forest as “natural capital” reflects a lack of understanding of the meaning of the category of *capital* in capitalist societies, which first and foremost is a social relation.

Another possible criticism in these different measures is the emphasis on consumption, as if it is always final demand that is making this push, in other words, individual’s consumption demand. The reality is that it is often the drive of accumulation, especially for intermediate goods, which leads to the increase in carrying capacity, ecological footprints or ecologically unequal exchange. Nevertheless, there is a need to recognize that consumption, especially in the Global North, needs to be reduced, even though the main driver for increases in these categories is capitalist accumulation.

Historically, this drive for accumulation and consumption from the Global North has been evident for centuries and even before capitalism dominated the globe, in the Brazilian Amazon. It is in this regional and historical context that the first recognized research employing the concept of ecologically unequal exchange was formulated by the trailblazing work of Stephen Bunker in 1985.

3.2. Bunker in the Amazon: Modes of Extraction

Bunker's book, *Underdeveloping the Amazon: Extraction, Unequal Exchange, and the Failure of the Modern State* was one of the first attempts to address the issue of unequal ecological exchange. as far back as 1985. He argued that the unequal exchange of energy and materials occurred to the detriment of extractive economies or "extreme peripheries." Bunker, similar to Emmanuel, refers to differential wages leading to unequal exchange between the periphery and center but in contrast, then includes "the transfer of natural value in terms of raw resources." He argues:

> "The outward flows of energy and the absence of consumption-production linkages combine with the instability of external demand and with the depletion of site-specific natural resources to prevent the storage of energy in useful physical and social forms in the periphery and leave it increasingly vulnerable to domination by energy-intensifying social formations at the core." (Bunker 1985: 45).

Bunker sought to incorporate the concept of 'mode of extraction' as the counterpart of the 'mode of production'. He arrived at this innovation given the context of the extreme peripheries, such as the Brazilian Amazon, considering the extraction of *drogas do sertão*[iii] and then the rubber boom, in addition to other exports. Bunker argued that:

> "… production models cannot explain the internal dynamics of extractive economies because the exploitation of natural resources uses and destroys values in energy and material which cannot be calculated in terms of labor or capital. When natural resources are extracted from one regional ecosystem to be transformed and consumed in another, the resource-exporting region loses values that occur in its physical environment. …An adequate model of the interaction between global and regional economies must account for both the differences and the interdependence between the two systems. The differences between the internal dynamics of modes of extraction and of modes of production create unequal exchange not only in terms of the labor value incorporated into products but also through the direct appropriation of rapidly depleted or nonrenewable natural resources…. Because this appropriation and its ecological results affect the class structures, the organization of labor, systems of exchange and property, the activities of the state, the distribution of populations, the development of physical infrastructure, and the kinds of information, beliefs, and ideologies which shape social organization and behavior, I introduce the idea, mode of extraction, to suggest the systemic connections between these phenomena." (Bunker, 1985: 22-23).

In connecting up the concept of ecologically unequal exchange to the earlier work by Emmanuel and others, Bunker wrote: “Thus, there are multiple inequalities in international exchange. One, certainly, results from the differential wages of labor. Another, however, is in the transfer of the natural value in the raw resources from periphery to center…. Finally, if the resources do not renew themselves naturally, the inequality of the exchange is intensified by the loss of resources and by the disruption of associated natural energy flows in the periphery itself” (Bunker 1985: 45).

In his attempt to present interdisciplinary analysis, much less common at the time, Bunker made a significant contribution to the field, forcing political economists, among others, to think about environmental and ecological issues. Nevertheless, he conflates mode of production with mode of industrial production, not recognizing that extractive activity carried out by capitalists, from the center or periphery is part and parcel of the capitalist mode of production. He correctly identifies many of the differences of extractive enclaves and the deleterious effects in terms of natural resources and stocks of energy that this implies for many parts of the periphery, not just the Brazilian Amazon[iv].

Nevertheless, it is clearly worth considering the case of estimating ecologically unequal exchange, in the context of the Brazilian Amazon currently in the 21st century. There is ample evidence of this modern day plunder, as presented in an excellent book by Gilberto Marques (2019), among other important contributions by authors in the region. The book analyzes the amazing amounts of wealth, in terms of both economic value and natural resources that are being actively plundered from the Brazilian Amazon in the present day, and the concomitant ecological degradation left by global transnational corporations (both Brazilian and foreign TNCs), not to mention the levels of poverty and inequality and displacements of indigenous and traditional populations. The Amazon has experienced incredible growth and exports resulting from extractive activities, from minerals, soy, cattle, petroleum and other products and has constituted a frontier of global capital accumulation in recent decades. This field of research deserves much more serious attention, not just lip service about the Amazon being the lungs of the planet, as observed at COP30 in Belém in 2025.

The theoretical category of ecologically unequal exchange linked to extraction needs to be more rigorous as extraction from one region to another occurs including within first world countries and has often taken place, e.g., northern states of the US and the underdeveloped Southern states. In fact, extractive products from a first world country are at times exported to the periphery. Notable examples include the US, Canada, Australia and France, and many resources, such as minerals, soy, cattle, agricultural and petroleum products. The geopolitical structures and institutions constitute a reality where there are much worse results for peripheral countries exporting extractive products compared to countries of the center. Evidently, this is an issue for any author working with the concept of ecologically unequal exchange.

3.3 Empirical Research on EUE (Jorgenson, Rice, Odum)

In recent decades, there have been several researchers, working from the world systems approach, and the framework of 'ecologically unequal exchange' that have carried out empirical analysis, often econometric analysis of trade data and also estimates of ecological-footprints. One of the main researchers, Jorgenson, made several contributions in this area. According to Jorgenson (2009, SF, p.24), "recently updated footprint estimates available from the Global Footprint Network (e.g., 2009) measure the bioproductive area required to support consumption levels of a given population from cropland (food, animal feed, fiber, and oil); grassland and pasture (grazing of animals for meat, hides, wool, and milk); fishing grounds (fish and seafood); and forest (wood, wood fiber, pulp, and fuelwood). It also includes the area required to absorb the carbon dioxide released when fossil fuels are burned, and the amount of area required for built infrastructure." He argues that the economic practices taking place within less-developed countries generally consist of agricultural and livestock activities, extractive processes, and export-oriented production.

Jorgenson argued that the EUE theory's assertions about the effects of the "vertical flow" of exports on environmental degradation for countries in the Global South have lacked systematic empirical evaluation. To investigate these assertions, he developed a weighted index which quantifies the relative extent to which the exports of a nation are sent to more-developed countries. The new weighted index was incorporated into a series of cross-national analyses of deforestation for 69 countries to test the hypothesis that less-developed countries with higher levels of exports sent to more-developed countries experience greater rates of deforestation within their borders. Findings for the analyses strongly support the hypothesis in particular and the theory of unequal ecological exchange in general (Jorgenson, 2006: 704-707). In another study, Jorgenson (2009) also presented empirical measurements related to EUE, by carrying out regression analyses for 66 lower income countries from 1975 to 2000 with similar results providing support for EUE theory.

Another key author, James Rice (2007), presented empirical research similar to the approach of Jorgenson, also working from a world-systems framework, using ecological footprint analysis for data from 2002 for 137 countries to show how trade contributes to ecologically unequal exchange. Based on the regression analysis Rice carried out, the results support the EUE argument. In addition to referring to the consumption and trade patterns in a hierarchical world system, he also refers to the role of accumulation and mentions the trailblazing work and class analysis by Bunker, as part of the defense of ecologically unequal exchange. It is worth noting Rice's definition of the latter: "We define ecological unequal exchange as the environmentally damaging withdrawal of energy and other natural resource assets from the periphery and the addition or externalization of environmentally

damaging production and disposal activities within the periphery of the world-system." (Rice, 2009: 221)

Much of the empirical research presented so far tends to work from a world-systems approach, in spite of coming out of different disciplines, and it can be argued that a key unifying insight is that capital accumulation is fundamentally rooted in the alteration of ecological systems and the exploitation of labor. Arguably, such a perspective tends to recognize that capital accumulation is the driving force of world-system processes and that it shapes ecological change over time and geographical space.

System ecology approach (emergy[v])

The last area of empirical research to be considered in this sub-section 3.3 is the system ecology approach and in particular the use of the concept of **emergy** (spelled with an m), carried out by the trailblazers of this field: the Odum brothers. Howard Odum and his older brother Eugene Odum are generally considered the foremost systems ecologists of the late twentieth century, having largely created the field (Hagen 1992: 122–145). H. Odum developed a method for measuring the total work of ecosystems embodied in commodities resulting from economic and ecosystem processes. This provided a way of calculating the extent of natural wealth (in energy terms) exchanged between countries, or the loss of a country's natural endowment through commodity trade. Emergy thus was meant, in Odum's conception, to provide a common energetic metric for measuring real wealth/use values.

For Odum (2007, 276), unequal ecological exchange arose as a result of 'imperial capitalism'. Moreover, Odum made it clear that he was not attempting to construct an energy theory of economic value. **EMERGY** is defined as the energy required directly and indirectly to produce a service or product. The essential idea of Odum's 'embodied energy' was one of the past energy, no longer physically present in the same form or degree, that went into making an object or product– an approach similar to Marx's concept of value as arising from dated inputs of labor, analogous to Marx's concept of direct and indirect labor time. (See Foster and Holleman, 2014: 211-212)

Foster and Holleman have considered the work by Odum as a major advance in spite of certain differences. Their criticism of a number of other empirical studies on ecologically unequal exchange, several considered above in this section, is a lack of rigor and a more ad hoc approach adopted in order to accommodate the empirical data available. They argue: "Although recent studies in environmental sociology and ecological economics strongly point to the existence of ecologically unequal exchange, there are serious problems at the level of both empirical analysis and, more importantly, underlying theory. Existing approaches have relied on data in which the ecological

(indeed physical) content of the goods is unknown and quantitative measures are in terms of prices rather than goods. As a result, very little is actually revealed in most current empirical studies of ecologically unequal exchange about the ecological nature of the exchange itself– in terms of matter, energy, resources, etc. (Foster and Holleman, 2014: 210)

Foster and Holleman argue that in spite of "the pioneering nature of such analyses, we learn little or nothing here about the processes involved or the real extent of the unequal exchange". Their concern is correct insofar as much of the empirical analysis cited above does not seek to actually measure 'ecologically unequal exchange' but are working primarily with ecological-footprint analysis, which is derived from the concept of carrying capacity. Often this is combined with an analysis of international trade between the Global North and Global South, BUT in price terms. Foster and Holleman (2014: 210) consider this research limited since it attempts "to establish broad correlations– as opposed to a historical-theoretical examination of the structures and processes of unequal ecological exchange within the world system". One would think that these authors working with a world system perspective would seek to develop their analysis more along the lines of classical-Marxian analysis. (See Foster and Holleman, 2014: 210).

As is often the case in economics, physical ratios, such as input-output coefficients, are derived from monetary transaction data, as the explicit details of physical quantities are often unknown or impossible to tease out of the available data. Foster and Holleman (2014) argue that although there remain a number of methodological problems, the main conclusion is still the expected result of the center countries consuming more of the natural resources and not paying for the environmental consequences, and instead it is the Global South employing its natural resources, be it energy, water, soil, or clean air, etc. to accommodate the excessive consumption in the North, and having to accept the concomitant environmental degradation.

3.4 Theoretical Debates

This sub-section 3.4 examines a number of key theoretical debates with regards to the concepts of unequal exchange, ecologically unequal exchange, and discussions regarding theories of value. An important contribution was made by Foster and Holleman regarding the contrast of the two key properties of a commodity as presented by Marx in the first few pages of Chapter 1 of Volume 1 of *Capital*, namely between use-value and exchange value and how this is relevant for comparing unequal exchange and EUE. Within the EUE literature there have been varying views of the concept of value or theories of value, but here we will concentrate on two of the main contributions in these debates: Foster and Holleman (2014) and Alf Hornborg (1998, 2014a, 2014b). The latter is an anthropologist with multiple contributions in the field of EUE. The debates range from discussion

over the concept or term ‘value’ in general versus the concept of economic value, energy theories of value and the economic mainstream’s dominant subjective theory of value, associated with neoclassical utility theory. This will not be an extensive discussion given space constraints. These theoretical debates are also quite relevant when addressing empirical analysis, as well as the significance of these categories and especially ecologically unequal exchange, which is the main topic of this paper. An important recent contribution regarding these theoretical debates over ecologically unequal exchange is that of Foster and Holleman (2014) who argue:

> “Unequal economic exchange is mainly concerned with a quantitative value problem related to exchange-value relations, while unequal ecological exchange is chiefly concerned with use-value relations and real wealth (including the contradictions between use value and exchange value).” Foster and Holleman (2014: 207)

Beyond the importance of Marx’s key distinction between use value and exchange value, emphasized by Foster and Holleman, other theoretical advances in discussions around EUE elaborate upon the biophysical dimension of such exchanges, drawing on concepts of carrying capacity and ecological footprints, as presented above. For example, when considering ecological footprints, it is the sum of natural resources, clean water, air, and soil, and energy, which a country uses to produce the resources consumed and to absorb wastes. All these need to be taken into account and they do not necessarily enter directly as commodities into the production process, though they may be necessary use values; part of the reproduction behind the production process (Global Footprint Network 2009).

The key distinction made between use value and exchange value, following the traditional marxist definitions, is crucial. Thus, the measurement of unequal (economic) exchange and other economic transfers, such as repatriation of profits, royalties and rents or bank loans and foreign debt and interest, from the periphery to the center or from the Global South to the Global North, will tend to simply be in monetary terms, and usually US dollars. However, when considering ecologically unequal exchange there is a need to consider multiple measures dealing with multiple forms of energy and matter, and their stocks and flows, and therefore the traditional measure of hectares for ecological footprints does not suffice, implying a single simple measure is inadequate for a rigorous analysis of this issue. One other point is that one should also include or make reference to the level of toxicity of the contamination produced, in the context of EUE, as the resources required to resolve this issue varies significantly depending on the toxic concentration. As Martinez-Alier (2002: 216–7) has often correctly argued, in the area of empirical research in ecological economics, there is the need for multiple criteria given the inadequacy of just monetary categories.

As mentioned above, Alf Hornborg, a cultural anthropologist, also working from a world systems school perspective, has written extensively on ecologically unequal exchange. His work has concentrated on more of the theoretical debates and less so on empirical measurements or analysis of EUE. In his 1998 article, Hornborg seeks to move toward an ecological theory of unequal exchange by articulating world system theory with ecological economics. He makes a strong critique of the original work on unequal exchange, arguing against the classical and marxist objective theories of value, and apparently supporting the neoclassical subjective theory of value. In fact, he argued that value was "subjective, cultural, and contextual" (Hornborg, 1998: 130). This is quite surprising, given the fact that he is working with a world-system's approach. Nevertheless, he strongly advocates the need to examine the unequal exchange of physical quantities, as well as incorporating thermodynamic analysis into the discussions of EUE. He is quite adamantly opposed to energy theories of value as well, and is very critical of the work of Odum on emergy and unequal exchange (see Hornborg, 1998: 130). Unfortunately, he confused Constanza's work on an energy theory of value with Odum, as pointed out by Foster and Holleman (2014: 224-225).

Hornborg has published multiple articles on EUE and delves into discussions around technology and debates with Marxism, in particular, regarding the use of the labor theory of value by marxists. The major confusion in his work is associating the term 'value' with our subjective use of the term 'value,' as in, "I value quality friendships' and he does not distinguish between that usage and 'economic value', as used by the classical economists and marxists. Evidently, he is definitely not alone, and thus it is almost a shame that the German word for value did not dominate the English usage, namely *Wert*, analogous to Worth, (a more objective connotation), clearly distinct from how humans value things, people, etc., which is quite subjective. This discussion seems to require an etymological perspective for clarification.

Given Hornborg's issues with Marx, marxists and Odum, it is not surprising that he presented a rejoinder or response (Hornborg, 2014b) to Foster and Holleman's piece on unequal ecological exchange and a Marx-Odum dialectic (Foster and Holleman, 2014). He strongly argues that there is a fundamental confusion of the biophysical and the economic, especially by F&H's favorable review (not without differences) of Odum and the concept of emergy. Hornborg also makes another strong push in support of the work by Georgescu-Roegen and the issue of thermodynamics, which is an important theme to address.

Overall, the theoretical work by Foster and Holleman has shown the most seriousness and care in addressing key issues related to value and ecologically unequal exchange so far. Much of the empirical evidence presented by authors such as Jorgenson, Rice and others, from world systems view, shed light on the matter of ecologically unequal exchange, though not yet reaching a sufficiently

worked out theoretical nor empirical analysis. The work by Odum and his system ecology approach, employing the concept of emergy has made a very important contribution, and he clearly recognized the importance of use values. As recognized by Foster and Holleman, "Although there is no single measure for unequal ecological exchange in all of its manifold historical and qualitative dimensions…Odum's emergy approach sought to create a common metric for energy used in production and to explore relations of unequal ecological exchange in this regard. Odum thus provided a mode of analysis and an empirical indicator with which to gauge the vast ecological gains realized by the center capitalist states, and the corresponding losses inflicted on the periphery" (Foster and Holleman, 2014: 200).

In spite of a number of advances in understanding ecologically unequal exchange examined in this paper, there is a strong need for greater theoretical clarity and more attempts at empirical analysis in order to reach eventual measurements of EUE, recognizing that this will be a composite of measurements, not a single numerical value, as so many economists are wedded to. The last section will present some final considerations reflecting upon the issues addressed in this paper.

4. FINAL CONSIDERATIONS

This paper began with a review of the concept of unequal exchange, or perhaps more appropriately, unequal economic exchange, and briefly considered the debates around the concept, which was a clear example of presenting the inequities associated with trade between the First World and the Third World, as referred to during the 1970s. A number of key authors, such as Emmanuel, Amin and Mandel were considered, though not in much depth, given the priority of the category which is the main topic of this paper, namely Ecologically Unequal Exchange.

A key difference between unequal exchange and ecologically unequal exchange is the former is regarding transfers of value or surplus value, namely economic exchange value or monetary categories while the latter refers to a range of physical quantities, namely matter and energy measures, associated with use values. The key point in common is how the Global North, over several centuries, has been pillaging the Global South in terms of wealth, be it monetary or in the form of natural resources. This arguably excessive consumption, be it by transnationals or consumers, resulted in the dumping an amazing amount of waste, causing environmental problems and leading to serious ecological degradation within the Global South. These latter aspects were completely absent from the discussion of economic unequal exchange.

In section 3 of this paper other categories were also presented, such as carrying capacity and ecological footprints and also ghost acres, which was a precursor to these biophysical measures. This was followed by the first recognized presentation of the category of EUE, namely by Stephen Bunker

in his analysis of the Brazilian Amazon and the particular phenomena associated with extractivism in the periphery. Moreover, the prospect and relevance of working towards a measurement of ecologically unequal exchange for the case of the Brazilian Amazon was briefly considered.

The paper continued by considering empirical research from the perspective of EUE, and often within the framework of world systems theory. Examples included multiple articles by Jorgenson, Rice and others. Another area addressed in this section is the field of system ecology, associated with the work of the Odums and the category of emergy. The latter concept was used by them to provide a common energetic metric for measuring real wealth, namely use values. Odum (2007) argued that it was 'imperial capitalism' which led to unequal ecological exchange and that his emergy analysis did not constitute an energy theory of economic value. Foster and Holleman (2014) considered this work as a major advance from a marxist perspective of understanding ecologically unequal exchange theoretically.

An assessment of Hornborg- a cultural anthropologist that has produced numerous articles and books related to EUE, working from a world-systems approach and yet in constant conflict with marxist value theory and the above-mentioned work of Odum using the concept of emergy. His contributions have been concentrated in the theoretical realm, and to the best of my knowledge has not carried out empirical analysis in the area of EUE, but should be recognized for being an important reference in this field.

In the sub-section on theoretical debates, a significant insight was made by Foster and Holleman regarding the analysis of unequal economic exchange as a quantitative value issue related to exchange values while ecologically unequal exchange is an analysis based on the qualitative value issue, namely use-values. In some ways connecting these two aspects up, when considering trade (and investment) in the same way that use-value and exchange value are two defining properties of all commodities, the latter being basic building blocks of any capitalist economy.

In spite of encouraging advances in research related to ecologically unequal exchange in recent years, a number of serious issues or problems still need to be addressed. Therefore, the ecologically unequal exchange framework must continue its efforts to move forward, both theoretically and empirically, in the coming future. It is necessary in order to improve the analysis of economic value, matter, and energy flows, and estimating international transfers, including both monetary and physical categories. Such analysis is crucial in addressing a range of problems of wealth and environmental imbalances in the current global economy and understanding how modern-day imperialism functions and what are its implications economically and ecologically.

Clark and Foster argue that "…the nature of ecological imperialism is continually to worsen ecological conditions globally. Capital in the late 20th and early 21st century is running up against

ecological barriers at a biospheric level; ones that cannot be so easily displaced, as was the case previously, through the spatial fix of geographical expansion and global labor and resource exploitation. Ecological imperialism – the growth of the center of the system at unsustainable rates, through the more thoroughgoing ecological degradation of the periphery – is now generating a planetary-scale set of ecological contradictions, imperiling the entire biosphere as we know it" (Clark and Foster, 2009: 331).

Increasingly, the empirical research examined in this paper was concerned with the environmental contradictions of capital accumulation and the ecological-distributional conflicts supporting the natural resource consumption of industrialized countries. Greater attention to these environmental contradictions contributes not only to the analysis of global environmental change but the continuing underdevelopment of peripheral countries. Further, cross-national disparities in terms of access to and utilization of natural resources, potentially shape the unsustainable social organization of human societies. The problem, in turn, is neither wealth nor poverty nor natural resources alone but their complex interrelationship at the global level.

BIBLIOGRAPHY

Amin, S. 1974. *Accumulation on a World Scale*, Vol. 1, New York: Monthly Review Press.

Borgström, G. 1965. *The Hungry Planet.* New York: Macmillan.

Bunker, S. J. 1985. *Underdeveloping the Amazon; Extraction, Unequal Exchange and the Failure of the Modern State*. Chicago: University of Chicago Press.

Clark, B. and J.B. Foster. 2009. "Ecological imperialism and the global metabolic rift: Unequal exchange and the guanos/nitrates trade." *International Journal of Comparative Sociology*, 50 (3–4), 311–334.

Cooney, Paul. 2004. *"*Towards an Empirical Measurement of International Transfers of Value*"* in Freeman, Kliman and Wells (eds.), *The New Value Controversy and the Foundations of Economics*, London: Edward Elgar, pp.241-260.

Emmanuel, A. 1972, *Unequal Exchange*, New York: Monthly Review Press.

Foster, J. B. and Holleman, H. 2014, "The theory of unequal ecological exchange: a Marx -Odum dialectic," *The Journal of Peasant Studies*, 41:2, 199-233.

Global Footprint Network, 2009. "Huella Ecológica y Biocapacidad en la Comunidad Andina", https://www.footprintnetwork.org/content/images/uploads/CAN_Teaser_ES_2009.pdf.

Hagen, J.B. 1992. *The entangled bank: the origins of ecosystem ecology*. New Brunswick, New Jersey: Rutgers University Press.

Hornborg, Alf, 1998, "Towards an ecological theory of unequal exchange: articulating world system theory and ecological economics," *Ecological Economics* 25 pp.127-136.

Hornborg, Alf, 2009, "Zero-Sum World Challenges in Conceptualizing Environmental Load Displacement and Ecologically Unequal Exchange in the World-System," *International Journal of Comparative Sociology*, Vol 50(3–4): 237–262.

Hornborg, A. 2014a. "Ecological economics, Marxism, and technological progress: Some explorations of the conceptual foundations of theories of ecologically unequal exchange", *Ecological Economics* Nr. 105, pp.11–18.

Hornborg, Alf, 2014b, "Why economics needs to be distinguished from physics, and why economists need to talk to physicists: a response to Foster and Holleman", *The Journal of Peasant Studies*, 1-6.

Jorgenson, Andrew. 2003. "Consumption and Environmental Degradation: A Cross National Analysis of the Ecological Footprint," *Social Problems*, 50: 374-39

Jorgenson, Andrew. 2005. "Unpacking International Power and the Ecological Footprints of Nations: A Quantitative Cross-National Study," *Sociological Perspectives*, 48: 383-4

Jorgenson, Andrew. 2006. “Unequal ecological exchange and environmental degradation: A Theoretical Proposition and Cross-National Study of Deforestation, 1990–2000.” *Rural Sociology*, 71, 685–712.

Jorgenson, Andrew K. 2009. “The Sociology of Unequal Exchange in Ecological Context: A Panel Study of Lower-Income Countries, 1975-2000,” *Sociological Forum*, Vol. 24, No. 1, pp. 22-46.

Jorgenson, Andrew, and Tom Burns. 2007. "The Political-Economic Causes of Change in the Ecological Footprints of Nations, 1991-2001: A Quantitative Investigation," *Social Science Research*, 36: 834-853.

Jorgenson, Andrew, and James Rice. 2005. "Structural Dynamics of International Trade and Material Consumption: A Cross-National Study of the Ecological Footprints of Less Developed Countries," *Journal of World-Systems Research* 1 1 : 57-77.

Mandel, E. 1975. *Late Capitalism*, London: Verso.

Marques, Gilberto de Souza.2019. *Amazônia: Riqueza, Degradação e Saque.* São Paulo: Expressão Popular.

Martínez-Alier, Joao, 2002, *The environmentalism of the poor.* Northampton, Massachusetts: Edward Elgar.

Odum, H.T. 1996. *Environmental accounting: Emergy and environmental decision-making.* New York: John Wiley and Sons.

Odum, H.T. 2007. *Environment, power, and society for the twenty-first century: The hierarchy of energy*. New York: Columbia University Press.

Peinado, G. 2019. “Economía Ecológica y comercio internacional: el intercambio ecológicamente desigual como visibilizador de los flujos ocultos del comercio internacional”. *Revista Economía*, 71(112).

Prebisch, Raúl. 1950, *The Economic Development of Latin America and Its Principal Problems* New York: United Nations, 1950.

Rees, William, 2017. “Ecological Footprints and Appropriated Carrying Capacity: What Urban Economics Leaves Out,” *Indian Institute for Human Settlements*, v. 2 (1), PP.1-12.

Rice, James. 2007. “Ecological Unequal Exchange: International Trade and Uneven Utilization of Environmental Space in the World System.” *Social Forces*, vol. 85, Nr. 3, 1369–1392.

Rice, James. 2009. “The Transnational Organization of Production and Uneven Environmental Degradation and Change in the World Economy,” *International Journal of Comparative Sociology*, Vol 50(3–4): 215–236.

Shaikh, Anwar. 1979. "Foreign Trade and the Law of Value." Part 1. Science and Society, 43.

Shaikh, Anwar. 1980. "Foreign Trade and the Law of Value." Part 2. Science and Society, 44.

Vallejo, M. C. 2009. *La estructura biofísica de la región andina y sus relaciones de intercambio ecológicamente desigual (1970-2005)*. Un estudio comparativo. Madrid: Fundación Carolina.

Wackernagel, Mathis and William Rees. 1996. *Our ecological footprint*. Gabriola Island, B.C.: New Society Publishers.

York, Richard, Eugene Rosa, and Thomas Dietz. 2003. "Footprints on the Earth: The Environmental Consequences of Modernity," *American Sociological Review* 68: 279-300.

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[ii] ISI or Import Substitution Industrialization was the strategy whereby countries of the periphery would aim to substitute imports of manufacturing goods through the combination of specialized protection combined with fomenting nascent industry, usually in light manufacturing, but after time, in heavy manufacturing as well. Examples include Brazil, Mexico, Argentina, Turkey, Iran, Egypt and South Korea, among others.

[iii] *Drogas do sertão* were the products exported from the Brazilian Amazon, starting in the colonial period, which included Brazilian nuts, guaraná, salsa, spices, among other products.

[iv] There have been a number of authors that have worked on ecologically unequal exchange in Latin America, for example, consider the works by Vallejo (2009) and Peinado (2019).

[v] Emergy is distinct from energy and exergy and is the total work of ecosystems embodied in commodities resulting from economic and ecosystem processes.