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Methodological and Ideological Options

The unequal exchange of Dutch cheese and Kenyan roses: Introducing and testing an LCA-based methodology for estimating ecologically unequal exchange

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ABSTRACT

The theory of ecologically unequal exchange (EUE) posits that international trade is structurally organized in a manner that allows a net transfer of resources from peripheral developing to core industrialized countries. The consequence, it is argued, is under-development in the periphery and augmented productive capacity in the core. EUE thus challenges the neoliberal free-market argument that exchange at market prices is symmetric and fair. An LCA-based methodology for estimating EUE that holds constant the variable market price is introduced and tested on contemporary trade of Dutch cheese and Kenyan coffee and roses. Specifically, the exchange of embodied land, water, energy, global warming potential, and labor is assessed. The results confirm the theory's hypothesis. At a fixed market price, more embodied Kenyan resources are exchanged for less Dutch resources. However, Kenyan roses give different results from coffee. EUE between countries can only be conclusively determined by considering the total biophysical trade balance, but by calculating quantities of embodied resources per unit of exchange value, it is possible to detect unequal exchange even at the level of individual commodities. While integration of biophysical metrics alongside monetary valuation is recommended, ultimately, rethinking the structure, policies and politics of international trade is necessary.

1. Introduction

International trade is structurally organized in such a way that some countries act as natural resource depots and sinks for the waste products of other countries. Materials and energy extracted from peripheral countries predominantly located in the Global South are being used to feed industrial processes and capital accumulation in core Northern countries. The consequence is environmental degradation, poverty, and general underdevelopment in the peripheral countries and improved productive capacity in the developed world (Rice, 2009). This exploitative international division of labor is the essence of the theory of ecologically unequal exchange (EUE). It is concerned with the unequal environmental and human well-being consequences of international trade and the relations of power that generate and maintain such inequality (Hornborg, 2009; Jorgenson et al., 2009). Rather than take present comparative advantages as a given, EUE theory questions the historical power relations that have shaped them and, in so doing, departs from neoclassical economic thought. By considering global terms of trade as favoring core countries to the detriment of the periphery (Jorgenson et al., 2009), the perspective takes a 'zero-sum' view of development (Hornborg, 2011) akin to David Harvey's (2003) 'accumulation by dispossession.'

Rooted in classical trade dependence, unequal exchange, and world-systems traditions (Jorgenson et al., 2009), EUE traces a direct genealogy to Karl Marx's 'metabolic rift' (Hornborg, 2009). The growing asymmetric exchange of nutrients and other material resources between town and countryside in 19th-century Europe amplified by long-distance trade deeply concerned Marx (Foster, 1999). Credited with coining the term unequal exchange, Arghiri Emmanuel (1972), through the labor theory of value, argued that developing countries always exchange a larger amount of their labor for less foreign labor. But it is Raul Prebisch who is credited with founding the theory of unequal exchange (Kohler and Tausch, 2002; Love, 1980). Refuting David Ricardo's theory of comparative advantage, Prebisch observed a hierarchy in the global economic system and deteriorating terms of trade for developing countries which he attributed to low income-elasticity of demand for primary products and asymmetries in the functioning of labor markets (UN., 1963). EUE has also benefited greatly from world-systems analysis (see Frank, 2008; Wallerstein, 1974). World-systems analysis sees an economic and geographical division of the capitalist world-economy into a strong core (metropolis) and weak periphery (satellite) in which surplus value flows from the periphery to the core, a process which limits the periphery's developmental potential. Through his research on the Amazon, Stephen Bunker inserted 'ecology' to earlier labor- and energy-based theories of unequal exchange and, in a sense, assembled the first formulation of a concept of ecologically unequal exchange (Hornborg,

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2009). He argued that (i) differences in the economies of peripheral and core countries create unequal exchange in terms of labor embodied in products *and* the appropriation of energy and matter from the periphery to the core, and (ii) the extraction and export of natural resources affect the subsequent developmental potential of the periphery (Bunker, 1985).

Ecologically unequal exchange rejects neoliberal economics' assumption that market prices are fair or tantamount to reciprocity. Free market transactions are by definition equal and fair since the actors voluntarily exchange currency or goods for what they assess to be of equal value (Clark and Tsai, 2009; Hornborg, 2009). This win–win positive-sum game is a liberal understanding of capitalism encapsulated in David Ricardo's theory of comparative advantage. But the free market functions as an ideology, a myth (Wallerstein, 2004). The equal exchange in monetary terms may very well be consistent with unequal exchange in physical terms. Monetary valuation excludes other possible measures of exchange through which it can be shown that free trade is indeed unequal (Hornborg, 2009). Georgescu-Roegen (1971) illuminated the inverse relationship in which raw materials are of low economic value while manufactures which have dissipated much of their productive potential have a high monetary value. That is why Hornborg (2011; 2009) argues for analytically separating human valuation and physical properties in order to reveal the inequality inherent in capitalist processes. Contrary to comparative advantage claims, free trade does not make all nations equally competitive but rather exposes the weak to the strong who, inevitably, devour the weak (Shaikh, 2007). Such 'free trade' policies are used to open up and integrate peripheral countries into relations of unequal exchange (Bieler and Morton, 2014).

The EUE theory is backed by a growing number of empirical studies using different approaches and methods (see Section 2). Most of these methods and studies take an economy-wide approach that tracks total flows rather than a product-specific perspective. Apart from showing the net flow of biophysical resources, most are also geared towards revealing the environmental or socio-economic impacts of such unequal exchange. What they fail to illustrate is the mechanism(s) through which EUE occurs. Reiterating that the core element of any EUE theory is the exchange of more ecological wealth for less, Foster and Holleman (2014) argue that existing EUE approaches rely on data whose quantitative measures are in monetary prices and which reveal little about the ecological nature of the exchange, i.e. in terms of embodied energy or other resources. As a result, "we learn little or nothing […] about the *processes involved* or the real extent of the unequal exchange" (ibid. pg. 210, emphasis added). This paper introduces a life cycle analysis (LCA)-based methodology for quantifying EUE that simultaneously investigates a key mechanism through which unequal exchange occurs — the free market ideology. The methodology is tested in the contemporary exchange of specific flagship export products from supposedly core (Netherlands) and peripheral (Kenya) countries. The modern nation state remains a crucial instrument by which industrial centers subordinate and attempt to control extractive peripheries, while systematic consideration of specific export commodities has many benefits (cf. Bunker, 1985; Hardt and Negri, 2000). Organizationally, the Introduction discusses the EUE theory, including its critique of free-market trade. Next is a review of some approaches to estimating EUE followed by the Methodology. Finally, the results are presented, discussed, and conclusions drawn.

2. Common Approaches to Estimating Ecologically Unequal Exchange

How societies organize their exchange of material and energy with the natural environment is termed social metabolism (Fischer-Kowalski and Haberl, 1997). Trade is an important socio-metabolic mechanism. While in conventional international monetary trade exports are 'good' and imports 'bad', the reverse is true for trade in physical terms: exports are a loss to the exporting country of the resources embodied in the exports and vice versa. Haberl et al. (2013) distinguish two approaches to analyzing social metabolism. Systemic approaches aims at a comprehensive account of all biophysical flows needed to build up, sustain and operate a defined socioeconomic system. The LCA approach, on the other hand, accounts for resource requirements, wastes and emissions resulting from a single product. As the following review reveals, most methods of quantifying EUE predominantly apply the systemic approach even if some (e.g. footprints and input–output analysis) incorporate elements of LCA.

Material flow analysis (MFA) is one approach to estimating EUE. Based on the mass balance principle from Lavoisier's law of conservation of mass, it accounts for biophysical flows in mass, usually metric tons (Bringezu and Moriguchi, 2002). Physical trade balance (PTB), an MFA-based indicator which measures an economy's physical trade surplus or deficit, can give insight into EUE. Mass is a robust measure in classical physics and PTB gives information on world resource supply and demand, inter-country group resource flows, and resource dependencies (Fischer-Kowalski et al., 2011). Using MFA, Pérez-Rincón (2006) has shown that between 1970 and 2002, 85% of Colombia's export was directed at satisfying the material and energy requirements of Northern countries, in particular the EU and USA. Several other studies (e.g. Behrens et al., 2007; Bruckner et al., 2012; Dittrich and Bringezu, 2010; Schaffartzik et al., 2014) apply MFA to arrive at similar proof of EUE. One drawback of MFA is that weighting of trade does not tell us the ecological impacts of the goods.

Another method, the human appropriation of net primary production (HANPP), estimates the sum of changes in net primary production (NPP) or biomass resulting from land-use change and human harvest from ecosystems, including losses thereof (Haberl, 1997; Haberl et al., 2012). Measured in units of carbon, HANPP is calculated by estimating a country's potential NPP (without human land use) using vegetation models, then calculating the actual NPP (often less than potential NPP), and finally determining the actual part of the NPP utilized by human beings. Embodied HANPP (eHANPP) involves adding the HANPP related to imports and subtracting that related to exports, hence can be used to estimate EUE. Krausmann et al.'s (2013) analysis of HANPP trends shows that Asia, Africa, and Latin America's high HANPP growth rates are due to their importation and consumption by industrialized countries.

Footprints take a consumer responsibility approach to provide a simple but graphic measure of the environmental impact of human activity (Hammond, 2006; Steen-Olsen et al., 2012). The 'footprint family' (Galli et al., 2012) refer to the ecological, carbon and water footprints. The ecological footprint (EF), measured in global hectares (gha), calculates human demand on the biosphere compared to the planet's 'supply' (Wackernagel and Kitzes, 2008). A popularization of Borgstrom's 'ghost acreages', it builds on the concepts of LCA, bio-productivity accounting, and embodied energy analysis (Moran et al., 2009). The water footprint (WF) or 'virtual water' is the total volume of freshwater used to produce a good or consumed by a community (Hoekstra, 2009a; Hoekstra et al., 2009; Mekonnen and Hoekstra, 2011). Expressed in volume per unit of product (m^3/t), the WF is a combination of the blue, green and gray water footprints. The carbon footprint is the total amount of carbon (or CO_2 equivalent) emissions caused by or accumulated over the life of a product or activity, or the sum of a country's emissions related to its consumption, including imports but excluding exports (Galli et al., 2012). It is expressed in kilograms or tons of CO_2 with no conversion to area. Primarily a measure of the appropriation of global sink capacity, the carbon footprint can also gauge EUE. For example, Steinberger et al. (2012) have shown that socio-economic benefits are accruing to carbon-importing rather than carbon-exporting countries. Steen-Olsen et al. (2012) have shown that the EU-27 displaces all the three footprints to the rest of the world through trade.

Input–output (I–O) analysis describes an economic sector's output and its relationship to the corresponding levels of activities in other sectors. Initially applied to economic impact analyses through monetary I–O tables (MIOTs), they have been extended to pollution and other