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Preceding and Governing Measurements: An Emmanuelian Conceptualization of Ecological Unequal Exchange

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With the combination of world-system analysis and ecological economics, the concept of unequal exchange has been interpreted in biophysical terms. Typically depicted as non-compensated net transfers of biophysical resources, several scholars have engaged with ecological unequal exchange by linking uneven consumption of natural resources with the stratification of the contemporary world-system. Proposing an alternative conceptualization of ecological unequal exchange, this chapter addresses two drawbacks with existing approaches. First, rather than depicting ecological unequal exchange in the net transfer sense, this chapter proposes a conceptualization that builds on the original Emmanuelian idea of factor cost differentials. Secondly, instead of using national resource consumption indicators as proxies for ecological unequal exchange, the herein suggested approach looks at actually occurring trade flows. Exemplifying the approach, world trade in fuel commodities for the 1990–2010 period is analyzed.

Introduction

In a world where the biophysical walls are literally closing in on us, the recent combination of world-system analysis and ecological economics provides a novel way to address one of the most pressing contradictions of global capitalism: the uneven distribution of natural resources and environmental burdens. As two scholarly strands sharing several conceptual overlaps, the biophysical lens of ecological economics can shed new light on existing ideas, themes and questions within the world-system school, as well as formulating new ones.

This disciplinary combination is characterized by its ecological interpretations of unequal exchange. Typically depicted as monetarily non-compensated net transfers of biophysical resources, a cadre of scholars has spent the last two decades specifying, theorizing, and operationalizing the concept of ecological unequal exchange. Seemingly, these attempts make analytical sense: in contradiction to the presumed equalization effect of mainstream theories of international trade, the global distribution of resources and environmental risk seems to constantly favor the few haves over the many have-nots.

Offering new insight into the biophysical dimension of the modern world-system, there are nevertheless shortcomings with existing conceptualizations of ecological unequal exchange. First, although explicitly concerned with exchange, few studies look at actual exchange that occurs on the world market. Rather, contemporary operationalizations seem more focused on national indicators of resource usage and environmental burdens, thus assuming that these reflect international exchanges that, additionally, are assumed to be of an ecologically unequal kind. Secondly, contrary to how unequal exchange was originally described, the ecological variety typically signifies the actual phenomenon of net resource transfers per se, rather than representing a hypothesis of the mechanism causing this phenomenon. As such, existing analyses are somewhat detached from relevant theoretical foundations found in the heterodox development tradition. Related to this, thirdly: despite claims of building on the original formulation, *l'échange inégal biophysique* has very scant—if any—ties to how Arghiri Emmanuel specified unequal exchange in terms of factor-cost differentials.

Building on insights from global commodity chain studies, this chapter proposes an alternative Emmanuelian conceptualization of ecological unequal exchange. Similar to the original formulation, it is a theory about factor-cost differentials, but instead of looking at labor and how wages differ between nations, the proposed theory looks at the third, oft-forgotten Ricardian production factor of "land"/resources. Building on Jorgenson's structural theory, the hypothesis is that such factor-cost differentials are related to positionality in the world-system, but rather than operationalizing such structural properties using Jorgenson's index, which I argue to be unreliable in this context, network methods for role analysis and blockmodeling are used to determine structural positionality.

Analyzing trade flow data between 1990–2010 for three commodities—coal, crude oil, and liquefied natural gas—selected to represent the "land" production factor, combined with a more comprehensive role analysis of the world economy of 1999–2001, this chapter exemplifies how this novel conceptualization of ecological unequal exchange can be operationalized and measured. A general evaluation of ecological unequal exchange as factor-cost differentials concludes this chapter.

Ecological economics: taking world-system analysis beyond the social sciences

Extending the postwar neo-Marxist and dependency traditions into the *longue durée* of the French Annales school of history, the world-system perspective offers a unique way to describe, analyze, and theorize about social change and global dynamics, past and present. Surpassing the ontogenetic assumptions of the "whole nation biases" as found in related disciplines (e.g., Snyder and Kick, 1979, 1097; Wellhofer, 1988, 282ff.), world-system analysis deems the only feasible unit of analysis in the modern world to be the world-system itself, where individuals, cities, nations and regions in various ways are tied together into a codependent and coevolutionary whole.

Despite a label that reflects its research area, it has been argued that world-system analysis is not primarily concerned with analyzing such singular historical world-systems:

> World-systems analysis is not a theory about the social world, or about part of it. It is a protest against the ways in which social scientific inquiry was structured for all of us at its inception in the middle of the nineteenth century. (Wallerstein, 1987, 309)

And indeed, the existing, and ongoing, partitioning of our knowledge about ourselves into distinct disciplines—anthropology, economics, political science, history, etc.—does obstruct our ability to ask questions about the social world that overlap these artificial domains, and it is this refusal to view the social, the economic, and the political as separate spheres of human existence that allows for social inquiry that surpasses the ontogenetic assumptions of each discipline.

But what about inquiries that, by their very nature, need to stretch into the natural sciences?

The world-system perspective has increasingly been combined with the strand of thinking known as ecological economics (e.g., Martinez-Alier, 1987; Costanza et al., 1997). Whereas mainstream economics begins with social entities—individuals, households, firms, institutions, etc.—and an assumed type of rationality among such agents, ecological economics typically starts off with the biophysical system which the economic system is seen as embedded in. Rather than describing economic processes and flows in terms of socially determined value schemes, ecological economics describes economic systems using the terminology of the underlying "base system"—such as flows of energy and materials, emission of hazardous chemicals, appropriated bioproductive hectares, and the like. This difference also separates ecological economics from environmental economics: whereas environmental economics "deal with the application of concepts of economics to the study of nature", such as reflected in its assignment of monetary values to biophysical resources and services, ecological economics represents "the ecological approach to the study of human society and economy" (Martinez-Alier, 1987, x).

World-system analysis and ecological economics have conceptual overlaps that make their combination particularly seamless. First, both schools are interested in the totality of systems, viewing such as something more than the sum of their parts. Instead of looking at individual sub-entities in Hobbesian isolation, both schools place greater emphasis on the structures that tie these parts into a grander whole. Through this, secondly, both schools recognize the finiteness of planetary systems, implying a greater emphasis on the distribution of resources and risks within single systems rather than modeling component parts as something detached from the evolution of others.

The usefulness of this scholarly combination is its provisioning of a biophysical dimension to the study of one of the most pressing and conflict-laden contradictions of global capitalism, i.e., the unequal sharing of planetary bounties and environmental burdens. Bridging the social and the material, this "new historical materialism" (Bunker and Ciccantell, 1999, 107) provides world-system analysis with the tools needed to situate studies of the contemporary world-economy into the grander biophysical system of which it has undeniably found itself to be a part.

Contemporary interpretations of ecological unequal exchange

The hallmark of this scholarly combination is the ecological approach to unequal exchange. Although interpreted in various ways—e.g., externalization of carbon dioxide emissions (Muradian et al., 2002; Roberts and Parks, 2007), distribution of organic water pollution (Shandra et al., 2009), transfers and appropriation of genetic resources (Fowler et al., 2001) etc.—ecological unequal exchange is typically used to signify monetarily non-compensated net transfers of biophysical resources (Bunker, 1984; 1985; Hornborg, 1998; 2001; 2003; 2006; 2009; Röpke, 2001; Martinez-Alier, 2004; Jorgenson, 2006; 2009; 2011; 2012; Rice, 2007a; 2007b; 2008; Jorgenson and Clark, 2009; Jorgenson et al., 2009; Hermele, 2012). This "net transfer" interpretation of ecological unequal exchange stipulates that even though the equality of a market exchange is defined by the mere occurrence of the exchange itself, the trading of goods of equal exchange value could very well imply an unequal exchange with regards to their biophysical properties, the resources that went into their production, or the environmental impact of their production and distribution. This is the underlying idea behind the works of Bunker, Hornborg, and Jorgenson, but variations in their respective analytical approaches and operationalizations motivate a closer look at these three scholars.

The idea of under-compensated net resource transfers is not a novel idea,[1] but the origin of the modern-day interpretation of ecological unequal exchange is typically attributed to Stephen Bunker (1984; 1985; see Martinez-Alier, 1987, 238; Rice, 2007a, 1371; Hornborg, 2009, 249). Proposing a functional distinction between extractive and productive economies, Bunker (1984, 1018, 1054) argued that "the unbalanced flows of energy and matter from extractive peripheries to the productive core provide better measures of unequal exchange in a world economic system than do flows of commodities measured in labor or prices," as "[t]he fundamental

1 In his impressive thesis on the history of unequal exchange, John Brolin (2006) finds a precursor to ecological unequal exchange in the mercantilist mind of Richard Cantillon, who combined labor values and income levels with trade in appropriated hectares: "When a State exchanges a small product of Land for a larger in Foreign Trade, it seems to have the advantage; and if current money is more abundant there than abroad it will always exchange a smaller product of land for a greater. When a State exchanges its Labour for the produce of foreign land it seems to have the advantage, since its inhabitants are fed at the Foreigner's expense." (Cantillon, 1931 [1755], 255; from Brolin, 2006, 28).

values in lumber, in minerals, oil, fish, and so forth, are predominantly in the good itself rather than in the labor incorporated in it." Without ruling out other possible manifestations of unequal exchange, Bunker (1985, 122) argued that a continued excessive concern with labor values, wages and profits sterilizes the development discourse by restricting it within its purely social domains.

Hornborg (e.g., 1992; 1998; 2001; 2003; 2006; 2009) has spent the last two decades refining his ideas on ecological unequal exchange. Although the biophysical metrics used by Hornborg have evolved during this time—from exergy/negentropy (Hornborg, 1992; 1998; 2001), to ecological footprints, space, and time (Hornborg, 2003; 2006; 2009)—a number of themes permeate all his studies. First, critical of how technology, economy and ecology are treated as separate fields of inquiry, Hornborg argues that an integrated perspective is necessary to understand the world-system and its societal distribution of planetary bounties and risks. A second recurrent theme is his critique towards "machine fetishism" where industrial technology, in liaison with neoclassical ideology, facilitates the unequal exchange of productive potential, labor time, and bioproductive space. Inspired by Georgescu-Roegen (1971) and Gudeman (1986), Hornborg takes a very thermodynamic perspective on international exchange, placing more emphasis on thermodynamically defined properties and less[2] on the social valuations that underpin such exchanges. Keeping the two realities analytically separated, Hornborg (2006) focuses on the intersection between socioeconomic valuations and objective material properties: as demonstrated in his study on nineteenth century English exports of manufactured textiles and imports of wool and cotton, it is the exchange ratio of such vertically traded commodities that, he argues, will reveal ecological unequal exchange.

From the macrosociological tradition, Andrew Jorgenson's writings on ecological unequal exchange are rich in empirical data and statistical methods. Contrasting how Hornborg envisions the combination of world-system analysis and ecological economics, Jorgenson treats the latter more as a supplement for understanding the effects of world-system dynamics. Seeing the biophysical dimension, such as ecological footprint indicators, as a missing piece of the puzzle (Jorgenson, 2003, 376), the puzzle in which this piece fits is nevertheless the macrosociological world-system perspective. In his articles, he argues that environmental outcomes, as reflected in national biophysical indicators on consumption, resource usage, and environmental burdens, are a function of world-system structural positionality. Modeling the latter as the independent variable and national environmental indicators as

2 "We can completely disregard the subjective 'utility' of the products, which is more or less arbitrary and ephemeral anyway—arbitrary because it is culturally defined (cf. Sahlins 1976), and ephemeral because it diminishes rapidly with use—and observe that if a finished product is priced higher than the resources required to produce it, this means that 'production' (i.e., the dissipation of resources) will continuously be rewarded with even more resources to dissipate" (Hornborg, 2001, 45).

dependent variables, as such underlining the above-mentioned conceptual difference with Hornborg, Jorgenson proposes, and thoroughly tests, a structural theory of ecological unequal exchange. Nevertheless, Jorgenson indeed depicts ecological unequal exchange as a net transfer of biophysical resources taking place through the assumed "vertical trade" between low- and high-income countries, where the former exchange their primary products for manufactures, but the implicit assumption in Jorgenson's work is thus that such unequal exchange is accurately reflected in the biophysical national indices selected for analysis.

The different environmental indices used by Jorgenson range from per-capita ecological footprints (Jorgenson, 2003, 2009; Jorgenson and Clark, 2009), deforestation (Jorgenson, 2006), both of these two (Jorgenson et al., 2009), and carbon emissions (Jorgenson, 2011). He also conceptualizes structural positionality in various ways—from the composite Kentor-index of world-system positionality (Jorgenson, 2003; see Kentor, 2000) and percentages of exports sent to higher income countries (Jorgenson, 2011) to his own weighted export index:

$$D_i = \sum_{j=1}^{N} p_{ij} a_j$$

where D_i is the weighted export index for country *i*, p_{ij} is the proportion of exports from country *i* sent to country *j*, and a_j is the per-capita GDP of receiving country *j*. The p_{ij} variables, summing up to unity for all values of *j* for each country *i*, is based on total export flows in two articles (Jorgenson, 2006; Jorgenson and Clark, 2009), whereas only primary goods exports are used in the latter (Jorgenson et al., 2009) article.

Shortcomings with existing conceptualizations of ecological unequal exchange

Strictly economically, unequal economic exchange is an oxymoron: even though markets may be imperfect and rational actors might find themselves rollercoasting the demand curves, the actual exchange that occurs on a market defines the exchange value equality of the goods, services, money, and credit changing hands. A barrel of oil contains a given amount of oil, but it is the spatiotemporal variations in supply, demand, and purchasing power that determine how much wheat this barrel of oil can be traded for. Even though a hectare of arable land is always a hectare of, hopefully, arable land, market exchange makes it possible, and likely very rational, to let the market transform one hectare of cash crop into two hectares of foodstuff—until saturated demand, changing preferences, and economies of scale (elsewhere) effectively could reduce that hectare to a fraction of its former capacity for sustenance. Intersecting the social and the material, ecological unequal exchange is uniquely situated to address such questions.

Whereas "ecological unequal exchange" denotes the net flow phenomenon per se, both Hornborg and Jorgenson provide theories on its underlying mechanisms. According to Hornborg, it is prices per se, and mediums of exchange, that acts as ideological agents, making market exchanges to appear as reciprocal (e.g., Hornborg, 2009, 240, 242ff.). Accordingly, ecological unequal exchange is the result of how the neoclassical school of economics upholds a cultural (mis)understanding of value, making people believe that they need, and thus value, a car, a CPU and a refridgerator more than the raw materials and energy that went into their production.

As a contrast, Jorgenson's structural theory (e.g., Jorgenson, 2006) is more open for formal hypothesis testing. In addition, Jorgenson's concern with the structural properties of the international network of trade as reflected in his weighted export index is more in line with core issues of world-system and dependency studies, such as monopoly capitalism, asymmetric trade structures, and dendritic trade structures (e.g., Frank, 1966; Galtung, 1971). Although an interesting hypothesis, there are, I argue, a couple of shortcomings in its operationalization and, more generally, in how ecological unequal exchange has been conceptualized so far.

First, although the concept explicitly refers to exchange, the studies by Jorgenson look at national environmental indicators that are assumed to reflect international trade flows that, it is further assumed, are of an ecological unequal kind. National indicators of consumption are also assumed *only* to reflect such net resource transfers among nations, excluding would-be endowments and domestic sink capacity. As Jorgenson look at the contemporary world-economy, for which detailed commodity trade data exists, less assumptions would be necessary in the study of ecological unequal exchange that looks at actually occurring exchange. In Hornborg's (2006) study of the textile trade of England in the 1850s, Hornborg partly uses historical trade flow records when estimating the trade ratio between raw materials and manufactures. Aware of possible errors in such data, it is surprising that Hornborg has not yet attempted to verify his thesis using contemporary, readily available, trade flow data.

Second, Jorgenson's operationalization of world-system structural positionality is, I argue, somewhat flawed. Intended to capture a country's trade dependence,[3] this index can be criticized on two accounts. First, although the proportions of ex-

3 Possible alternatives to the weighted export index (and the measure used in Jorgenson 2011) that captures a similar notion of structural positionality are the share-of-trade index employed by Gidengil (1978, 56) and the relative acceptance index (Savage and Deutsch, 1960; see also Domínguez, 1971). Designed to capture partner concentration within core-periphery/hub-and-spoke structures, these indices are not only more established (and thus tested) than the weighted export index but they are also applicable identifying *both* core and periphery alike, i.e., not only a predetermined set of low-income countries.

ports to other countries (i.e., the p_{ij} variables) are calculated using relational data, their marginal-normalization *de facto* discards differences in significance of exports between countries.[4] Second, the multiplication of proportions with per-capita GDP of the receiving country (i.e., a_j) has a profound impact on results. Hypothetically, if all export vectors were perfectly balanced (i.e., where the shares of exports from each country are perfectly distributed across potential receivers), the rank order of the weighted export index and GDP per capita would be identical. As high-income countries mostly trade with each other, their weighted export indices would thus be very high.

Third, the existing conceptualizations of ecological unequal exchange have scant, if any, ties to how Arghiri Emmanuel defined unequal exchange as based on factor-cost differentials. Emmanuel (1969; 1972) built his theory of unequal exchange on assumptions of free international trade and perfect competition, void of market irregularities, where the difference between labor and capital was the (partial) mobility of the latter. His model contained no monopoly capitalism or asymmetrical trade in the dependency tradition (e.g., Frank, 1966), nor was it technological rent, capital-intensity differentials,[5] product-specific properties, or Singerish demand elasticities that caused unequal exchange. Rather, a wage differential between developed and developing countries was the exogenous independent variable that led to unequal exchange (Emmanuel, 1975a, 39; Brolin, 2006, 179, 215; see also Emmanuel, 1972, 126ff.). Thus, although Hornborg, Jorgenson, and Rice dutifully refer to Emmanuel, placed alongside dependency and world-system scholars, claiming that their respective conceptualization builds on Emmanuel (e.g., Jorgenson et al., 2009, 264), they are not concerned with production factors and their cost differentials that characterized unequal exchange according to its founder. Even though Hornborg's (2006) study on the English textile trade is only a paragraph away from Emmanuel's factor-cost-oriented specification of unequal exchange, no such connection is made; instead, Hornborg proposes a continued mapping of "total" ecological unequal exchange, encompassing *all* traded commodities.

As global resources are channeled through the global market, the differences in the magnitude of one's consumption and, particularly, the geographic range from which resources are obtained are by themselves, I argue, adequate indicators for the

4 For instance, a country whose relatively insignificant exports go to a singular high-income country would get a higher scoring than another country whose relatively significant exports go to another high-income country with a slightly lower GDP.

5 Emmanuel (1962) began his theoretical exposition by describing the exchange of products with unequal amounts of socially necessary labor time and based on different capital intensities, this being referred to by his tutor Bettelheim as unequal exchange in the broad sense. However, although many authors have referred to Emmanuel's *two* types of unequal exchange (e.g., Chase-Dunn, 1989, 231), the capital-intensity variety was not unequal exchange according to Emmanuel (1975b, 80), but only a demonstrational device to distinguish and compare with the wage-differential situation of unequal exchange proper (Brolin, 2006, 180).

existence of under-compensated net resource transfers. Describing such flows in minuscule quantitative detail could be worthwhile, but it does not necessarily help us understand their historical roots and underlying mechanisms. Additionally, as the social valuations that determine an economic exchange are disconnected from the biophysical properties of the goods and services changing hands—e.g., the decision to buy the *Plants vs. Zombies* smartphone game is based on perceived fun and purchasing power rather than its inherent productive potential (which I have found to be negative) or the resources that went into its production—we can safely assume that practically *all* exchanges are ecologically unequal as any linear relationship between social valuations and material properties would be nothing but coincidental.

Even though Jorgenson's structural theory is tied to world-system ideas on inter-national structures, contemporary conceptualizations of ecological unequal exchange do not utilize existing theory, insights, and lines of thought to their fullest extent. Rather, the world-system tradition and the heterodox strands of social and economic development thinking are more of a compatible backdrop to the ecological-econometrics on fairly obvious net transfers of biophysical resources, rather than providing the historical ideas and conceptions that should precede and govern such measurements. In what follows, an alternative conceptualization of ecological unequal exchange will be proposed that, I argue, is more in line with the original idea of unequal exchange as specified by Arghiri Emmanuel. Refining Jorgenson's structural theory through network-analytical methods, furthermore looking at actually occurring exchange rather than assumed proxies of such exchanges, the proposed conceptualization is nevertheless first and foremost a theory in the Emmanuelian mold, i.e., a theory about factor-cost differentials.

Towards an Emmanuelian interpretation of ecological unequal exchange: learning from global commodity chains

Proposed by Hopkins and Wallerstein (1982; Wallerstein and Hopkins, 2000 [1986]), the global commodity chain (GCC) approach was conjured up to address a particular historical question: whether a world-economy, characterized by fragmented production and an international division of labor, existed between the sixteenth and eighteenth century. The study of internationally segmented chains of commodity production and the local and global causes and effects of such—the origins, costs, and provisioning of inputs, organic compositions, regulations and institutions, social and environmental impacts, the local share (and distribution among factors) of total value-added etc.—has crystallized into a distinct speciality (e.g., Gereffi, 1994; Applebaum et al., 1994; Heintz, 2006; see particularly Bair, 2005, 2009). Whether the Age of Reason had its GCCs or not, their contemporary counterparts are definitely more than hypothetical constructs—the Ford Escort I had in Sweden was apparently produced in 15 different countries, spanning three continents (Gereffi and Korzeniewicz, 1994, 1)—and the constant reconfigurations of chain segments reflect a rational search for cost minimization and profit maximization. The study of such chains poses a new, upgraded approach for understanding distributional aspects of the world-economy (see also Heintz, 2003, 2006):

> If one thinks of the entire chain as having a total amount of surplus value that has been appropriated, what is the division of this surplus value among the boxes of the chain? This is the kind of issue that lay behind the debate on unequal exchange. (Hopkins et al., 1994, 49)

This chapter draws on two somewhat more rudimentary insights from the GCC school. The first insight is that the traditional perception of an industrial core and a non-industrial periphery is too simplistic:

> What the commodity chain construct makes evident is that the Colin Clark trinity of primary, secondary, and tertiary sectors is descriptive and not terrible helpful. Each box in the chain transforms something and is therefore "industrial." . . . In any case, there is no long-term fixed priority for the "secondary" sector as a motor of capitalist development. (Hopkins et al., 1994, 50)

This contemporary logic of dislocation makes it somewhat straggling to ground debates on unequal exchange on assumptions of vertical trade. If machines and industrial technology constitute the engines for core dominance and if the exports of manufactures characterize the beneficiary of ecological unequal exchange, can the relative (secondary sector) deindustrialization of the core fit into such a theory? Global commodity chains do not end ecological unequal exchange as we know it, but they do change the inbound parameters and assumptions—little has changed since 2006 and much has changed since the 1850s (cf. Hornborg, 2006).

Secondly, global commodity chains tell us something about international factor mobility that differs from neoclassical assumptions of immobility (e.g., Ohlin, 1933; Samuelson, 1948). Similar to most assumptions of mainstream trade theory, the factor immobility postulate was inherited from the classics:

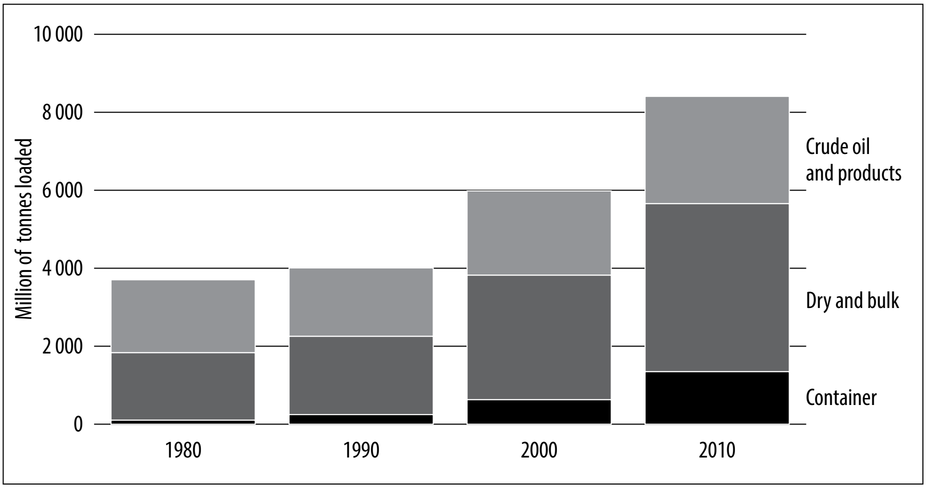
> Experience . . . shows that the fancied or real insecurity of capital, which not under the immediate control of its owner, together with the natural disinclination which every man has to quit the country of his birth and connections, and intrust himself, with all his habits fixed, to a strange government and new laws, check the emigration of capital. (Ricardo, 1996 [1817], 95)

Ricardo's family history tells another story about factor mobility. Abraham and Abigail Ricardo, a Dutch banking family originally from Portugal, were apparently okay with a strange government and new laws when, prior to David's birth, moving from Amsterdam to London. Salvaging Ricardo's theory on comparative cost advantages, John Stuart Mill (1849 [1848], 113) redefined international trade as trade between regions separated by factor immobility (Condliffe, 1950, 187), a definition that implies that international trade today is pretty much nonexistent.

Although a prerequisite for global commodity chains, the mobility of a production factor depends on its type. Indeed, foreign guest workers constitute 94 percent of Qatar's economically active population and the Swedish company Norrskensbär employs seasonal Thai workers to pick lingonberries, but the mobility of labor is not at par with the seemingly frictionless global movement of capital. Reflecting most strands of development thinking, the focus remains on these two production factors—capital and labor—and specifically on how the mobility of the former combines with the overall immobile latter in different organic compositions of production at various locations, resulting in chains that, for instance, stretch over three continents and 15 countries.

Through ecological economics, the world-system perspective can access the full triad of production factors: labor, capital, and land. Representing physical raw materials, this third Ricardian production factor is typically ignored in the Marxist discourse on wages and profits, as well as neoclassical Cobb-Douglas production functions. The "production" of natural resources roughly follows their geographical endowment patterns, but once commodified, they are injected into the same global commodity trade networks as any other commodity, eventually combined with labor and capital around the world. As demonstrated by its significant share of total global trade (see Figure 1), the (Alfred) Weberian logic of industrial location between resources and markets hardly seems like a determining factor in chain

Figure 1: Trend in composition of global material flows, 1980–2010



Source: UNCTAD (2011, 10).

configurations; rather, similar to capital, and possibly to an even greater degree, the third production factor made tangible through the biophysical lens of ecological economics traverses the network of international trade, feeding segments and chains with the material basis of production.

Ecological unequal exchange as factor-cost differentials

Following Emmanuel, the conceptualization of ecological unequal exchange proposed in this chapter is concerned with factor-cost differentials. Whereas Emmanuel examined national price differentials for labor, i.e., wages, this chapter looks at national price differentials for the land production factor. Emmanuelian ecological unequal exchange is thus not concerned with measuring total net resource flows between countries; instead, focusing explicitly on commodities representing this particular production factor, it is perceived as would-be differences in import costs (and export revenues) per unit of biophysical resource.

Similar to Emmanuel's theory of unequal exchange, the hypothesis here is that factor-cost differentials are related to the properties of social systems. However, whereas Emmanuel theorized that wage differentials between countries reflected national differences in the organization of labor, the hypothesis here is that cost differentials for "land" are related to structural positionality in the contemporary world-economy. Following Jorgenson, and the world-system and dependency traditions at large, the hypothesis is that advantageously positionalized actors in global exchange networks typically are at the "better end" of ecological unequal exchange, whereas those disadvantageously positionalized are relatively worse off in terms of relative factor costs.

In what follows, the proposed Emmanuelian conceptualization of ecological unequal exchange, including its structural theory, is exemplified using fossil fuel trade data for the period 1990–2010. The data and methods chosen for this analysis, and the structural theory per se, do not rule out other possible ways to measure would-be price differentials of the third Ricardian production factor across the world and to theorize about such occurrences.

Testing the factor-cost version of ecological unequal exchange

To test the structural theory of Emmanuelian ecological unequal exchange, i.e., whether cost and revenues of the third production factor are related to structural positionality in the world-economy, two data series are needed: an index that adequately captures the notion of structural positionality in world-systems, and national data on import costs (and export revenues) per traded unit of natural resource.

Production factors of the third kind: fuel commodities

Selected as adequate representations of the "land" production factor with a huge importance in global trade, the commodities chosen (and their respective SITC categories[6]) are (non-agglomerated) coal (SITC 3212), crude oil (SITC 3330), and liquefied natural gas (SITC 3431). Data on bilateral commodity flows between 96 countries, measured in exchange value (US$) as well as physical mass (metric tonnes), were prepared[7] for three time periods: 1990–1992, 1999–2001, and 2008–2010. Whereas original mass quantities were used in the commodity-specific analyses below, these were converted into total energy flows in the aggregate analyses.

Structural positionality: network analysis and regular blockmodeling

The use of blockmodeling and role analysis in world-system analysis have a relatively long and, seemingly successful, track record (e.g., Snyder and Kick, 1979; Nemeth and Smith, 1985; Smith and White, 1992; Mahutga, 2006), and a sequence of studies traces the growing confidence in the "natural wedding" (Snyder and Kick, 1979, 1123; see also Breiger, 1981, 354; Nemeth and Smith, 1985, 521; Smith and White, 1992, 858). Contrary to categorizations into core, semiperiphery and periphery based on country attributes (e.g., Kentor, 2000), measures that "do not represent such positions any more than an individual's income or education measures his or her (discrete) class position" (Snyder and Kick, 1979, 1102), network-analytical studies engage with the structural tenets of the world-system school in a "referential context," where "the focus of the analysis is no longer on characteristics of individual countries, but on the relationships between countries" (Nemeth and Smith, 1985, 522).

Similar to these studies, this chapter uses regular blockmodeling to determine world-system structural positionality. As a general network-analytical procedure, blockmodeling groups social entities (actors) into role-equivalent sets based on

6 Explicitly recommended for comparative analyses by United Nations Statistics Division, the Standard International Trade Classification (SITC) nomenclature (3rd revision) was chosen for this study.

7 Extracting data from the Comtrade database (UNCTAD, n.d.) for a total of nine years, three-year averages were calculated for each period. Bilateral data with missing quantity units were excluded from the dataset. Whereas excluded flows were insignificant for coal (<0.05 percent), 17.5 percent of the value of crude oil flows in 1992 had missing quantity units, thus only 1990 and 1991 were used to calculate mean annual trade in crude oil for the 1990–1992 period. Whereas the original data covered 118 countries, those with total imports below one million U.S. dollars were excluded from the analysis, resulting in a set of 96 countries.

similarities in their interaction patterns.[8] Even though it is plausible that the structure of the world-economy changed, possibly considerably, between 1990 and 2010, this chapter establishes structural positionality for the 1999–2001 period only.

The multilayer data for the role analysis consists of trade flow values for six broad commodity categories,[9] measured in exchange value, among the 96 countries in the fuel commodity data (see above), with the assumption that such commodity flow patterns reflect the structure of the contemporary world-economy. Using five iterations of the REGE algorithm[10] (White and Reitz, 1983, 1985) in a simultaneous analysis of these six flow matrices, a subsequent single-link hierarchical clustering determined the various sets of role-equivalent sets at different cutpoints. Anova density tests[11] guided the number of partitions to choose: the highest absolute R^2 value occurred at eight partitions, where the largest relative increases occurred when going from two to three, and from four to five partitions. As we are only looking at one aspect of the world-economy, we are not theoretically bound to the assumed trimodality of the world-system; to increase resolution, a partition with eight positions[12] was chosen. These positions and their aggregate net value and energy flows for the selected commodities are given in Table 1.

The United States separates itself from the countries in position D forming a singleton position at the 7-positional partition. Whereas most high-income European countries are found in position D, this position also contains the Southeast Asian countries (including Japan) as well as Mexico and Canada, both deeply connected to the United States. The Scandinavian countries are found in position C, which they share with the Central and East European countries, India, South Africa, and a few

8 Role analysis and blockmodeling is a well-established approach within social network analysis, see, e.g., Wasserman and Faust (1994) and Scott (2000).

9 Included commodities were Food, Live animals (SITC 0), Mineral fuels, etc. (SITC 3), Chemicals, related (SITC 5), Manufactured goods (SITC 6), Machinery etc. (SITC 7), Miscellaneous Manufactures (SITC 8). Together, the commodities in these six SITC divisions correspond to 92 percent of total trade in the 1999–2001 period. Note that this data used to determine structural positionality is at a higher aggregate level than the 4-digit SITC categories used to determine factor-cost differentials.

10 Even though used previously in world-system contexts (Smith and White, 1992; Mahutga, 2006), the REGE algorithm is not the only way to partition a network according to regular equivalence (cf. Doreian et al., 2005; Reichardt and White, 2007; Ziberna, 2008). Despite its popularity, the REGE algorithm has been criticized for its point-scoring procedure and its ability to identify regular role-equivalence, particularly in valued datasets (see Borgatti and Everett, 1991; 1993). For simplicity in this example study, I assume that the REGE-derived partitions reflect subsets of nations sharing similar structural positionality.

11 See Luczkovich et al. (2003) for an example on how Anova density tests are used to identify suitable partitions.

12 In network-analytical terminology, a "position" is a subset of actors that are considered role-equivalent and/or part of a blockmodel.

Table 1: The 8-positional partition of international trade 1999–2001 (with positional net flows of value and energy content)

Position	Countries	Positional net flows (selected commodities)	
		Millions of U.S. dollars	Terajoules
A	Pakistan, Sri Lanka	1 324	588 849
B	Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Peru, Trinidad and Tobago	–704	–191 407
C	Argentina, Belarus, Chile, Czech Republic, Denmark, Egypt, Finland, Greece, Hungary, India, Israel, Luxembourg, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, South Africa, Sweden, Tunisia, Turkey, Ukraine	–15 582	–4 993 119
D	Australia, Austria, Belgium, Brazil, Canada, China, Hong Kong, France, Germany, Indonesia, Ireland, Italy, Japan, Malaysia, Mexico, Netherlands, Philippines, Republic of Korea, Singapore, Spain, Switzerland, Thailand, United Kingdom	103 911	30 689 393
E	Albania, Bolivia, Croatia, Cyprus, Estonia, Ghana, Iceland, Jordan, Kenya, Latvia, Lebanon, Lithuania, Madagascar, Malta, Mauritius, Paraguay, Senegal, Serbia and Montenegro, Macedonia FYR, Uruguay	2 882	1 057 555
USA	United States	59 199	18 027 776
F	Algeria, Colombia, Iran, Iraq, Kuwait, Nigeria, Oman, Qatar, Saudi Arabia, United Arab Emirates, Venezuela	–151 086	–45 192 434
G	Mozambique, Nepal, Uganda, Tanzania, Zimbabwe	56	13 387

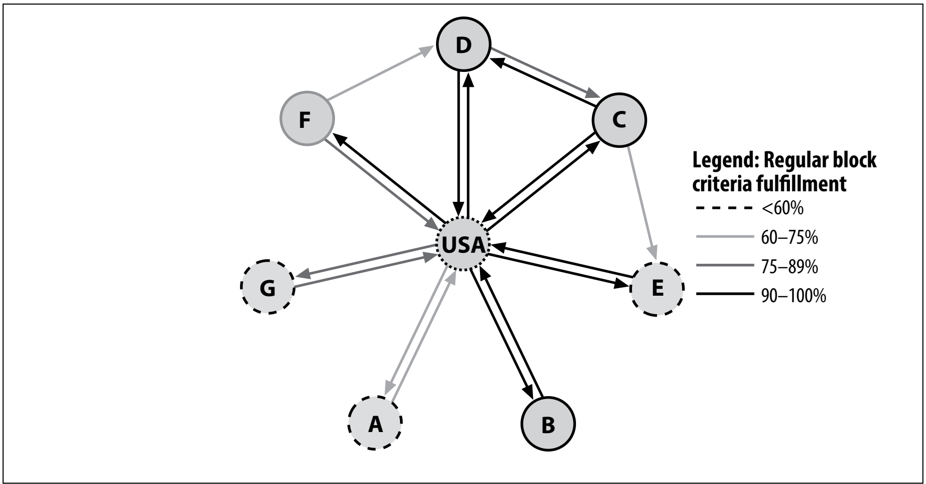
Source: Comtrade (UNCTAD, n.d.) (see footnote 7).

geographically dispersed countries in North Africa, the Middle East, and southern Latin America. The northern Latin American countries, however, have their own position (B). Even though fuel commodities only constituted one (out of six) major commodity categories, these flows are apparently sufficiently distinct (and apparently substantial—see Figure 1) to result in the distinct role-similar position F. Apart from position F and A, the other (non-singleton) positions contain a mix of net-importing and -exporting countries.

Complementing the blockmodel, a regular image graph was created,[13] see Figure 2. Mapping the functional anatomy of the network, the regular ties between and within each position were identified using a heuristic explicitly designed to handle datasets with huge value spans (Nordlund, 2007), where the different shades reflect criteria-fulfillment for regular ties. Compared with what a regular block image for

13 The criteria-fulfillment percentage was calculated using formula 3 in Nordlund (2007, 63). The 2-dimensional coordinates were established using a force-directed layout algorithm using the criteria-fulfillment percentages as relational data. Visualized using Ceunet (cnslabs.ceu.hu).

Figure 2: Regular image graph of world trade, 1999–2001



Notes: Cf. Table 1 for more details on positions A–G.
Source: Comtrade (UNCTAD, n.d.) (see footnote 9).

Galtung's (1971) structural topology looks like,[14] we are indeed looking at a core-periphery topological structure, especially as the United States and the countries in position D merge at partitions below seven positions.

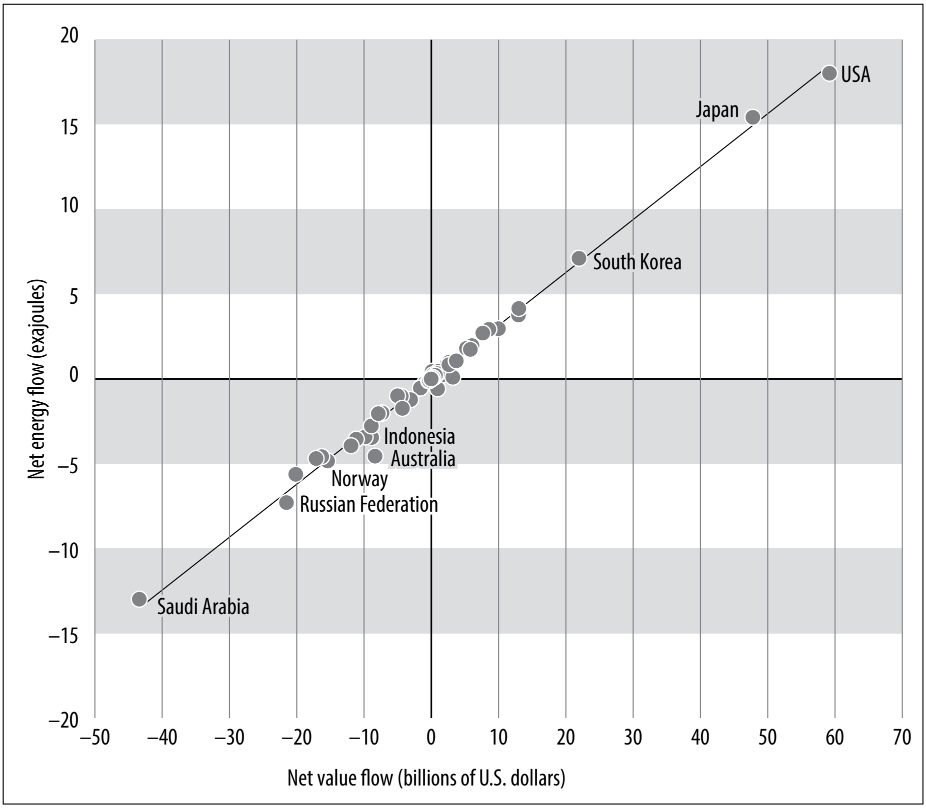
Ecological unequal exchange as monetarily under-compensated net energy flows

Converting the quantity flow matrices for each fuel commodity type into corresponding energy flow matrices, subsequently calculating aggregate matrices containing total value and energy flows, we can assess occurrences of ecological unequal exchange in the net transfer sense for these three commodities. The scatterplot in Figure 3 depicts national net flows of value and energy for the 1999–2001 period.

Evidently, the trend is strongly linear: a net inflow (outflow) of energy implies a net import (export) of commodity value, and the ratio between energy and value appears to be relatively similar. Still, the scatterplot above obfuscates an exception: even though Guatemala had a (mean) annual net import of fuel commodities in the 1999–2001 period, valued at US$47.5 million, its external trade in these three

14 A regular block image of Galtung's (1971, 89) classical feudal interaction structure as a typological core-periphery structure results in two role-equivalent positions—a core and a periphery—where the core has a regular self-tie, the periphery lacks such, and there is a regular tie between core and periphery.

Figure 3: National net flows (energy and value), 1999–2001



Source: Comtrade (UNCTAD, n.d.) (see footnote 7).

fuel commodities implied a net energy *outflow* of 2.9 petajoules. A closer inspection reveals that almost all of Guatemala's imports of fuel commodities came from Venezuela, carrying a relatively high price tag of US$3.98 per gigajoule, whereas Guatemala's subsequent export of fuel commodities, overwhelmingly to the United States, only gave US$2.33 per gigajoule in revenue. Even though the Venezuelan data could be unreliable,[15] the low cost of U.S. energy imports from Guatemala is

15 With obvious anomalies removed from the datasets, the export price data from Venezuela was consistently higher than the world average. However, as import data rather than export data was used in this analysis, would-be error sources should be found among importers rather than exporters such as Venezuela, thus making it difficult to motivate a removal of the Venezuelan export vectors in the flow matrices.

nevertheless approximately a dollar cheaper than what it on average pays its energy suppliers.

As we are only looking at three fuel commodities in this analysis, the observed proportionality between energy and value is not very surprising. As indicated by Hornborg (2006), a complete mapping of this net flow variety of ecological unequal exchange must by necessity cover virtually all commodities traded on the global market, and by including more commodities of different types, it is more feasible that we would find countries placed in the "unequal" quadrants as well. What the above trend line does show us, albeit slightly, is that there are indeed slight variations in the cost and revenues from energy trade. Russia, placed slightly below the trend line, earns less per exported joule than Saudi Arabia and Norway, placed above the trend line. Similarly, the United States gets fewer joules per dollar than South Korea and Japan do.

Inter- and intrapositional energy flows and costs

Continuing with the total energy flow data for 1999–2001, Table 2 contains energy flows (in terajoules; 10^{12} J) within and between the eight role-equivalent positions. By far the largest positional energy flow goes from the energy exporters in position F to the mostly high-income countries of position D. Corresponding to about a third of all energy flows in the dataset, these 27.3 exajoules are more than double the energy flow from position F to the United States. However, the second largest value represents *intra*positional flows within position D, i.e., energy flows between these 23 "developed" countries, thus by far outranking the cohesiveness of the other positions (see Table 2).

Expressed as petajoules (10^{15} J) and excluding positional flows below one petajoule, the topological features of inter- and intrapositional flows are highlighted better in Figure 4. The contrast between the significant cohesiveness of position D and the low intrapositional density of position F is per se a definition of a core-pe-

Table 2: Inter- and intra-positional energy flows (terajoule), 1999–2001

	A	B	C	D	E	USA	F	G
A			2 340	24 214				
B		186 621		155 304	1	497 419	45	
C	2 971	8 828	5 219 949	10 296 598	567 495	940 891	11 059	103
D	56 922	75 540	1 637 011	15 832 736	21 233	6 686 728	247 456	
E		23	82 675	110 673	3 523	3 964	1	69
USA		3 976	106 066	1 516 341	1 788		8 541	
F	555 511	372 995	5 005 571	27 306 821	663 601	11 535 487	9 674	19 554
G			1 254	4 240	842		2	101

Notes: Cf. Table 1 for more details on positions A–G.
Source: Comtrade (UNCTAD, n.d.) (see footnote 7).

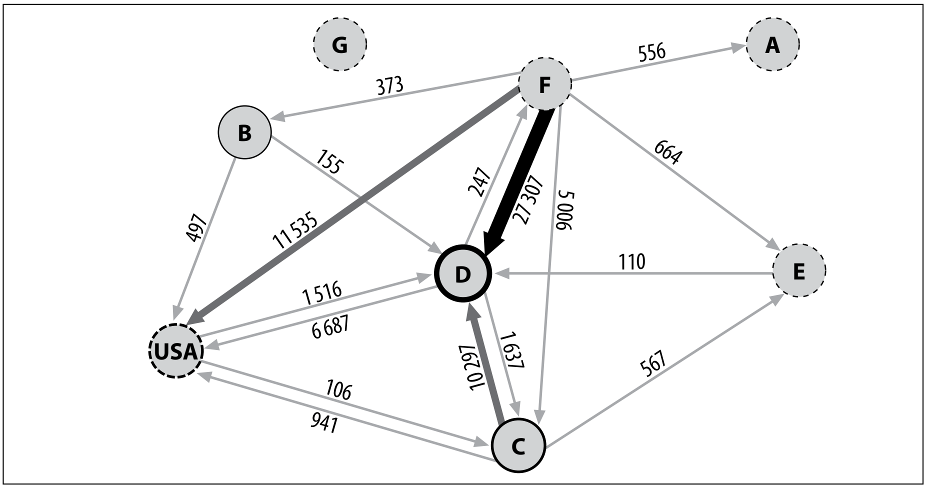
riphery topology (Borgatti and Everett, 1999), especially since the criterion of connectivity is fulfilled by the flow of 27 exajoules (10^{18} J) between F and D.

As already noted (Table 1), position C acts as an alternative net energy exporter in the system. Contrary to the main fuel-exporting position (F), position C is quite cohesive, having the second-largest intrapositional flow. However, even though C is an aggregate net energy exporter, only seven of its 25 countries are net energy exporters—including Norway and Russia with net energy exports[16] at 5.6 and 7.3 exajoules respectively.

Providing position D with an alternative source for its energy needs, it is noteworthy that very little energy flows from position C to the United States. Instead, it is position D that is the second largest source of U.S. imports of energy: even though position D is the largest net energy importer in the structure, the 6.7 exajoules from D to the United States are quite significant.

By dividing the aggregate value flow matrix with its energy counterpart, the cost-per-joule for each bilateral flow for the period 1999–2001 is calculated. Mapping this price matrix on the blockmodel and its partition, we arrive at the cost-per-energy prices given in Figure 5. Several interesting observations can be made here, par-

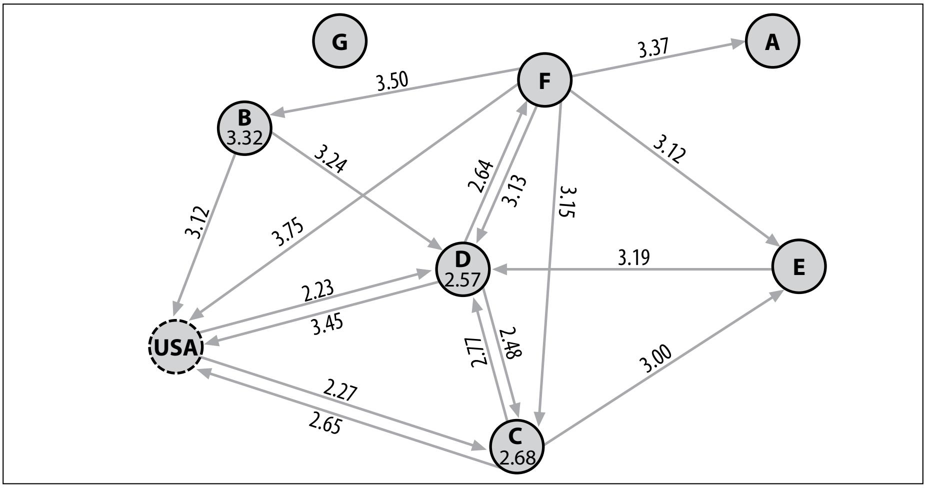
Figure 4: Inter- and intra-positional energy flows (petajoule), 1999–2001



Notes: Cf. Table 1 for more details on positions A–G. Thickness and color of arrows and nodes reflect inter- and intra-positional flow magnitudes. Dashed lines for nodes reflect intra-positional energy flows below 1 petajoule.
Source: Comtrade (UNCTAD, n.d.) (see footnote 7).

16 The net energy export figures for Norway and Russia include exports to other countries within position C.

Figure 5: Inter- and intra-positional energy prices (U.S. dollars per gigajoules), 1999–2001



Notes: Cf. Table 1 for more details on positions A–G.
Source: Comtrade (UNCTAD, n.d.) (see footnote 7).

ticularly with regards to position D. First, regarding imports from position F, it can be noted that position D pays less per joule than the United States pays (3.13 vs. 3.75 US$/GJ). Also, it can be noted that the energy flows from C to D are even lower[17] at 2.77 US$/GJ. But even if these energy costs are relatively low, the intrapositional energy cost within position D is significantly lower than that for its extrapositional trade.

Apart from paying relatively little for its energy inflows, position D is also the second largest source for the United States. Although slightly cheaper than U.S. imports from position F, position D earns US$3.45 for each gigajoule flowing to the United States. Together, this points to the peculiar situation of the United States: highly dependent on a singular positional energy source (F), supplemented by imports *from* the largest net-importing position (D), and paying relatively a lot for each imported joule, the United States actually seems to be on the disadvantageous side in Emmanuelian ecological unequal exchange of these commodities.

17 The relative insignificance of energy flows from C to the United States makes their price tag equally insignificant.

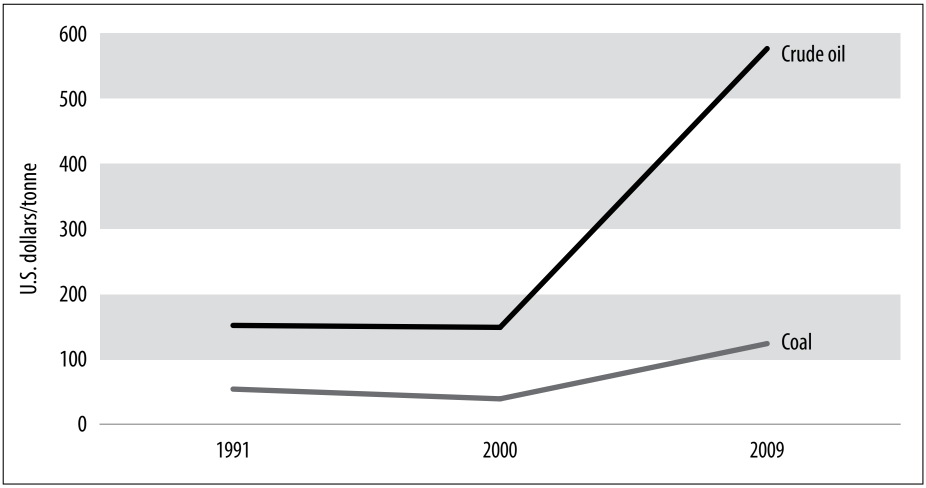
Price trends and positional differences: individual fuel commodities

Although total energy flows are interesting from a purely thermodynamic perspective, it is doubtful whether different dollar-per-energy measurements are readily comparable with each other. Obviously, the price of a particular fuel commodity does not only reflect its energy density: even though an exchange of one tonne of crude oil for 1.67 tonnes of coal might be thermodynamically equal, it is doubtful that trading partners would consider this an equal exchange. The missing component is of course utility: not only is coal 67 percent heavier than energy-equivalent crude oil, but solid coal is also less versatile than liquid oil. Few large-scale power plants run on crude oil and even less cars run on coal: just as with labor and capital, there are different kinds of "land," and this empirical analysis is rounded off by looking at cost differentials for the respective fuel commodity.

Based on total flows of exchange value and quantities of coal and crude oil, Figure 6 illustrates how fuel commodity prices increased during the 1991–2009 period. Whereas prices remained relatively stable between 1991 and 2000, there was a sharp price increase for the two commodities during 2000–2009.

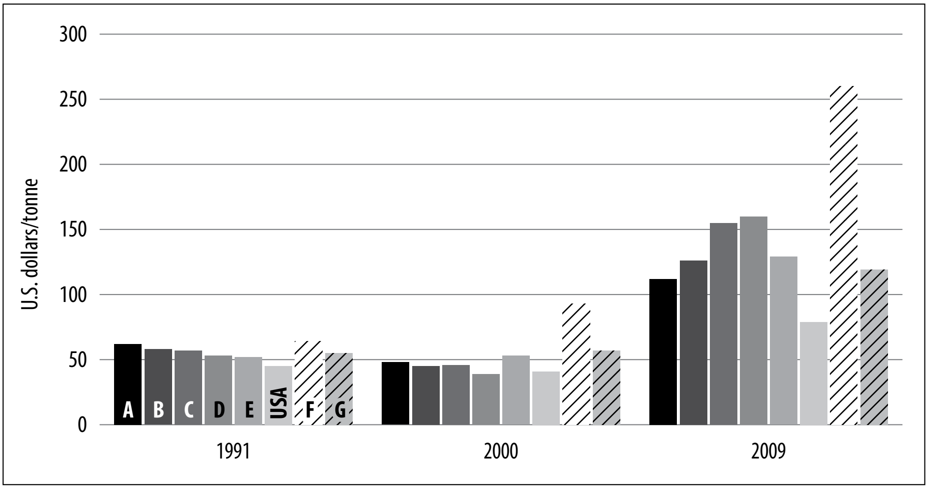
Whereas the import costs and export revenues for the respective fuel commodity were relatively similar among positions in the first two periods, the sharp post-2000 increase corresponds to positional differences with regards to import costs and/or export revenues. Exemplifying this, Figure 7 depicts the import cost of coal

Figure 6: Price trends for coal and crude oil, 1991–2009



Notes: These price trends were calculated using the extracted trade flow data alone.
Source: Comtrade (UNCTAD, n.d.) (see footnote 7).

Figure 7: Coal: mean positional import prices



Notes: Cf. Table 1 for more details on positions A–G.
Source: Comtrade (UNCTAD, n.d.) (see footnote 7).

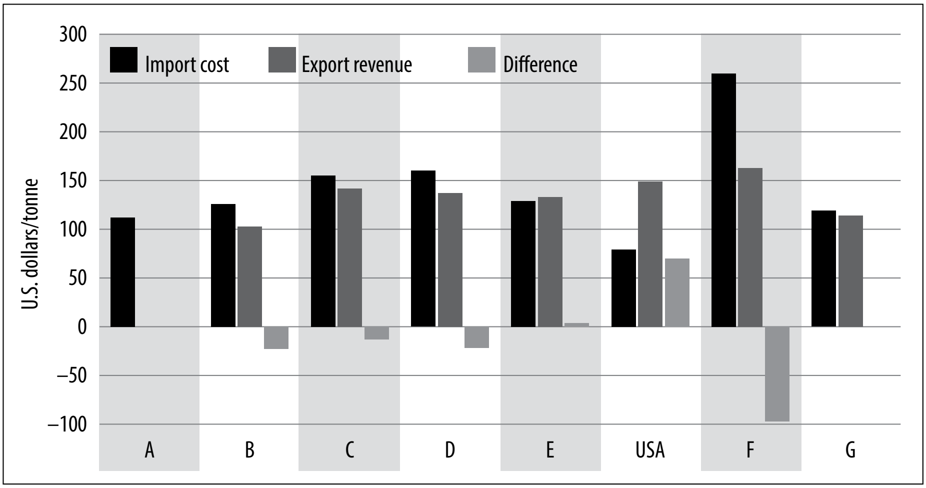
for each position and time period. Of particular interest is the price of U.S. coal imports: although increasing from US$45 to US$79 per tonne over the whole period, this increase remains relatively modest in comparison to the doubling, tripling, and, in the case of position F,[18] quadrupling of import costs for coal from 1991 to 2009.

Combining import costs with export revenues for 2009, Figure 8 depicts cost-revenue differentials of coal for the respective position. With a significantly lower import cost relative to other positions, the United States seems to accumulate US$70 for each exported tonne of coal that is matched to a corresponding import. Contrasting with this, the "throughput" ratio of coal imports and exports for position F is, despite relatively high revenue for its exports, seemingly very detrimental.

Corresponding comparisons of costs and revenues for the other two commodities in 2009 are given in Figure 9 (crude oil) and Figure 10 (liquefied natural gas). Whereas the high cost of crude oil imports to position F should be interpreted with care (being based on five relatively minor flows), the findings for position D could point to a more interesting situation. Obtaining US$788 per exported tonne, most of it exported to the United States, position D seemingly "earns" US$193 for each tonne of crude oil that passes through. For liquefied natural gas (Figure 10), it is instead position C that has a significant differential between import costs and export

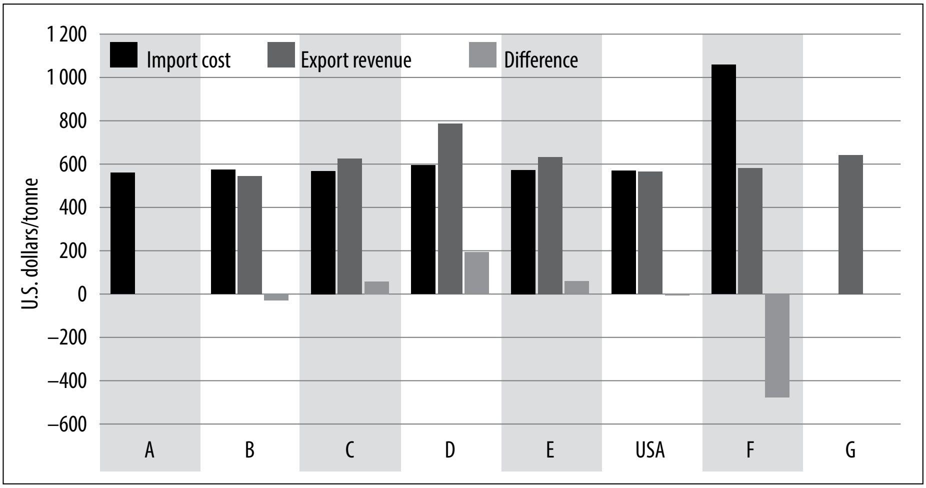
18 Although position F is a net exporter in coal, particularly due to Colombia being the fourth largest coal exporter, gross coal imports for position F rose from 837 million to 1.2 billion tonnes over the period studied.

Figure 8: Coal: comparing positional import costs with export revenues, 2009



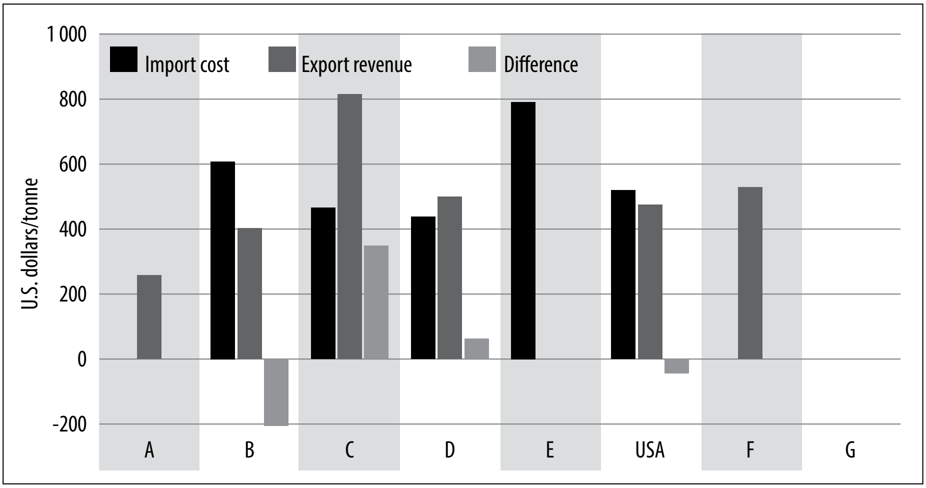
Notes: Cf. Table 1 for more details on positions A–G.
Source: Comtrade (UNCTAD, n.d.) (see footnote 7).

Figure 9: Crude oil: comparing positional import costs with export revenues, 2009



Notes: Cf. Table 1 for more details on positions A–G.
Source: Comtrade (UNCTAD, n.d.) (see footnote 7).

Figure 10: Liquefied natural gas: comparing positional import costs with export revenues, 2009



Notes: Cf. Table 1 for more details on positions A–G. In contrast to coal and crude oil, the number of available data points for liquefied natural gas is somewhat lower, only allowing for interpreting cost-revenue differences for positions C, D, USA, and possibly also B. The number of data points for import prices for these positions (in brackets) are 4 (B), 47 (C), 107 (D) and 9 (USA). Corresponding data coverage for exports are 23 (B), 36 (C), 44 (D), and 7 (USA).
Source: Comtrade (UNCTAD, n.d.) (see footnote 7).

revenues (US$349), seemingly categorizing its trade in liquefied natural gas on the beneficial side of ecological unequal exchange as interpreted in terms of factor-cost differentials.

The dissolving of significant distinctions

To aggregate coal, crude oil and natural gas into a common biophysical unit seems like a straight-forward exercise: as the utility of these commodities is obtained through incineration, the energy content is a suitable unit for the biophysical accounting. Still, even for these very similar commodities, it is apparent that their values not only reflect energy content, but other properties as well. That is: ecological equal exchange is likely only equal in the thermodynamic sense.

When aggregating *different types* of raw materials, finding a common biophysical unit complicates matters further: how to convert lumber, fuel, rubber, metal ore, water and other production factors of the third Ricardian kind into a common unit that makes sense in the context of ecological unequal exchange, whether net-flow or Emmanuelian? Seemingly imperative for measuring "total" (net flow) ecological unequal exchange, efforts striving towards common monodimensional units, such as ecological footprints, should indeed be questioned. It is true that "[t]he alchemy of money, with its power of commensuration, lies in its ability to dissolve distinctions between value schemes or measuring rods, and to create the fiction that a flattened, comparable world exists" (Gudeman, 2001, 15), but this does not imply that a similar simplification can be made with respect to the outer, biophysical system. Thus, even though the aggregate energy flow matrices tell us something thermodynamically, we are in effect mixing apples and oranges in a way that is not necessarily required.

As a snapshot of the 1999–2001 period, the mapping of energy flows and their prices onto the blockmodel does nevertheless give us some interesting insights. With significant internal trade and relatively low import costs from multiple sources, the role analysis did identify position D as a core in the network-topological sense. Even though the United States joins the countries of position D at a lower partition cutoff level, its role is evidently different, with a singular and relatively expensive source for most of its energy imports, only supplemented with equally expensive imports from position D. Another interesting phenomenon is position C: as an alternative energy source to position F, it is more cohesive but earns slightly less per exported gigajoule than position F.

Thus, even though a net-flow analysis depicts the United States at the receiving end of ecological unequal exchange in the net-flow sense, the Emmanuelian conceptualization of ecological unequal exchange, where the focus is on factor costs rather than net flows, points to a less advantageous situation for the United States and a significantly better one for position D.

The analysis of individual fuel commodities reveals a more nuanced picture of Emmanuelian ecological unequal exchange. In the case of coal, a consistently low price tag on U.S. imports over the period results in an advantageous throughput ratio. Position F suffers from a disadvantageous situation, where the cost of an imported tonne of coal overshadows the revenues from an exported tonne. For crude oil, position D is the clear beneficiary. As a partial gateway between position F and the United States, position D accumulates almost $200 for each tonne of crude oil that passes through its positional borders. Position F is also interesting in this regard: even though rich in natural endowments of crude oil, this does not translate into an exceptionally high price tag on oil exports: the price tag of oil exports from D exceeds those from position F by approximately $200 per tonne. Finally, although the data flows for liquefied natural gas are somewhat sparse, the 2008–2010 data allows some interpretation: it can be noted that position C is a beneficiary of Emmanuelian ecological unequal exchange, earning significantly more per exported tonne than positions D, E, F, and the United States.

The commodity-specific analysis indicates that position C, D and the United States each have their own commodities that they are benefiting from—liquefied natural gas in the case of C, crude oil for position D, and coal in the case of the United States.

Concluding remarks

Critical of existing conceptualizations of ecological unequal exchange, this chapter proposes an alternative approach that is, it is argued, more in line with the original formulation of Arghiri Emmanuel. Rather than mapping total net transfers of biophysical resources, the emphasis here is, similar to the original formulation of Emmanuel, on factor-cost differentials among nations. Whereas Emmanuel looked at labor and wage differential, the herein proposed conceptualization of unequal exchange looks at the third Ricardian production factor, i.e., land/natural resources, and cost differentials of such. The suggested hypothesis, building on Jorgenson's structural theory of ecological unequal exchange, is that such factor-cost differentials are related to structural positionality within the world-system.

To test the proposed conceptualization, three fuel commodity categories were chosen to represent the land production factor. Looking at bilateral trade data for 96 countries in the last three decades, factor-cost differentials were compared with structural positionality determined through a blockmodel analysis for the 1999–2001 period. Aggregated as total energy flows, as well as for individual commodities, the analyses yielded novel findings for both of these approaches.

The chosen raw material commodities could be different, and structural positionality could be operationalized differently, but it seems evident that the proposed Emmanuelian conceptualization of ecological unequal exchange yields interesting insights worthy of further research, both methodologically and substantively.

However, despite its ties to the foundational ideas of unequal exchange, a conceptual orthodoxy might not necessarily serve us well. As underlined by Wallerstein (2000, 153), concepts relate to, and are best defined through, particular historical systems and timespace context, and it is indeed possible that an Emmanuelian, factor-cost-based conceptualization of ecological unequal exchange is more orthodox than useful for understanding contemporary global dynamics. Still, as a historically oriented field of study, we are nevertheless obliged to connect past and present thoughts, something that I hope this chapter has succeeded in doing.

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