ECOLOGICAL UNEQUAL EXCHANGE: INTERNATIONAL TRADE AND UNEVEN CROSS-NATIONAL SOCIAL AND ENVIRONMENTAL PROCESSES

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To the faculty of Washington State University:

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Chair

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Abstract

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Ecological unequal exchange refers to the inequalities enacted through international trade wherein economically dominant export partners appropriate value embodied in natural resource assets. Countries advantageously situated within the global economy secure favorable terms of trade promoting disproportionate access to global natural resources and sink-capacity services of ecological systems. This facilitates the externalization of the negative environmental consequences of domestic production and consumption onto less developed countries.

The present study empirically evaluates three dimensions underlying ecological unequal exchange: 1) *Environmental cost-shifting* or externalization of the negative consequences of material consumption; 2) Disproportionate cross-national utilization of global *environmental space* or available sink-capacity and biologically productive area; and, 3) *Underdevelopment* as a consequence of the reliance upon and undervaluation of natural resource exports.

This study examines the differential impacts of international trade through utilization of slope dummy interaction terms within a series of ordinary least squares regression models. The sample consists of 148 countries at all levels of development.

Results illustrate low and lower middle-income countries with a greater proportion of exports to the core industrialized countries exhibit lower consumption of environmental resources. This suggests the structure of international trade supports the disproportionate per capita material consumption of industrialized countries concurrent with the under-consumption of the poorest countries in the world.

Further, low income countries with a greater proportion of non-fuel natural resource exports demonstrate lower levels of social development. When fuels are included in the calculation low, lower middle, and upper middle-income countries with a greater proportion of natural resource exports are characterized by lower social wellbeing.

Analysis reveals low-income countries with a greater proportion of natural resource exports demonstrate higher rates of deforestation, 1990-2000. In addition, low income and upper middle-income countries with a greater proportion of exports to the core exhibit higher deforestation, providing evidence of environmental cost-shifting dynamics.

The present study uncovers evidence of each of the three dimensions of ecological unequal exchange, suggesting structural relations underpinning capital accumulation on a global scale forge systemic patterns of ecological transformation. Cross-national ecological interdependencies contribute not only to processes of global environmental change but also the underdevelopment of peripheral countries.

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DEDICATION

This dissertation is dedicated to the girls in my life. To Julie for her optimism, sacrifice, and grace under pressure. And, to my beautiful little ones: Bailey and Sydney. Thank you for making it all worthwhile.

CHAPTER ONE

INTRODUCTION

Viewed from nighttime satellite photos, the luminous agglomerations of the built infrastructure of the industrialized countries are readily discernable against the relatively empty expanses characterizing less developed countries. This illumination is only loosely coincident with the distribution of population density around the globe. It is, however, tightly linked to a fundamental division regarding the flow and consumption of energy and materials within the global economy (Hornborg 2001). Mainstream theories of development and underdevelopment have failed to sufficiently consider such ecological dynamics (Bunker 1985). The incandescent presence of the industrial technomass and the empty expanses of the periphery do not exist in isolation but are interwoven, a reflection of not simply domestic processes but the socioeconomic metabolism or material throughput of the world-system. In turn, systemic global patterns of ecological access, utilization, and degradation shape the uneven development of human societies.

The built infrastructure and complex social organization of the industrialized countries is reliant upon the extractive economies of many less developed countries (LDCs).[1] The trade of natural resources supports the disproportionate per capita material consumption characteristic of industrialized countries. Ecological flows, when systematically undervalued in monetary terms, displace the environmental costs of this uneven consumption to LDCs. In addition, it allows industrialized countries to inequitably appropriate limited global environmental space or carrying and sink capacity of ecological systems well beyond their own borders. In sum, the divide within the global economy in terms of the energy and material consumption visible in nighttime satellite

[1] In this study less developed countries (LDCs), the periphery, and the "South" refers to countries categorized as low, lower middle, and upper middle income according to the World Bank's income classification system (World Bank 2002). Reference to developed, industrial, and the "North" refers to countries classified as high-income.

photos is, to a substantial degree, founded upon complex processes of ecological unequal exchange.

Ecological unequal exchange refers to the inequalities enacted through international trade wherein economically dominant export partners appropriate value or productive potential embodied in natural resource assets originating within LDCs. It is based upon the assertion that countries advantageously situated within the structural interaction networks of global exchange, in part a consequence of wealth, and political and military strength, are more likely to secure favorable terms of trade promoting disproportionate access to global natural resources and sink-capacity services of ecological systems. In turn, this access facilitates the externalization of many of the negative environmental consequences of domestic production, consumption, and disposal activities. This perspective is concerned with the environmental contradictions of capital accumulation and the ecological-distributional conflicts supporting the natural resource consumption of industrialized countries.

The theory of ecological unequal exchange builds upon the dependency/world-system perspective asserting the hierarchical ordering of countries relative to position in the international division of labor and the imposition of unequal exchange relations. Broadly, unequal exchange refers to the inequalities enacted through cross-national trade between economically and militarily non-equivalent partners wherein value, typically labor value, is appropriated by dominant trading partners. Unequal exchange shapes the enactment and structural reproduction of relations of dominance-dependence whereby some countries disproportionately benefit through trade relative to less advantageously situated partners.

It is problematic if not impossible to substantiate empirically the “value” embodied in natural resource assets in a manner convincing to both neoclassical economists and orthodox

Marxist scholars. Neoclassical economics defines value as the exchange price obtained for a commodity in an open and non-monopolized market situation. Value is the price a rational actor is willing to sell at and another is willing to pay. Orthodox Marxist-oriented scholars typically reject such a subjective definition preferring instead to define value as an objective, underlying standard defined by what a worker produces rather than what they are paid for their labor. The discrepancy between the two constitutes the surplus value appropriated by the employer and the exploitation shouldered by the worker.

Despite the incommensurable nature of value between different perspectives, it is possible to empirically examine the proposed cross-national consequences of ecological unequal exchange. In other words, empirical evidence of the inequalities shaped through international trade in a manner consistent with propositions derived from the perspective of ecological unequal exchange helps substantiate the validity of its underlying arguments.

Accordingly, processes of ecological unequal exchange are characterized by three interrelated empirical dimensions: 1) *Environmental cost-shifting* or externalization of the social and ecological costs of extraction and distribution of natural resource exports from LDCs, enhancing environmental degradation and depletion at the local level; 2) The disproportionate and uncompensated utilization of global *environmental space* or available sink-capacity and biologically productive area, limiting utilization opportunities of LDCs; and, 3) *Underdevelopment* as a consequence of the out-flow of value associated with the export of cheap natural resources, eroding socio-economic development potential.

Research Problem

The research problem guiding this study, in turn, encompasses the following: The assertion of ecological unequal exchange, varying according to position in the global economy,

requires explicit, quantitative empirical evidence oriented towards illustrating the cross-national interconnections shaping environmental cost-shifting, appropriation of environmental space, and underdevelopment. The challenge lies not in documenting the relatively greater environmental and socio-economic problems in LDCs but in connecting such outcomes to the structure of trade relations between LDCs and industrialized countries. It is the structure of international trade that binds countries together in an environmentally significant manner. In turn, it is not trade, per se, but the structure of trade in terms of export partner concentration and composition of exports that promotes dynamics of ecological unequal exchange.

The overarching need in the academic literature is for greater large sample, quantitative research designed to test such assertions in order to establish a body of nomothetic propositions sensitive to the ecological interdependencies and differential environmental advantages and burdens forged at a cross-national level. Inferential quantitative research is crucial because the theory of ecological unequal exchange is essentially a systemic, global-level theory. Its plausibility is predicated upon cross-national ecological-distributional processes. In turn, such research efforts potentially have direct implications for both neoclassical and orthodox Marxist conceptions of value in particular and the broader debate over the sustainable development of human societies in general.

Contributions and Limitations of Previous Research

Bunker's (1984, 1985) case study of the underdevelopment of the Amazon region as a consequence of incorporation into the capitalist world economy as a source of natural resources for distant industrializing countries provides an important reference point. His work is explicit in its delineation of the unique developmental logic and internal dynamics of natural resource exporting LDCs. One of the strengths of Bunker's account is his sensitivity to the ideograhic or

historically particular dynamics of various natural resource exporting regimes within the Amazon concurrent with his efforts to derive plausible nomothetic or general propositions applicable across a variety of natural resource exporting LDCs. Bunker's analysis contains numerous insights applicable to a mutually beneficial merging of the insights derived by scholars studying the dynamics of the contemporary world-system and scholars examining environmental sociology. Nevertheless, researchers have been slow to join together these two lines of inquiry, making progress in this regard only in the last ten years. Despite Bunker's efforts to adjudicate between ideographic explanation and nomothetic extrapolation, his own subsequent research never adopts a large sample, quantitative orientation evaluating the general propositions derived from his earlier work (1984, 1985).

Examples of previous research adopting a theoretical and empirical stance explicitly evaluating cross-national ecological-distributional conflicts, consistent with the assertion of ecological unequal exchange, includes research on the uneven processes of deforestation in the world-system (Burns, Kick, Murray, and Murray 1994; Burns, Kick, and Davis 2003, 2006; Kick, Burns, Davis, Murray, and Murray 1996; Jorgenson 2006). Previous research also highlights the differential impact of the driving forces of domestic environmental consumption relative to position in the world-system (Jorgenson 2003). Urbanization, for example, has a greater impact upon demand for natural resources in the most industrialized countries (Jorgenson 2004). Further, LDCs with a greater proportion of exports to more economically dominant countries exhibit lower environmental consumption demand, suggesting the over and underconsumption of natural resources is tied to the structure of international trade (Jorgenson and Rice 2005).

A series of studies employing a materials flow analysis (MFA) methodology are explicitly defined as efforts to test claims of ecological unequal exchange. These studies examine cross-national material flows enacted through trade. This line of research is notable in that it evaluates the divergence between global natural resource flows measured in biophysical terms, typically by weight, relative to monetary measurement. Research shows the export of many categories of natural resources from LDCs to industrialized countries appears to be declining monetarily but by weight continues to increase (Giljum and Eisenmenger 2004; Giljum and Muradian 2003; Muradian and Martinez-Alier 2001a). The movement of non-renewable resources from South-North, particularly minerals and fuels, increased dramatically between the mid-1970s and mid-1990s, even as prices declined (Muradian and Martinez-Alier 2001a). Further, Northern imports of semi-processed metals generally exhibit a steady increase in demand rather than a de-linking of Northern economies and Southern non-renewable exports (Muradian and Martinez-Alier 2001b).

Materials flow analysis documenting the overall South-North movement of natural resources provides empirical evidence of the limited dematerialization of industrialized countries in absolute terms. It is also significant in providing a more complete description of international material flows than can be captured through purely monetary indicators. The substantial weakness of this line of research is that it is difficult to derive inferential models suitable for developing nomothetic propositions. This is a function of the descriptive nature of this research and severe data limitations encountered in comprehensively measuring trade by weight for large subsets of countries.

This study builds upon the long tradition of cross-national quantitative research conducted in sociology since the mid-1970s examining social and economic underdevelopment

but incorporates an explicit ecological orientation. It builds, in particular, upon the ideas first propounded by Bunker (1984, 1985) concerning the precarious position in the global economy of natural resource exporting LDCs and approaches the idea of ecological unequal exchange from a different methodological perspective than that adopted by researchers utilizing materials flow analysis. In turn, the present study seeks to contribute to the theoretical and empirical work on the ecological-distributional dynamics underlying international trade.

Potential Contributions of the Present Study

Ecological unequal exchange provides a framework for conceptualizing how the socio-economic metabolism or material throughput of industrialized countries may negatively impact more marginalized countries in the global economy. It focuses attention upon the uneven flow of energy, natural resources, and, inversely, the waste products of industrial activity between less and more developed countries. The point is not that industrialized countries do not encounter domestic environmental degradation, undoubtedly they do. But, arguably the world's most serious environmental issues are increasingly located within LDCs. Many LDCs encounter environmental problems as a consequence of poverty and localized conflicts over natural resources. This does not preclude, however, the additional consideration of exogenous forces shaping environmental degradation within LDCs, many of which, in turn, influence poverty rates in the first place. Environmental degradation may be both a cause and consequence of poverty within peripheral countries.

Ecological unequal exchange endeavors to conceptualize the cross-national processes and structural relations perpetuating the unbalanced flow of energy and materials within the world-system, shaping patterns of uneven development. It is focused upon the contingencies underlying variable cross-national socioeconomic metabolism in a manner not previously envisioned by

traditional theories of development/underdevelopment. This perspective is relevant to a more comprehensive understanding of the mechanisms of global environmental use and degradation, the variable consequences of economic globalization, and concern with broad-based and equitable sustainable development. It forces consideration of the ecological foundation of human societies as constituted by domestic and exogenous forces disproportionately shaping and constraining environmental burdens and advantages cross-nationally.

Greater attention to the environmental contradictions underlying uneven capital accumulation contributes not only to the analysis of global environmental change but the continuing underdevelopment of peripheral countries. Further, cross-national disparities in access to and utilization of natural resources potentially shape the unsustainable social organization of human societies writ large. The problem, in turn, is neither wealth nor poverty alone but their complex interrelationship at the global level. To more fully conceptualize uneven development it is necessary to examine the ecological basis of these interdependencies. To better understand global environmental change it is instructive to evaluate their consequences.

If, indeed, industrialized countries shift significant environmental consequences of their consumption-production-accumulation activities to LDCs then the theory of ecological unequal exchange tempers the optimistic conceptions offered by many neoclassical economists that the industrialized countries are characterized by the most sustainable environmental policies (see Taylor 2002). Further, it challenges the ecological modernization theory suggestion that many industrialized countries represent burgeoning “environmental states” (see Mol and Buttel 2002).

Statement of Purpose

The objectives of this study are twofold. First, engage in theoretical elaboration upon ecological unequal exchange by incorporating and synthesizing complementary insights from

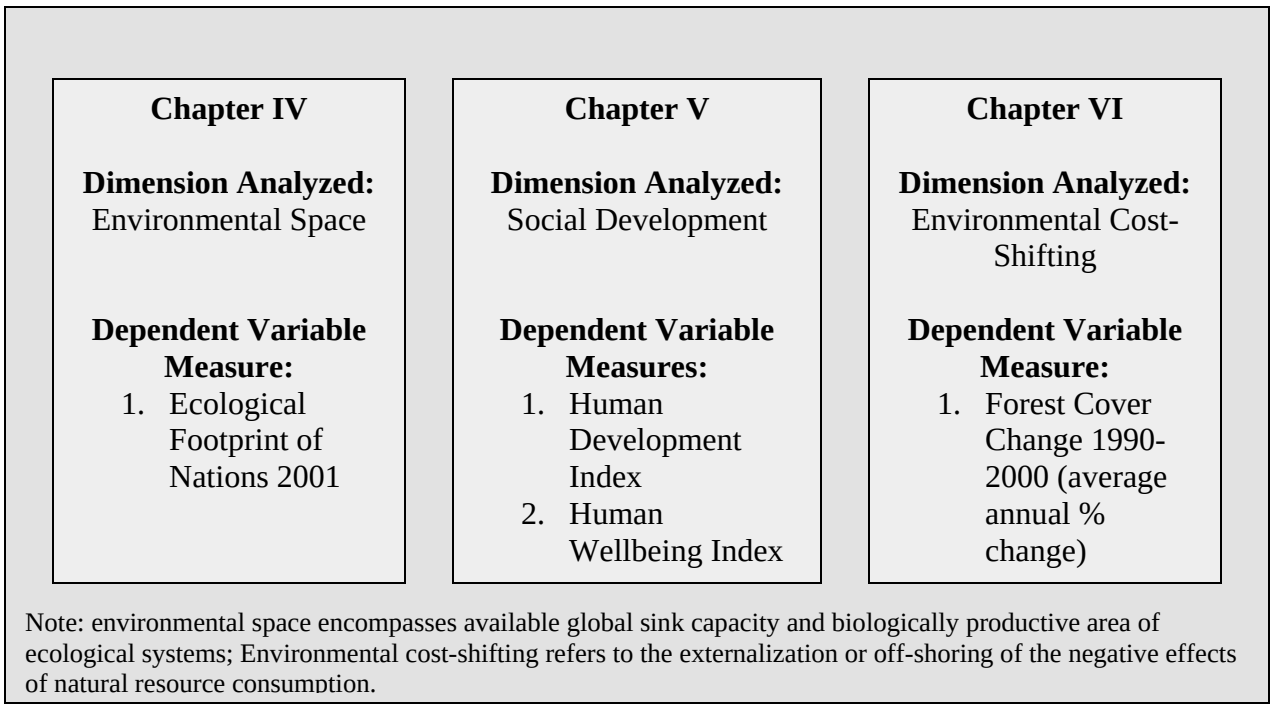
world-systems analysis, political ecology, ecological economics, and anthropology. This effort is congruent with Hornborg's suggestion that the theory of ecological unequal exchange is most profitably drawn from the unexplored interface of different disciplinary boundaries (2001). The goal, in turn, is to contribute to the debate concerning processes of uneven development and global environmental change by pulling together ideas and arguments from numerous perspectives united by an overarching assumption: the hierarchical structure of the global economy is shaped by and, in part, perpetuated through uneven cross-national access to and utilization of ecological resources and services. An important aspect of this theoretical elaboration entails establishment of a "sustained dialogue" between the divergent expectations of ecological unequal exchange and the theory of comparative advantage, an underlying narrative pursued throughout the study.

The second objective is to empirically examine the dimensions of ecological unequal exchange highlighted in the theoretical overview in an effort to move the debate forward regarding the environmental space allocation, cost-shifting, and underdevelopment dynamics existing at a cross-national level. The empirical results, in turn, are then interpreted relative to the theoretical expectations of both the theory of comparative advantage and the assertion of ecological unequal exchange processes.

Figure 1 outlines the three empirical chapters in this study. Chapter four examines the disproportionate utilization of environmental space by industrialized countries relative to LDCs. The ecological footprint is utilized as a measure of cross-national appropriation of environmental space. The ecological footprint is a measure of the biologically productive area required to satisfy the consumption of renewable natural resources and absorption of carbon dioxide waste of a particular country (Chambers, Simmons, and Wackernagel 2002). Because footprint

calculation is based upon a trade balance methodology, wherein exports do not constitute part of a country's footprint demand but are added to the calculation of importing countries, it provides a means of evaluating the cross-national flow of biologically productive area. The objective of chapter four is to evaluate the relational structures of international trade as it both facilitates and constrains cross-national ecological footprint consumption.

Figure 1. Outline of Empirical Chapters



Note: environmental space encompasses available global sink capacity and biologically productive area of ecological systems; Environmental cost-shifting refers to the externalization or off-shoring of the negative effects of natural resource consumption.

Chapter five evaluates the direct effect of natural resource exports upon social development. This provides a good test of the potential comparative advantages of natural resource exports from LDCs relative to counter-arguments derived from the unequal exchange perspective. The Human Development Index and the Human Wellbeing Index are utilized as measures of social development. The Human Development Index is the most widely employed measure of cross-national social development in the sociological literature over the last 15 years. It is based upon four indicators: life expectancy at birth, adult literacy rate, school enrollment,

and standard of living as indicated by gross domestic product (GDP) per capita. The Human Wellbeing Index is a broader measure, comprised of the average of indicators of health and population, wealth, knowledge, community, and equity.

Chapter six analyzes environmental cost-shifting through evaluation of the cross-national demand for forest products relative to forest cover change, 1990-2000. This chapter examines empirical evidence of a "consumption/environmental degradation paradox" wherein countries with the highest per capita consumption of forest products, typically industrialized countries, have the lowest rates of deforestation. Conversely, countries with the lowest demand typically have the highest deforestation rates.

Overarching Analytical Strategy

A methodological strategy employed in this study is the examination of the differential impacts of international trade by country income level through utilization of slope dummy interaction terms. Slope dummy interaction terms are calculated by multiplying a set of categorical dummy variables by a single continuous or interval-level variable (Feinstein and Thomas 2002; Hamilton 1992). The result is a series of new variables taking the form of either 0 or the interval-level value. In contrast to traditional intercept dummy variable indicators that have either a 0 or 1 value, all slope dummy interaction terms can be entered into a regression analysis without producing perfect multicollinearity (Hamilton 1992). This allows for the examination of the relative contribution of each slope dummy interaction term in explaining variation in the dependent variable.

The present study examines 148 countries with available data, comprised of both LDCs and industrialized countries. To create slope dummy interaction terms the sample is divided into income positions following the World Bank's income categorization of countries (World Bank

2002). The result is four groups based upon gross national income (GNI) per capita for 1999. This includes low, lower middle, upper middle, and high-income countries. These countries are listed in table A1 in the Appendix. The slope dummies are incorporated into ordinary least squares (OLS) regression analysis to test for the differential impacts of the structure of international trade relative to country income level, net the appropriate control variables.

Included in the analyses are control variables drawn from previous research. This includes appropriate dependency/world-system measures and various facets of population dynamics consistent with the neo-Malthusian and human ecology theories. Based upon previous research efforts, control variables suggested by social and economic modernization theory are included where appropriate.

As an additional explanatory variable, a reconceptualized measure of trade partner concentration is incorporate into the analyses. Previous research evaluating the potential dependency effects of trade partner concentration generally focuses upon the single largest export partner. In contrast, this study operationalizes trade partner concentration as the proportion of exports to the countries at the core of the global economy as identified through network analysis studies. These countries (N = 11) are identified in table A1 in the Appendix. This produces a broader indicator of the degree to which a country is integrated into the global economy through exports to the most developed capitalist countries, not simply the one or several largest export partners. Arguably, this is a more appropriate specification of the constellation of vertical trade relations in which LDCs are enmeshed, and it is a more accurate approximation of the potential dominance-dependence relations enacted through international trade, particularly in terms of asymmetrical consumption of natural resources.

Proportion of natural resource exports as a percent of GDP is included as an additional explanatory variable. The effects of this variable with fuels included and excluded from the calculation are examined. Inclusion of natural resource exports evaluates integration into the global economy by composition or type of exports traded, delineated by country income position.

Empirical Results Reported in the Present Study

Descriptive and inferential empirical analyses conducted in this study highlights evidence relevant to each of the three dimensions comprising ecological unequal exchange. First, chapter four is oriented towards examination of one key question: does international trade create uneven access to global environmental space relative to country income position? Environmental space encompasses the stocks of natural resources and sink capacity or waste assimilation properties of ecological systems supporting human social organization. Ecological unequal exchange argues industrialized countries are increasingly appropriating both global natural resources and the sink capacity of ecological systems (Martinez-Alier 2002). They are, in short, disproportionately utilizing global environmental space, constraining present and future utilization opportunities of LDCs. This uneven appropriation supports the enormous disparities in production and consumption patterns and standards of living cross-nationally. Further, trade between economically imbalanced partners is proposed as a key mechanism shaping cross-national disparities over access to environmental space (Andersson and Lindroth 2001).

Descriptive analysis examining the ecological footprint illustrates high-income countries, on average, consume more natural resources than are available domestically, exhibiting an overall ecological deficit. Non-high income countries generally use fewer natural resources than are available domestically. This suggests industrialized countries may be promoting the

unsustainable utilization of global environmental resources rather than at the forefront of sustainability dynamics, an argument contrary to ecological modernization thought. Further, from 1991-2001 per capita ecological footprint consumption within low-income countries, on average, declined substantially concurrent with a significant increase among high-income countries and a modest increase among upper middle-income countries.

Subsequent regression analysis illustrates low and lower middle income countries with a greater proportion of exports to the core industrialized countries are characterized by lower consumption of environmental resources. This result, arguably, is a consequence of the disproportionate utilization of global environmental space by core countries at the expense of countries less advantageously integrated into the global economy. This suggests the structure of international trade supports the disproportionate per capita material consumption rates characteristic of industrialized countries but, equally problematic, it also potentially shapes the under-consumption confronting the poorest countries in the world. In turn, the analysis presented in chapter four is relevant to considerations of sustainable development as the results imply trade with core countries is associated with greater polarization rather than convergence of natural resources consumption.

Second, chapter five addresses a fundamental gap in the social science literature on differential cross-national social development. That is, few studies directly examine the export of natural resources as an explicit independent variable impacting level of social development in a systematically contingent, and uneven manner. Chapter five seeks to overcome this limitation by incorporating a measure of natural resource exports, with and without the calculation of fuels included, into a series of regression models evaluating level of cross-national social development delineated by country income position. This focus is logically supported by the theoretical

arguments underlying the assertion of ecological unequal exchange among countries. Bunker's work, in particular, suggests natural resource extractive economies are linked in a substantive manner to the socio-organizational acceleration and increasing complexity of industrialized countries and their own deceleration, simplification, and progressive underdevelopment (1984, 1985). Accordingly, the theory of ecological unequal exchange proposes that LDCs with a greater proportion of natural resource exports will be characterized by lower levels of social development, net the appropriate control variables.

Regression analyses reported in chapter five employing the Human Development Index illustrates low-income countries with a greater proportion of natural resource exports exhibit lower levels of social development. This effect remains statistically significant with and without fuels included in the calculation.

Further, regression analyses utilizing the Human Wellbeing Index reveals the greater the proportion of non-fuel natural resource exports among low-income countries the lower the level of social development. Conversely, the greater the proportion of non-fuel natural resource exports among upper middle and, in particular, high-income countries the higher the level of social development. This dichotomy suggests countries variously positioned in the global economy accrue differential liabilities and benefits from the export of non-fuel natural resources.

Thus, the poorest countries, those the theory of comparative advantage suggests should typically benefit from natural resource extraction, are those characterized by lower levels of social development as a consequence of their natural resource extraction-oriented integration into the global economy. Conversely, the richest countries, those the theory of comparative advantage suggests should benefit the least from the export of natural resources as their comparative

advantages lie elsewhere, are those characterized by higher levels of social development as a consequence of their natural resource exports.

Further, when fuels are included in the calculation the effects upon social development as measured by the HWI are substantially enhanced. Low, lower middle and upper middle-income countries with a greater proportion of natural resource exports (including fuels) are characterized by lower levels of social development. This effect is particularly strong among low-income countries. The positive correlation between natural resource exports and level of the HWI in high-income countries, in turn, weakens and drops from statistical significance when including fuels in the calculation.

The empirical results reported in chapter five are indicative of dynamics of ecological unequal exchange. The countries in which natural resource exports are generally viewed as a comparative advantage, low-income countries thought to have few other options, exhibit lower levels of social development the more integrated into the global economy they are through such exports. These results are suggestive of the contingent, dominance-dependence relations underlying exchange relations within the global economy. Industrialized countries are more advantageously positioned to not only engage in the most dynamic industrial-economic opportunities for capital accumulation but also benefit disproportionately even from the export of primary products relative to low-income countries. This is likely a consequence of greater economies of scale, subsidization of extractive activities, and more efficient technologies in the developed countries. Further, low-income countries appear to exhibit socio-economic deceleration or progressive socio-economic stagnation as a consequence of their extraction-oriented role in the global economy, consistent with the theorization of Bunker (1984, 1985; see also Bunker and Ciccantell 2005).

Third, the results illustrated in chapter six are suggestive of environmental cost-shifting in terms of the uneven processes shaping relative forest product consumption and deforestation at a cross-national scale. Environmental cost-shifting refers to the displacement of the negative ecological consequences of the natural resource consumption rates of industrialized countries onto extraction-oriented LDCs. Descriptive evidence is presented in this regard highlighting the "consumption/environmental degradation paradox," wherein those countries with the lowest consumption of forest products exhibit the highest deforestation rates. High-income countries, for example, are characterized by an average per capita forest product demand that is 24 times that of low-income countries. Nonetheless, deforestation 1990-2000 is clearly the most pronounced among low-income countries, on average, while high income countries exhibit reforestation over the period.

In an effort to specify the mechanisms promoting such cost-shifting outcomes, regression analyses incorporating measures of the proportion of exports to the core and proportion of natural resource exports are examined. The analyses reveal low-income countries with a greater proportion of natural resource exports are characterized by higher rates of deforestation 1990-2000, net a series of appropriate control variables. Low-income countries more integrated into the global economy as suppliers of non-fuel natural resources, which may or may not include forest products, are characterized by greater deforestation.

In addition, low income and upper middle-income countries with a greater proportion of exports to the core exhibit higher deforestation over the period. These effects obtain net the influence of economic growth, population dynamics, proportion of natural resource exports, and alternative dependency variables. These results support an ecological unequal exchange interpretation as it suggests that not only are low-income countries with a greater proportion of

natural resource exports characterized by higher rates of deforestation but low-income countries with a greater proportion of exports to the core also exhibit greater forest loss, as do upper middle-income countries. In combination, this provides inferential evidence of environmental cost-shifting dynamics underwriting both differential rates of forest product consumption and deforestation cross-nationally. Further, it is primarily the flow of natural resources from low-income countries and their structural interaction with the most industrialized countries that appears to be central to such cost-shifting dynamics.

Overall, the regression analyses in chapter six support the contention that the structure of international trade is a salient consideration in accounting for uneven deforestation rates at a cross-national scale. The results are congruent with Bunker's general assertion that the mechanisms of environmental degradation vary systematically by position in the world-system (1984, 1985) and previous research in particular substantiating the impact of international trade upon deforestation within LDCs (Kick et al. 1996; Jorgenson 2006). Moreover, they support the assertion that more-developed countries externalize their consumption-based environmental costs upon LDCs (Jorgenson 2006).

General Outline of the Study

Chapter two begins by outlining the contrasting theoretical tenets between comparative advantage theory and unequal exchange. Following upon this distinction, the theory of ecological unequal exchange is presented and the mechanisms generating its uneven application cross-nationally are discussed. We incorporate into the discussion general tenets drawn from world-systems analysis, particularly arguments concerning trade dependency processes.

Chapter three includes an overview of methodological design, including the rationale for and creation of slope-dummy interaction terms and division of the dataset into country income

positions. Chapters four, five, and six empirically examine dynamics of cross-national utilization of environmental space, social development, and environmental cost-shifting respectively, drawing upon theoretical propositions derived in chapter two. Chapter seven discusses the empirical results of this study in relation to international trade, ecological unequal exchange, and considerations of cross-national sustainable development.

CHAPTER TWO

ECOLOGICAL UNEQUAL EXCHANGE: A THEORETICAL OVERVIEW

Introduction

Ecological unequal exchange suggests there are substantial inequalities between countries in terms of access to under-valued energy and natural resources as well as the imposition of negative environmental externalities within the periphery, a consequence of the activities of industrialized countries. The structure of international trade is central to such dynamics. The assertion of ecological unequal exchange processes, in turn, is fundamentally at odds with mainstream economic arguments concerning the universally positive consequences of international trade. In particular, a focus upon ecological-distributional conflicts enacted at a cross-national level through trade relations presents a challenge to comparative advantage theory.

Comparative Advantage Theory

Trade has been a key focus of economic thinking since the time of Adam Smith (Bhagwati 2004), and the theory of comparative advantage popularized by David Ricardo (1951 [1817]) is the cornerstone of current neoclassical economic arguments concerning the universally positive benefits accruing through international trade relations (Choi and Yu 2003; O'Brien and Williams 2004). Harrigan (2003) suggests:

> Economists are proud of the theory of comparative advantage, seeing it as both beautiful and profound: beautiful because of its simplicity and elegance, profound because it is surprising and has deep implications for economic policy and our understanding of real economies (p. 86).

Comparative advantage maintains that if a country focuses production and trade upon the one or several commodities over which it is most efficient relative to other activities, thereby minimizing opportunity costs or losses from activities foregone, and trades with other countries pursuing their comparative advantage the consequence is greater and more efficient economic

output. Both Smith and Ricardo argued removing impediments to free trade permitted national specialization in production and export and an international division of labor promoting the most efficient utilization of scarce factors of production on a global scale, improving economic efficiency, general welfare, and promoting greater consumption opportunities, above and beyond that which could be attained through various regimes of trade protectionism (O'Brien and Williams 2004).

Prior to Ricardo it was widely believed international trade was beneficial only if a country had an *absolute* advantage in producing a commodity, whereby they could produce it cheaper than any other country (O'Brien and Williams 2004). Ricardo's revolutionary contribution entailed elaboration upon the argument that if a country pursued its comparative advantage, in textile production for example, it would benefit through freer trade even if another country possessed an absolute advantage in that area (i.e., textile production) (O'Brien and Williams 2004). Remarking upon the implications of Ricardo's argument, O'Brien and Williams (2004) state:

> Under this theory even countries that are economically weak will benefit from a free trade system because their resources will be used more efficiently. Free trade was a universal good (p. 89).

Under free trade a country is rationally drawn to its comparative advantage, suffering economic inefficiencies and disincentives if it is not (O'Brien and Williams 2004; Ricardo 1951 [1817]). And, international trade overall constitutes a positive-sum endeavor wherein all countries benefit despite some possessing unique absolute advantages (O'Brien and Williams 2004). Ricardo (1951 [1817]) states:

> Under a system of perfectly free commerce, each country naturally devotes its capital and labour to such employments as are most beneficial to each. This pursuit of individual advantage is admirably connected with the universal good of the whole. By stimulating industry, by rewarding ingenuity, and by using most efficaciously the peculiar powers

> bestowed by nature, it distributes labour most effectively and most economically: while, by increasing the general mass of productions, it diffuses general benefit, and binds together by one common tie of interest and intercourse, the universal society of nations throughout the civilized world (p. 133-134).

The theory of comparative advantage is considered relevant to all countries but it is envisioned as particularly salient to low-income countries. This is because trade is envisioned as an "engine of growth" promoting labor productivity, technological capacity, and organizational learning that is key to economic development (O'Brien and Williams 2004:140).

Figure 2 is based upon a hypothetical scenario illustrating the proposed gains accrued through comparative advantage.[2] This example, adapted from O'Brien and Williams (2004), shows the United States and Brazil both produce steel and cloth, at varying rates of productivity. The United States has an absolute advantage in production of both commodities, hypothetically the consequence of more advanced technology and newer production facilities. Nevertheless, the theory of comparative advantage suggests trade between the two will still be mutually beneficial.

Stage 1 illustrates the absence of trade. The United States employs 100 workers for a given period of time and produces 900 units of steel, a ratio of 1 to 9. Employment of 100 workers in Brazil over the same time period is less efficient and results in the production of 400 units of steel, a ratio of 1 to 4. The employment of 100 workers in cloth production in the United States produces a return of 300 units of cloth. Again, Brazilian production is less efficient and the same investment returns 200 units of cloth. Total output of steel and cloth between the two countries is 1800 units.

Stage 2 illustrates the reallocation of resources within each country in preparation for trade with one another congruent with their respective comparative advantages. The United States, for example, shifts 10 workers from cloth to steel production. The consequence is the

[2] Figure 2 is constructed from an example provided in O'Brien and Williams (2004: 90-91).

Figure 2. Comparative Advantage Example

Country	Domestic Resources Employed	Total Product Produced	Overall Products Produced
Stage 1: No Trade Between the United States and Brazil			
United States	100 Steel Workers	900 Units (1:9)	**1800 Units** (1300 of steel + 500 of cloth)
Brazil	100 Steel Workers	400 Units (1:4)	
Total Steel		1300 Units	
United States	100 Weavers	300 Units (1:3)	
Brazil	100 Weavers	200 Units (1:2)	
Total Cloth		500 Units	
Both the United States and Brazil produce steel and cloth but at different rates of productivity. For example, 100 U.S. workers can produce 900 units of steel in a given time frame, a ratio of 1 to 9, while 100 Brazilian workers produce 400 units. The U.S. is also more efficient at cloth manufacturing, wherein 100 workers can produce 300 units in given time frame relative to 200 units within Brazil. Overall production in the absence of trade is 1800 units of both steel and cloth.			
↓	↓	↓	
Stage 2: Specialization in Respective Comparative Advantage			
United States	110 Steel Workers	990 Units (1:9)	**1820 Units** (1310 of steel + 510 of cloth)
Brazil	80 Steel Workers	320 Units (1:4)	
Total Steel		1310 Units	
United States	90 Weavers	270 Units (1:3)	
Brazil	120 Weavers	240 Units (1:2)	
Total Cloth		510 Units	
If both countries shift resources to take advantage of their relative comparative advantage in preparation for trade, the U.S. would employ more workers in steel manufacturing and less in cloth. Conversely, Brazil would emphasize the commodity in which it is the most competitive compared to the U.S., cloth production. The consequence is greater individual and overall productivity due to efficiency gains, a total net increase of 20 units (i.e., 1820 vs. 1800 units) within the same time frame as illustrated in stage 1.			
↓	↓	↓	
Stage 3: Trade Between the United States and Brazil			
The U.S. can compensate for its cloth shortfall, a consequence of realignment, by importing 30 units from Brazil. This returns domestic consumption to 300 units, the pre-trade level illustrated in stage 1. Conversely, Brazil can compensate for its steel shortfall, which is 80 units, by importing this amount from the U.S. In sum, trading 30 units of cloth for 80 units of steel adjusts for any shortfalls in production within both countries as a consequence of realignment while maintaining the overall net increase of 20 units (10 in steel and 10 in cloth) acquired through greater specialization.			
↓	↓	↓	
Stage 4: Results After Trade			
United States: 990 units of steel produced – 80 units exported = 910 units of steel, an *increase* of 10 units relative to no trade ties with Brazil (as illustrated in stage 1). Further, 270 units of cloth produced + 30 units imported = 300 units, same as pre-trade stage.			
Brazil: 320 units of steel produced + 80 units imported = 400 units, same as pre-trade stage. Further, 240 units of cloth produced – 30 units exported = 210 units of cloth, an *increase* of 10 units relative to no trade ties with the U.S.			

production of more steel but less cloth. Conversely, Brazil shifts 20 workers from steel to cloth production, therefore producing more cloth but less steel. This reallocation, however, results in greater productivity because of efficiency gains within both countries. Through reallocation the United States has gained 10 extra units of steel and Brazil has gained 10 extra units of cloth, without altering the underlying ratios of investment to production illustrated in stage 1. This increase is a consequence of shifting scarce fixed resources into more efficient production activities. As a result the *overall* production of steel and cloth increases by 20 units.

Stage 3 assumes that the pre-trade level of steel and cloth production in each country is necessary to meet domestic demands. Because of reallocation of production, however, the United States has a shortfall of 30 units of cloth and Brazil has a shortfall of 80 units of steel. Through trade with one another the United States can import cloth and Brazil can import steel to meet their respective pre-trade levels of consumption.

Stage 4 illustrates that through reallocation of domestic resources and trade both countries can meet their respective pre-trade consumption of steel and cloth while increasing production output of each by 10 units. This, in turn, is Ricardo's substantive contribution. By shifting to those activities produced the most efficiently and importing inefficiently produced commodities from other countries pursuing their unique comparative advantage the consequence is greater individual and overall wealth. Despite the absolute advantages the United States possesses in both steel and cloth production, in sum trade relations between Brazil and the United States is characterized by a positive-sum outcome.

National economic specialization congruent with differential comparative advantages within a market system promotes a hierarchical international division of labor between producers (Gilpin 1987). In the short term, this creates a core group of countries characterized by advanced

levels of technology and economic development and a periphery dependent upon the core as a market for commodity exports (Gilpin 1987). Over the long term, however, there is a diffusion of advanced technology, economic production processes, and, subsequently, evolving changes in comparative advantages within the periphery (Gilpin 1987). The market system redistributes wealth and economic activities between societies and benefits all countries in absolute terms, although relative gains may be uneven (Gilpin 1987).

The theory of comparative advantage attributed to Ricardo is based upon the efficiency of labor-input as the central determinant of differential cross-national costs of production (Gilpin 1987). For Ricardo, the value of all foreign goods is based upon labor and land productivity (1951 [1817]). Mainstream economists still follow this lead. However, in the 20th Century Ricardo's formulation began to be viewed as overly narrow and restrictive (Gilpin 1987; van Marrewijk 2002). Subsequently, economists have expanded upon Ricardo's argument by embracing the Heckscher-Ohlin model that maintains comparative advantage is based not simply upon labor productivity but also the relative abundance of factors of production that includes physical and human capital, natural resources, management, and technology (Gilpin 1987; van Marrewijk 2002). The standard formulation of the theory of comparative advantage is now the argument that the driving forces underlying international trade flows are cross-national differences in factor endowments (Gilpin 1987; van Marrewijk 2002). This is especially true of North-South trade given it is still predominantly characterized by inter-industry trade or the exchange of substantially different types of commodities (Gilpin 1987).

Further, the universal economic benefits of an advanced international division of labor are central to contemporary mainstream economic thought, a direct outgrowth of Adam Smith's original contribution (Smith 1985 [1776]) and Ricardo's subsequent refinement (1951 [1817]).

And it is central to efforts of the International Monetary Fund (IMF) to induce LDCs to engage in structural adjustment and World Trade Organization (WTO) efforts to reduce trade barriers (O'Brien and Williams 2004).

The Theory of Unequal Exchange

In contrast to the positive-sum conceptions of trade proposed by the theory of comparative advantage, unequal exchange refers to the inequalities enacted through cross-national trade between economically and militarily non-equivalent partners. Mainstream economists generally dismiss the idea of unequal exchange and the assertion of systemic peripheral exploitation through international trade. Gilpin (1987), for example, argues evidence of such systemic processes is unsubstantiated. He suggests the cause of declining terms of trade for LDCs, or the ratio of export prices received to import prices expended, is internal to their own economies rather than a consequence of the structure of the global economy.

From a neoclassical economics perspective unequal exchange is, by definition, impossible within a non-monopolized free market context (Hornborg 2003). This is because mainstream economists tend to equate "utility" with "exchange value," such that rational actors maximizing their self-interest in a market system define the value of a commodity through the price mechanism (Hornborg 1992:2). In a situation of non-coerced free trade the market price or that which someone is willing to sell and someone willing to pay determines the value of a commodity.

Conversely, from a Marxist perspective the assertion of unequal exchange is implicitly based upon the insistence of some objective underlying *under-valuation* shaped by international trade whereby the true interests of some countries are constrained while other countries are disproportionately rewarded. There exists, moreover, a suspicion that monetary exchange values

or prices and utility are not always synonymous (Hornborg 2003). In turn, unequal exchange suggests the objectively asymmetric transfer of real value that cannot be identified simply through reference to prices, which more often obscure than illuminate the substantive flows South to North underlying trade relations (Hornborg 2003).

The label *unequal exchange* is attributed to Arghiri Emmanuel who coined the term in the 1950s in an effort to refute the theory of comparative advantage as formulated by David Ricardo (Wallerstein 2004). Emmanuel notes the ideology of comparative advantage has long reined concurrent with, somewhat paradoxically, the real-world engagement in various forms of trade protectionism by the even the most enthusiastically capitalist countries, suggesting an historical contradiction between word and deed (1972).

Unequal exchange can be broadly defined as the assertion of asymmetrical power relationships between industrialized countries and LDCs wherein the former gain disproportionate advantages at the expense of the latter through international trade. The assertion of unequal exchange relations diverges from neoclassical economic thought by inquiring into the historical power relations that have shaped present comparative advantages, rather than taking present comparative advantage as a given (O'Brien and Williams 2004). In addition, Marxist critiques point to the influence of international trade as a mechanism stabilizing the international division of labor thereby making development problematic within the periphery and concentrating economic power in the industrialized countries (O'Brien and Williams 2004).

Over time unequal exchange produces structural tendencies facilitating and constraining the "action capabilities" of particular countries or the ability to seize opportunities, generate new options, and influences the conditions and terms of exchange in which they are enmeshed in the global economy (Baumgartner, Buckley, and Burns 1976: 51). Baumgartner et al. (1976) argue

cross-national exchange may be unequal because of: 1) unequal productive capabilities allowing for the differential ability to take advantage of positive opportunities and avoid negative outcomes. This includes the ability to restructure internally so as to remain flexible and adaptable in relation to other countries and evolving circumstances; and, 2) differential capacity to shape the broader structure of exchange relationships to influence the relative benefits and liabilities likely to accrue to different actors in the future.

Mainstream economic conceptions of comparative advantage neglect, therefore, the structural history shaping present exchange relationships as well as the dynamic and evolving efforts of industrialized countries to exercise relational control or power over the institutions and rules governing cross-national economic exchange (Baumgartner and Burns 1975). The creation of OPEC in the 1970s is arguably an example of a counter-hegemonic attempt by oil-producing developing states to assert some relational control to improve their terms of trade through unified action (Baumgartner and Burns 1975).

The suggestion of unequal exchange lies at the heart of world-systems analysis, as it is a central mechanism of exploitation upon which the systemic relations between countries is enacted and reproduced. Many world-systems theorists do not view unequal exchange as exclusively zero-sum but, rather, disadvantageous such that alternative systemic relationships could potentially produce greater relative benefits for LDCs but, nonetheless, their realization is improbable given the structural momentum of the world-system and the powerful vested interests seeking to maintain asymmetrical relations.

Dependency, in contrast, refers to a situation in which the dominant modes of production, division of labor, and overall political-economic dynamics of a country are subject to and fundamentally shaped by the political-economic activities of other countries in a manner that

generally tempers or constrains development potential (see, for example, dos Santos 1970). Unequal exchange is a mechanism that perpetuates and shapes dependency relations. There tends towards, moreover, a reciprocal relationship between unequal exchange and dependency.

Emmanuel (1972) formulated a more specific definition of unequal exchange, attempting to specify its particular mechanisms. He argues trade generally consists of the export of capital intensive, high wage products from industrialized countries in exchange for labor intensive and low wage products from the periphery. Wage differentials, moreover, cannot be explained simply as the consequence of divergent labor productivity but are strongly influenced by historical development patterns that have largely protected the disproportionate wage rates in the industrialized countries. Low wage rates in the periphery are perpetuated by the substantial cross-national immobility of labor but relatively greater mobility of core investment capital, allowing access to the abundance of reserve labor in LDCs. As a consequence, Emmanuel argues, international trade reinforces differential cross-national wage rates and contributes to relatively higher labor exploitation and coercion in peripheral countries. This exchange is unequal as capitalists within industrialized countries capture significant portions of the labor value that otherwise would accrue within the periphery (Emmanuel 1972). Following Emmanuel's argument, there is a "flow" of labor value from South to North through international trade that cannot be conceptualized through exclusive reference to neoclassical economic suggestions that the market price for labor is congruent with labor productivity.

In critiquing the theory of comparative advantage, Emmanuel notes that after elaborating upon the economic benefits of trade Ricardo never inquired into the proportions by which hypothetical trading partners share the consequent efficiency gains (1972). Ricardo presupposed exchange on an equal basis. In other words, using figure 2 as an example, Ricardo never

seriously considered the mechanisms by which the 20 units of overall productivity gained through trade between the United States and Brazil would be allotted to each.

Emmanuel's conception of the mechanisms of unequal exchange is arguably the most well known. The debate, however, over the precise mechanisms of unequal exchange remains an important but divisive issue among Marxist-oriented scholars. Wallerstein's well-known elaboration upon the development of the contemporary world-system over the past 500 years (1974) largely adopts Emmanuel's conception of the exploitation of peripheral labor and the drain of surplus value not only at the point of production but also through cross-national exchange relations. Wallerstein views the international division of labor, which Smith praised for its efficiency, as facilitating the exploitation of the periphery or LDCs by the core industrialized countries. Wallerstein states (1974):

> We have defined a world-system as one in which there is an extensive division of labor. This division is not merely functional—that is, occupational—but geographical. That is to say, the range of economic tasks is not evenly distributed throughout the world-system. In part this is the consequence of ecological considerations, to be sure. But for the most part, it is a function of the social organization of work, one which magnifies and legitimizes the ability of some groups within the system to exploit the labor of others, that is, to receive a larger share of the surplus (p. 349).

Asserting an Ecological Dimension of Unequal Exchange

In addition to the transformative dynamics of labor, human societies require the continual appropriation of energy and raw materials from and externalization of waste products or pollution with ecological systems. Socioeconomic metabolism refers to this cycling of biophysical flows between human societies and ecological systems (Fischer-Kowalski and Haberl 1998). Further, human societies are connected not only to nature but interwoven into systemic patterns of cross-national exchange of energy and natural resources. Structured relations forged through international trade shape the socioeconomic metabolism of countries at

different positions in the global economy. Such interactions shape the socioeconomic metabolism of the world-system more broadly, constituting the material foundation of capital accumulation and standards of living of human societies.

The socioeconomic metabolism of the world-system, in turn, consists of the interdependent flows of energy, natural resources, and waste products between countries, shaping the differential processes of production-consumption-accumulation at different positions in the global economy. The patterns reflected in nighttime satellite photos are indicative of these flows and evidence of the ecological foundation of the core-periphery divide (Hornborg 2001).

Ecological unequal exchange is based upon the argument that there are objectively asymmetrical transfers of value embodied in South-North flows of energy and natural resources. It is increasingly recognized as a mechanism, in addition to labor exploitation, underlying the socio-economic and environmental disparities between countries and as a regulative mechanism shaping the socio-economic metabolism of the world-system. Diverse strands of research in political ecology, world-systems theory, anthropology, sociology, and ecological economics focus upon such ecological-distributional patterns (Andersson and Lindroth 2001; Bunker 1985; Giljum and Eisenmenger 2004; Hornborg 1998a, 1998b, 2001; Jorgenson 2004; Muradian and Martinez-Alier 2001a). Despite such diverse disciplinary starting points, arguably a key unifying insight is that capital accumulation is fundamentally rooted in alteration of ecological systems and the exploitation of labor. It shapes both the social relations of production and the structure and integrity of ecological systems.

Bunker's work (1984, 1985) represents one of the first attempts to elaborate upon an ecological dimension of unequal exchange. He argues the underdevelopment of the Amazon through incorporation into the capitalist world economy is principally based upon extraction of

value from nature and secondarily the drain of surplus labor. He reasons from this case study that peripheral countries primarily based upon the export of natural resources have unique internal dynamics and socio-organizational logic distinct from LDCs integrated into the global economy primarily through low-wage labor. Natural resource exports from the periphery tend to be characterized by a low ratio of capital and labor incorporated into the final exchange value. Such modes of extraction interact with the social, legal, political, and commercial activities of industrial processes wherein labor and technology is a central dynamic but they do not reduce to nor are they synonymous with such modes of production (Bunker 1985).

Marx focused upon the capital-labor relationship as the keystone of his theory of value, and the divergence between what workers produce and what they consume constitutes surplus value and the source of accumulation (Deleage 1994). Commodities in which equal quantities of labor are incorporated, Marx argued, or which can be produced in the same time are equivalent in terms of value (Deleage 1994). Nature primarily remained the under-theorized object subject to labor transformation but scarcely an additional determinant of surplus value, also subject to the dynamics of the market system (Deleage 1994). In turn, in many respects Marx's theory of value was congruent with the classical political economists of his era he was attempting to refute in this regard, Deleage argues (1994). In the contemporary era global processes of accumulation are straining the physical limits of ecological systems and it is increasingly apparent that natural capital has intrinsic value and is exploited in an uneven manner as a consequence of capital accumulation (Deleage 1994).

Hornborg adopts and elaborates upon many of Bunker's substantive arguments. He suggests neoclassical economics is blind to the under-valuation and perpetual transfer of "productive potential" South-North through natural resource exports, a consequence of

conflating exchange value and utility (2003). Undercompensation for energy and natural resources from the periphery is signified by exchange rates allowing the industrialized countries to increase their relative share of scarce natural capital at the expense of LDCs (Hornborg 2001). It is this discrepancy between productive potential and economic valuation enacted through and obscured within market exchange that fuels the disproportionate socio-economic metabolism supporting the technology, infrastructure, and consumption profiles of industrialized countries, Hornborg argues (2001). Accelerating industrial production and cross-national trade, in turn, are mutually reinforcing. Further, the orthodox Marxist view suggesting labor exploitation is the only source of derivation of surplus value is overly narrow, neglecting the thermodynamic basis of human economies as they appropriate and dissipate energy (Hornborg 2001).

The work of Bunker, Hornborg, and increasingly other scholars whose work diverges from mainstream neoclassical economics and orthodox Marxist approaches are united in the insistence that unequal exchange encompasses more than simply the drain of surplus labor value from the periphery. There exists, moreover, systemic ecological unequal exchange draining the periphery of energy and natural resource assets in order to support the material consumption demands of industrialized countries. Conceptualization of development and underdevelopment requires a broader consideration of the ecological origin of the materials subsequently transformed through labor.

Defining Ecological Unequal Exchange

Ecological unequal exchange argues countries advantageously situated within the structural interaction networks of global exchange, in part a consequence of wealth, and political and military strength, are more likely to secure favorable terms of trade promoting disproportionate access to global natural resources and sink-capacity services of ecological

systems. In turn, this access facilitates the externalization of many of the negative environmental consequences of domestic production, consumption, and disposal activities supporting their standard of living and maintenance of their built industrial infrastructure.[3] Further, the macrostructural empirical consequences of ecological unequal exchange are manifested in three interrelated processes:

1) *Environmental cost-shifting* or externalization of the social and ecological costs of extraction and distribution of natural resource exports from LDCs, enhancing environmental degradation and depletion at the local level.
2) The disproportionate and uncompensated utilization of global *environmental space* or available sink-capacity and biologically productive area, limiting utilization opportunities of LDCs.
3) Environmental cost-shifting and appropriation of environmental space contribute to *processes of underdevelopment* within LDCs. Underdevelopment is a consequence of the out-flow of value associated with the export of undervalued natural resources and diminishing environmental space utilization opportunities. This exacerbates socio-economic and demographic dislocations at the local level and contributes to environmental degradation and exhaustion of natural resource assets.

Countries at various structural positions within the global economy are arguably subject to these processes in different ways. However, LDCs integrated into the global economy predominantly through the export of raw and minimally processed natural resources and/or exports to the most industrialized countries are likely to be particularly vulnerable.

Analysis of ecological unequal exchange builds upon and complements social science research focused upon the driving forces of global environmental change. Further, it seeks to evaluate the non-linear and contingent dynamics underlying the differential environmental burdens and opportunities facing countries at divergent hierarchical positions in the world-system. This focus is based upon the increasing recognition of many non-monotonic

[3] Our definition and elaboration is drawn from numerous sources, many of which do not necessarily incorporate this label. It is a broad synthesis of varying, but we argue, congruent processes.

relationships between position in the world-system and environmental outcomes (Burns, Davis, and Kick 1997).

Underlying the monetary indicators that are the conventional evidence of the increasing economic interconnectedness of nation-state economies are the material or ecological flows underwriting economic globalization. These ecological flows are easily overlooked when referencing only monetary indicators but become more visible through reference to biophysical measures. For example, examining non-renewable resources central to economic growth exported South-North between the mid-1970s and the mid-1990s, including fossil fuels, iron, and aluminum, there is evidence that by weight export of these materials has increased for 14 of the 18 resources studied (Giljum and Eisenmenger 2004). The export of aluminum by weight, for example, increased 660 percent over this period. For 16 of these 18 non-renewable resources, in contrast, the price dropped over the 20-year period (Giljum and Eisenmenger 2004). From a monetary perspective the movement of natural resources South-North appears to be decreasing, but in physical terms there is clearly an increasing movement or flow of materials South-North over this 20-year period.

Whereas Emmanuel (1972) highlighted the asymmetrical flow of labor time between developing and developed countries underlying monetary indicators, ecological flows suggest the asymmetrical movement of natural space (Hornborg 2003). This natural resource asymmetry, moreover, constitutes the peripheralization of environmental burdens both intra and inter-nationally along asymmetries in power and opportunity. Environmental pressures, therefore, are often directly and indirectly the consequence of the export-import of biophysical or material flows of natural resources (Muradian and Martinez-Alier 2001c), as well as manufacturing activities.

Domestic environmental pressures include the pollutant emissions, land use degradation, deforestation, toxic wastes, and other ecological burdens as well natural capital and sink-capacity loss arising through extraction, production, and distribution supporting export activity. Natural capital includes the stocks of natural resources that yield important goods and services, including such assets as forest, fish, and water resources (Wackernagel and Rees 1996.) Sink-capacity refers to the waste assimilation properties of ecological systems.

Foster and Clark (2004) argue ecological imperialism or the looting of ecological resources of the periphery has long been an important engine of accumulation for core countries as this allows for enhanced capital accumulation at unsustainable rates through the degradation of ecological resources within the periphery. This process includes the imposition of "socio-ecological regimes of production" within peripheral countries or a restructuring of labor and environmental resources oriented towards the intensification of production and capital accumulation for the core (Foster and Clark 2004:194). An example includes the development of export-oriented monocultural agricultural operations within peripheral countries. Such operations often monopolize the most productive agricultural land, promote the destruction of subsistence farming, and utilize large quantities of chemical pesticides (Smith 1994). Monoexport agricultural operations generally increase aggregate output measured in market prices, a consequence of importation of industrial technology and organization, but is also implicated in the concurrent decline in local food consumption and nutrition (Smith 1994).

Environmental flows move both from and to the periphery as ecological unequal exchange is dependent upon not only resource flows South-North but pollution and waste moving North-South. Mining operations are environmentally intensive at the local level, increasingly located in LDCs, and primarily oriented towards export to the industrialized

countries (Muradian and Martinez-Alier 2001b). Many mining operations in LDCs are directly tied to environmental degradation, heavy metal contamination of soils and waterways, and impairment of the health of local populations as a consequence of the extraction and distribution for export of unprocessed and semi-processed minerals and ores (Muradian and Martinez-Alier 2001b). The life cycle of oil, the most valuable commodity in world trade, is characterized by a multitude of environmental externalities or unpaid and generally unaccounted for environmental costs or burdens (O'Rourke and Connolly 2003). From the early stages of exploration, drilling, extraction, and transport, to subsequent refining and consumption, the negative social and environmental costs of oil are predominantly borne by indigenous groups, migrant workers, and the poor, both intra and inter-nationally (O'Rourke and Connolly 2003). Increasing movement of mining and petroleum operations to the periphery constitutes one example of a broader process of displacement of ecological burdens and of sink-capacity needs of industrialized countries.

In addition, Frey (1998, 2003) documents the cross-national movement of hazardous manufacturing production processes, and consequently hazardous waste production, from industrialized countries to LDCs (see also Clapp 2001). Ostensibly, this is an example of evolving cross-national socio-ecological regimes of production that are essentially "pollution havens" or locales in the periphery offering lower environmental and labor regulations. Frey (2003) argues transnational corporations (TNCs) appropriate ecological carrying capacity for and displace risk from the developed countries through such transfers to the periphery of the global economy. Export processing zones within LDCs, areas designed to attract foreign direct investment and promote export-oriented growth through less stringent import-export restrictions, taxes, and labor and environmental regulations, are the location of many transfers of hazardous industries. Further, peripheral governments often lack the expertise and resources to effectively

manage the social and ecological problems that are a consequence of this transfer of environmentally intensive production processes (Frey 2003).

Energy is the largest category of trade in natural resources (Goldstein, Huang, and Akan 1997) and a central dynamic of South-North ecological flows. Energy includes such commodities such as oil, natural gas, coal, nuclear, and hydro-electricity. The trade in energy South-North accelerated significantly after World War II (Goldstein et al. 1997; Podobnik 2002). Overall, the North imports and the South exports energy, even as the developed economies continue to increase their energy efficiency over the long-term (Goldstein et al. 1997; Podobnik 2002). LDCs account for approximately 76 percent of global population but only 26 percent of the world's commercial energy consumption (Goldstein et al. 1997).

Podobnik (2002) argues global trade in energy approximates a zero-sum, bounded-system wherein the gain to one country implies a loss for another, despite the potential for technological change or adaptation. He argues this is a consequence of: (1) the fact that 90 percent of the commercial energy consumed in the world consists of non-renewable resources; and, (2) the substantial global ecological problems that energy consumption creates. Further, there is a strong association between energy consumption and efficiency of energy use and economic output measured as gross domestic product (GDP) (Hale 1997). Energy acquisition and efficiency, in turn, are important factors in a nation's ability to project international power (Hale 1997).

To clarify the potential ecological-distributional processes underlying North-South trade relations, researchers have adopted the concept of environmental terms of trade (ETT) (Giljum and Eisenmenger 2004; Muradian and Martinez-Alier 2001a; Muradian, O'Connor, and Martinez-Alier 2002). Environmental terms-of-trade characterizes the environmental pressures of a country's exports relative to its imports (Giljum and Eisenmenger 2004; Muradian et al.

2002). Efforts to measure ecological flows and consequent environmental terms of trade attempts to make visible the off-shoring or displacement of environmental loads or pressures created by the production-consumption-accumulation activities within an importing country, or even entire region, but realized within the exporting partner, a consequence of the structure of their trade relations.

Muradian et al. (2002), for example, estimate the embodied air pollution emissions in trade between the United States, Japan, and Western Europe and their respective trade partners. Japan and Western Europe illustrate improving environmental terms of trade with developing countries as embodied air pollution in imports exceeds that incorporated into exports, suggesting a progressive off-shoring over the period (Muradian et al. 2002). In contrast, the United States is characterized by deteriorating environmental terms of trade with developing countries from 1976-1994, suggesting that for the pollutants under examination U.S. exports are increasingly more environmentally intensive than are imports.

The shifting balance of environmental loads made possible through cross-national trade complicates the assessment of the validity of the environmental Kuznets curve. The environmental Kuznets curve refers to evidence that some environmental burdens increase with economic growth but eventually reach a point at which environmental impact per unit of economic output begins to decline, a consequence of increasingly efficient technology, rational institutional structures, and civil society demands. There may exist, therefore, an inverted-U relationship between some environmental burdens and economic growth. This potential applies in particular to the relatively more mature industrialized countries, and it is an important theoretical focus of neoclassical economics and the ecological modernization perspective within sociology.

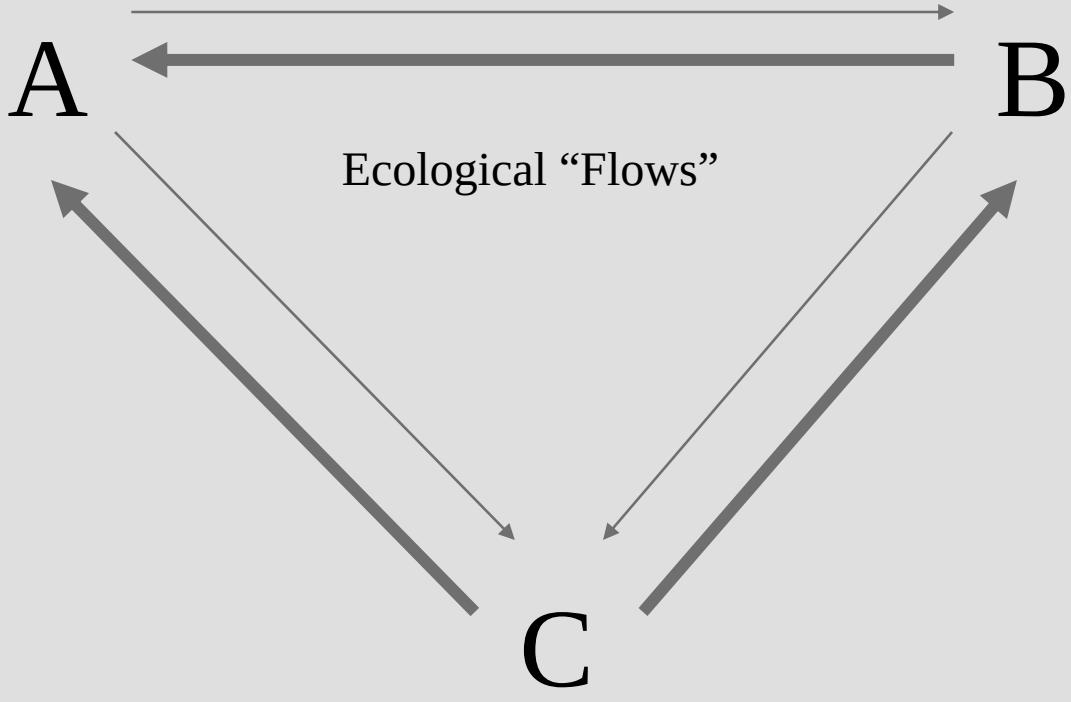
Instances of declining environmental impact in some countries may be partially or wholly based upon evolving trade relations as opposed to the greening of technology and production processes. Muradian et al. (2002) highlight the point that if over time embodied pollution in imports exceeds local reductions in pollution within industrialized countries this may be less the consequence of a decoupling of environmental pollution and economic growth than the progressive displacement of environmental burdens abroad. Environmental burdens, in other words, will have declined as a consequence of evolving trade relations rather than evolving technological and organizational change.

The hypothetical scenario in figure 3 illustrates the concept of ecological flows and consequent environmental terms of trade between countries. For example, the exports from country B to A are characterized by a greater domestic environmental load or burden than are imports to B from A, as indicated by the heavier arrow. Country B can therefore be defined as exhibiting an environmental terms of trade surplus relative to A in that its exports produce greater environmental pressures. The exports of country C, in contrast, are domestically more environmentally intensive than are its imports from either A or B. In this scenario, therefore, A is in the most advantageous position regarding relative environmental terms of trade. Country C, however, is in the most disadvantageous position.

This scenario depicts what (Held, McGrew, Goldblatt, and Perraton 1999) refer to as the globalization of the environment or what others refer to as the increasing ecological flows underlying the global economy. A key question is whether the relationships depicted in figure 3 constitute ecological unequal exchange.

Muradian et al. (2002) define ecological unequal exchange as a situation in which the environmental load of a country increases in tandem with the simultaneous decrease within a

Figure 3. Hypothetical Environmental Terms of Trade Scenario



Note: Ecological flows refer to the cross-national movement of natural resource assets and liabilities. Arrows represent direction and weight of environmental loads or negative ecological pressures transferred between three hypothetical countries through trade. Heavier arrows symbolize greater environmental load or burden. For example, as depicted above, the exports of "B" to "A" are characterized by greater domestic environmental load than are the imports to B from A. Therefore, B is defined as exhibiting an environmental terms of trade surplus relative to A.

trading partner, a situation clearly illustrated in figure 3. Hornborg (2003) suggests ecological unequal exchange constitutes the asymmetric transfer of productive potential, other than money, enhancing the productive capacity of one partner at the expense of the other. Andersson and Lindroth (2001) refer to unequal ecological exchange as an imbalance, calculated in ecological footprints, between imports and exports and as unsustainable if such trade promotes a progressive reduction in natural capital in at least one trade partner. They note unequal ecological exchange is the general rule in the global economy and may be mutually beneficial, despite the net-transfer of biocapacity, as trade may enhance allocative efficiency or the more

efficient utilization of resources among all trade partners and need not lead to long-term ecological problems. Such exchange may also, in contrast, promote unilateral or mutually unsustainable ecological consequences (Andersson and Lindroth 2001).

Figure 3 could illustrate a situation in which A is a net importer of biocapacity and net exporter of environmental sink-capacity. If A's trade relations with B and C provide increasing access to natural resource consumption opportunities while decreasing domestic environmental burdens, to the detriment of either within B or C, then the assertion of unequal environmental exchange appears warranted. Such a scenario illustrates how trade can lengthen the ties between domestic production-consumption-accumulation and environmental outcomes. If the relatively more environmentally intensive exports of B and C are systematically undervalued, in turn, then both B and C are in situation of ecological unequal exchange relative to A wherein not only natural capital may be depleted but human and physical capital as well as social and economic development are declining.

The theory of ecological unequal exchange is most profitably drawn from the unexplored interface of different disciplinary boundaries (Hornborg 2001). This includes in particular sociology, ecological economics, anthropology, and political ecology. This study relies upon previous theoretical and empirical work from all of these areas but, in particular, conceptualizes issues of ecological unequal exchange from a world-systems perspective. This is congruent with Bunker's work (1984, 1985) and Hornborg's insistence that cross-national ecological-distributional dynamics conform to the uneven and inequitable processes of capital accumulation (1998a), a dynamic that is the central focus of world-systems scholars. Ecological transformation, moreover, is shaped by the interdependencies among countries, of which trade is a central expression, and not simply domestic-level dynamics. There is a substantial theoretical

and empirical body of work in dependency and world-systems analysis useful as a point of departure in examining issues of ecological unequal exchange.

Overview of World-Systems Analysis

The failure of many LDCs in not following the development trajectory of the industrialized countries is a conundrum embraced by world-systems analysis, a perspective that gained prominence beginning in the mid-1970s subsequent to Wallerstein's publication of *The Modern World System I* (1974). Wallerstein's analytical perspective shares many of the tenets of earlier dependency theory but is arguably a more detailed historical account of cross-national political-economic relations. Less developed countries, Wallerstein argued, are not likely to follow a parallel trajectory towards economic development because the world economy is structured into zones delineated by power and societal position in the global division of labor and production. Social conflict is at the root of these systemic relations, moreover, and "development" within the context of the world economy is characterized by substantial zero-sum contests among nations, vying for advantage within global processes of capital accumulation.

World-systems scholars view the global economic system as comprised of nation-state economies that fall into relatively distinct hierarchical positions composed of core, semi-peripheral, and peripheral societies (Chase-Dunn and Grimes 1995; Chase-Dunn and Hall 1997; Wallerstein 1974). The Western industrialized countries and Japan constitute the core of the system and are characterized by the control of capital, value-added manufacturing, natural resource imports, preferential trade relationships, and political and military control of the integrity of the structure of the system. The underlying international division of labor is not based upon comparative advantage but systemic relations of exploitation characterized by differential specialization within a global system of production and exchange of commodities.

From this viewpoint, the world economy can be conceptualized as a treadmill of production that is increasingly global in scope, even as the relative benefits remain inequitably distributed (Bunker 2005).

The world-system is a consequence of systemic intersocietal networks of interaction exhibiting patterned structural reproduction and development over time (Chase-Dunn and Hall 1997). Such interconnections shape the differentiated but interacting parts that constitute the systemic relations among countries (Chase-Dunn and Hall 1997). World-systems dynamics also influence collectivities at smaller scales, including cities, sub-national regions, communities, firms, and even households (Chase-Dunn and Hall 1997).

Capital accumulation is the driving force of world-system processes (Wallerstein 1974), shaping economic, political, and ecological change and forging distinctive dynamics relative to position in the global economy. Over the last 500 years capitalism has spread throughout the globe and now constitutes the deep structural logic and infrastructure connecting the forces of production, technology, and class relations of virtually every country in the world (Wallerstein 1974). It is these global networks of production, distribution, and consumption that give systemic form to the world-system (Wallerstein 1974).

This system of exploitation and interdependence has shaped economic, social, political, and environmental dynamics over the past 500 years (Wallerstein 1974), perhaps longer (Chase-Dunn and Hall 1997; Chew 2001). Chase-Dunn (1999) argues that in the contemporary era core nations attempt to maintain their privileged positions by controlling trade relations and raw material imports, rather than conquering each other to exact tribute or taxes as in previous world system configurations. Further, the militarism of dominant industrial states both contributes to the stability of global hierarchical structures and produces non-market environmental burdens

(see Hooks and Smith 2005). Set in motion by arms races and geopolitical posturing, the "treadmill of destruction" involves the research, development, maintenance, and employment of military capacity by dominant states both in peacetime and in war (Hooks and Smith 2004, 2005:21). The environmental burden posed by militarism, moreover, can be far-reaching and characterized by the inequitable imposition of environmental externalities cross-nationally.

In contrast to the neoclassical economics focus upon efficiency and the prospective mutual benefits to be gained among nations through trade, world systems theorists see the potential for exploitive systemic relations. This skepticism, moreover, leads world-systems theorists to question the environmental consequences of international trade relations. Environmental degradation, like economic exploitation, is based upon the hierarchical processes of commodity production, capital accumulation, and labor and natural resource exploitation. Environmental exploitation, in turn, is primarily rooted in unequal exchange whereby core countries appropriate the natural resources of less developed countries.

Development and underdevelopment are mutually constituted, the former made possible by the latter (Frank 1966). Over time peripheral countries exhibit characteristics of underdevelopment as developmental potential remains largely unrealized or is siphoned away as a consequence of structured interaction with more economically and politically dominant countries. Underdevelopment, Amin observes (1974), is not synonymous with poverty. It is characterized by economic, class, social, and political structures within peripheral countries congruent with narrow endogenous and exogenous vested interests often incongruent with broader development goals.

World-systems analysis constitutes a profound break from the conception of development as a linear process of social structural reorganization, technological development and adoption,

and establishment of market oriented institutional practices and the rule of law, as embodied in Rostow's stages of economic growth (1960). Further, world-systems theory represents a counterpoint to many neoclassical economic tenets suggesting development in the periphery is a consequence of increasing economic integration in a free-market global economy, combined with domestic institutions that support and protect domestic market activity.

There are three conceptual levels within the world-systems perspective. Each is an important context for empirical examination. These include: (1) positional or structural location *within* world-system positions, (2) distributional or *between* world-system position processes, and (3) domestic level dynamics.

In order to situate the discussion of ecological unequal exchange within previous analysis from a world-systems approach, the next section distinguishes a distributional focus from the domestic and positional levels. All three can be analytically separated but, ultimately, are mutually constituted, in essence interdependent "layers" contributing to the complexity of global social and environmental change.

Distributional Level Processes

Distributional dynamics between positions in the global economy is at the heart of world-systems analysis (Chase-Dunn and Grimes 1995; Wallerstein 1974). Such relational processes both shape and stabilize the hierarchical structure of the global economy. Numerous studies based upon a network analysis methodology provide evidence of the asymmetrical structure of global economic and political relations or an identifiable "form" to international exchange relations (Snyder and Kick 1979; Nemeth and Smith 1985; Smith and White 1992; Mahutga forthcoming). For example, core countries trade heavily with each other, particularly in terms of

intra-industry trade, and with the periphery, in terms of inter-industry trade, but peripheral countries are relatively isolated from each other.

Processes of ecological unequal exchange are fundamentally distributional but such factors interact with both domestic and positional dynamics. Further, the negative impacts of distributional processes are often the most substantial to be greatest between the core and peripheral countries, and less so between the core and semi-peripheral countries. This is consistent with the hierarchical structure of the world-system (Wallerstein 1974) and Galtung's logic of imperialism through trade relations (1971).

Positional Level Processes

There are often structural similarities or general tendencies within world-system positions. Arguably, these positional dynamics are shaped by the variable historical incorporation of different regions of the world into the capitalist global economy and the subsequent development opportunities that are available. For example, research illustrates the positional or zone specific impact of urbanization upon deforestation is strongest in the periphery and semi-periphery, while percent of the population composed of adults, the most economically active segment, is only significantly related to deforestation in semi-peripheral countries (Burns et al. 2003). This research illustrates that not only do rates of forest cover change vary systematically by world-system position but so do the driving socio-economic forces of deforestation.

Domestic Level Processes

Examination of positional location within the world-system or the distributional processes of between position dynamics are arguably insufficient for conceptualizing all social and environmental outcomes. Countries within world-system positions can exhibit considerable

variance on particular environmental indicators, evidence of the importance of internal factors, even as there tends to be recognizable patterns or structural similarities across respective world-system positions on these same indicators, suggesting the validity of external factors as well. The social organization of production and consumption, population growth, political structure, civil society social movements, degree of labor organization, and other domestic dynamics are relevant explanatory factors, although from a world-systems perspective domestic processes are never truly divorced from the larger structural context. For example, carbon dioxide emissions inefficiency is relatively greater in countries characterized by higher military spending, irrespective of world-system position (Roberts, Grimes, and Manale 2003). Nonetheless, political regime repressiveness is also positively associated with carbon dioxide emissions inefficiency but the effect is the most substantial within non-core countries (Roberts et al. 2003).

The Generation of Ecological Unequal Exchange

Examination of ecological unequal exchange is oriented towards refinement in conceptualizing the layers and complexity of global environmental and social change within the world-system. The global economy is based upon an increasingly internationalized environment wherein economic and political interests far from the physical location of specific resources influence their form and utilization (Redclift 1987). Accordingly, environmental outcomes are increasingly the consequence of transnational processes (Redclift 1987).

Economic dependency is characterized by a situation wherein the economy of some countries is shaped by and conditioned through the development and expansion of other countries (dos Santos 1970). Similarly, processes of ecological unequal exchange suggest structured relations of “environmental dependency” or a situation wherein the ecological resources of some countries is shaped through their exchange relations with state and capital

interests of more economically developed countries. As Chew (2001:2) notes, industrialized countries cast “ecological shadows” extending well beyond their geographic/political boundaries, influencing the socio-economic and environmental context of LDCs.

Bunker’s detailed history of the incorporation of the natural resources of the Brazilian Amazon into the global division of labor is an early example illustrating the ecological side of unequal exchange (1984, 1985, 2003). Bunker stresses theories of development and underdevelopment have failed to account for the fact that extraction and export of natural resources South-North constitute both: 1) a transfer of value embodied in matter and energy; and, 2) path dependent dynamics as extractive activities at one point in time shape the ecological, demographic, organizational, and infrastructural context in which subsequent development efforts are situated, often complicating future value-added production in resource extraction oriented LDCs.

Further, theories of development/underdevelopment have insufficiently recognized the fundamental differences between the internal dynamics and logic of accumulation of extractive and productive economies (Bunker 1984, 1985). This distinction is crucial as Bunker locates the origin of ecological unequal exchange within the interdependent but differing internal dynamics of each (1984, 1985). It is not extraction of natural resources and energy, per se, promoting ecological unequal exchange but the socio-organizational consequences this tends to produce between and within exporting and importing regions. The historical interactions between modes of extraction and production create path dependent dynamics shaping the historical development trajectories of differentially situated countries (Bunker 1984, 1985).

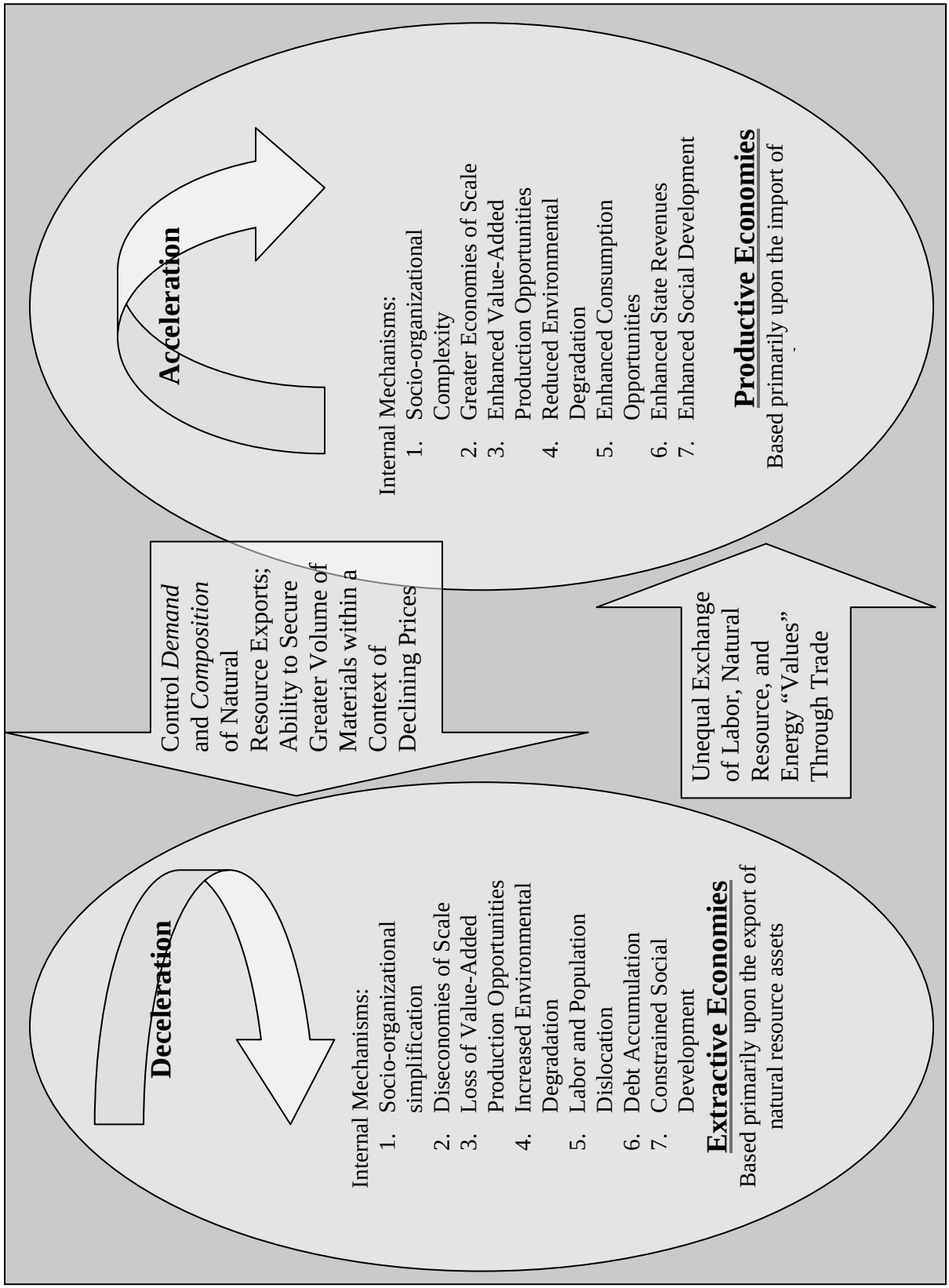
Figure 4 illustrates Bunker’s argument concerning the interrelation of extractive and productive economies in the world-system and the production of ecological unequal exchange

(1984, 1985). The ideographic dynamics connecting a particular natural resource exporting LDC into the global economy are fundamentally shaped by the physical characteristics of the predominant commodities exported, their arrangement and abundance topographically, and the transport systems devised to overcome the obstacles encountered through movement of the commodities over physical space (Bunker 1985). Such dynamics differ in important respects across individual cases. Conversely, figure 4 illustrates the nomothetic propositions derived from an overview of Bunker's analysis of the incorporation of the Amazon region into the capitalist global economy.

Extractive economies tend to possess a unique class structure, organization of labor, property relations, activities of the state, and physical infrastructure of sub-national regions oriented towards the export of geographically and topographically site-specific and unique natural resources (Bunker 1985). The export of monetarily undervalued natural resources from extractive economies is characterized by a loss of value that cannot be measured solely in terms of the appropriation of surplus labor (Bunker 1985). However, labor reorganization and exploitation within such modes of extraction is also crucial to the unequal appropriation of value between productive and extractive economies (Bunker 1985). The mechanisms of cross-national exploitation and underdevelopment reside, therefore, in the complex interaction of internal and external forces, the unequal appropriation of value from labor and nature within extractive economies (Bunker 1985).

Productive economies, in turn, are characterized by a division of labor, spatial organization of firms and enterprises, technological capacity, and physical infrastructure oriented

Figure 4. Ecological Unequal Exchange Mechanisms



towards a multitude of complex processes of value-added production (Bunker 1985). The energy and materials flowing through productive economies in the industrialized countries is partially conserved in useful forms that include built infrastructure and physical and human capital, promoting complex social and economic organization. Conversely, retention of energy and materials in extractive economies often proves problematic. This promotes the simplification of social and economic organization over time. There is, in turn, a process of acceleration-deceleration between productive and extractive economies. Further, Bunker (1985) argues:

> Analysis of energy flows between regions and of different uses of energy in different regional formations provides a much fuller explanation of uneven development than any drawn from conventional economic models. If energy and matter necessarily flow from extractive to productive economies, it follows that social and economic processes will be intensified and accelerated in the productive economy and will become more diffuse and eventually decelerate in the extractive economy. The flow of energy and matter to productive societies permits the increased substitution of nonhuman for human energies, allows for increased scale, complexity, and coordination of human activities, stimulates an increasing division of labor, and expands the specialized fields of information which this entails (p. 47).

Ecological unequal exchange, therefore, is contingent upon differential cross-national social organization and accelerated production-consumption-accumulation linkages in the industrialized countries, facilitating the ability of state and private capital interests to determine global demand for natural resources (Bunker 1985; Hornborg 2001). The capacity to control demand ensures core interests engage in the substantive decisions regarding global export activity and subjects peripheral countries to ever-changing market forces (Bunker 1985). Local populations, social organization, infrastructure, and ecosystems within extractive regions in LDCs are often continually disrupted in the face of malleable core needs. Extractive regions failing to reorganize to conform to core interests, in turn, are likely to be subject to declining terms of trade or abandoned entirely in lieu of natural resource exports originating elsewhere.

Productive and extractive economies are mutually dependent upon the other but the form, boundaries, and constraints underlying these interconnected relations are asymmetrical. Extractive economies are *directly* dependent upon natural resource production within their own borders and a limited number of potential markets for their commodities (Bunker and Ciccantell 2005). In contrast, productive economies are characterized by *diffuse* dependence. They require access to cheap raw materials but this dependence is more flexible as productive economies have the ability to obtain natural resources from multiple extractive economies, possess the capacity to shape and reshape transport technology and infrastructure to suit their needs, and can often leverage two or more LDCs against each other to obtain favorable trade-related concessions (Bunker and Ciccantell 2005). Trade-dominant productive countries, moreover, reorganize world markets to achieve cheap and stable access to raw materials (Bunker and Ciccantell 2005), rather than world markets unfolding by some inherent, natural logic.

The generation of ecological unequal exchange arises from the complex interplay between modes of production and extraction both at the local and the global level and the consequent transfer of value embodied in energy and natural resources (Bunker 1985; Hornborg 2001). The social organization of human energy within productive economies aligned congruent with a complex division of labor, and characterized by the coordination of specialized tasks acting upon a continual flow of undervalued raw materials, is an important dimension shaping the production and reproduction of differential cross-national social and economic power (Bunker 1992). Power over natural resources, therefore, is interwoven with economic and social power (Bunker 1992).

Similar to Bunker's analysis, Hornborg locates the origin of ecological unequal exchange within the asymmetric transfer of energy and materials laden with productive potential primarily

captured or realized within importing centers of world economic power and the inverse movement of entropy or thermodynamic disorder embodied in pollution and waste (2001). This contributes to the cycle of expanding industrial production and consumption in the North and deceleration in the periphery, a divergence visible in nighttime satellite photos (Hornborg 2001). There is, moreover, an inverse relationship between productive potential and economic value (Hornborg 1998b). Unlabored and semi-processed natural resources possess considerable productive potential that is dissipated along the production chain. Economic value tends to grow inversely with the realization of this concrete, productive potential. Finished products, in turn, contain diminished productive potential but enhanced economic value and utility, the control of which facilitates the acquisition of even greater raw, unlabored energy and materials necessary to maintain and expand the industrial technomass (Hornborg 1998b).

This systematic appropriation of energy and materials, and consequent realization of economic value, is the foundation of the industrial infrastructure reproducing cross-national inequalities in the world economy and uneven ecological outcomes (Hornborg 1998b). Congruent with Bunker, Hornborg argues differential cross-national social power, in turn, is based upon historically contingent social relationships forged through the ability to control asymmetrical flows of environmental resources and risks (Hornborg 2001). The mechanisms of development/underdevelopment are substantially rooted in spatial, material realities. Hornborg (2001) argues:

> The luminous agglomerations of industrial infrastructure in the satellite photos are the result of uneven flows of energy and matter, and these processes of concentration are self-reinforcing, because the increasingly advantageous economies of scale in the center progressively improve its terms of trade and thus its capacity to appropriate the resources of the hinterland. Extractive economies are thus pressed to overexploit nature, while those parts of the landscape in industrial nations that have not been urbanized can instead be liberated from the imperative to yield a profit and rather become the object of conservation programs (p. 29).

The net transfer of energy and materials laden with productive potential contributes to the cycle of expanding industrial production and consumption in the North (Hornborg 1998b). Asymmetric terms of trade essentially constitute a factor of production, proceeding actual production, supporting the techno-economic maintenance and growth or "development" of industrial countries (Hornborg 2001). Hornborg (2001) suggests this cycle shapes the underdevelopment of natural resource exporting developing countries, arguing:

> The ecological and socioeconomic impoverishment of the periphery are two sides of the same coin, for both nature and human labor are underpaid sources of high-quality energy for the industrial "technomass"… Marx was too focused on labor to see that exploitation could also take the form of draining another society's natural resources (p. 11 and 61).

Both Bunker and Hornborg imply more than simply reliance of industrialized countries upon undervalued natural resource assets from the periphery, as they are articulating a model of acceleration and social organizational complexity and deceleration and simplification between productive and extractive economies. In tandem, productive economies gain flexibility and adaptability while extractive economies become increasingly rigid, inflexible, and vulnerable to the shifting demands of global capital accumulation.

Although cross-national economic integration is argued to underlie the increasingly visible ecological unequal exchange between countries, the dynamics of ecological unequal exchange have a long history. The development of global markets for raw materials and secure access to cheap natural resources is the historical foundation of economic growth and stability of dominant, industrialized nations (Bunker 1994). Access strategies by dominant states and industrial firms are shaped by the characteristics of particular commodities, changes in technology, in markets, in transport capacity, and world political and economic organization (Bunker 1994). Cooperation of economically and politically powerful allies within resource-rich

areas in LDCs enhances access strategies of industrial firms even as the environmental and social wellbeing of localized communities are often compromised (Bunker 1994).

Despite a long history of supplying natural resources upon the world market, the Amazon Basin remains one of the poorest and most underdeveloped areas in the world (Bunker 1984, 1985). Resource extraction in the Amazon exemplifies the negative consequences of underdevelopment characteristic of many resource-exporting regions. The area is historically characterized by few horizontal linkages to other productive economic activities and therefore lacks the development of locational advantages fostering mutually beneficial economic enterprises (Bunker 1984, 1985). This is, in part, based upon the unique infrastructural requirements of extractive economies and their vulnerability to the unstable nature of commodity prices on the world market. Integration into the global economy not only resulted in ecological degradation and transformation but impacted domestic class structures, distribution of populations, and the organization of labor in the region (Bunker 1984, 1985). Resource extraction in the Amazon is further characterized by decreasing returns to scale (Bunker 1984, 1985). As resource extraction in the region expanded the per unit costs of materials extraction increased as the most easily accessible resources were used up, increasing environmental impacts and diminishing local use values. Overall, there has been little productive development in the region and continual susceptibility to further extractive exploitation (Bunker 1984, 1985).

Hornborg (forthcoming) measures the unequal exchange of labor time and natural space (productive land) through analysis of British cotton imports from the colonial periphery and exports of wool products during the mid-19th century. Hornborg's analysis is based upon a comparison of the hectares of agricultural land and human labor time invested or embodied in raw cotton imported to England from America and in woolen manufacturers exported from

England. He concludes the British saved both natural space in terms of productive land and human labor time through trade, in combination with their relatively more advanced technologies devoted to capital accumulation. He suggests this is one example of the unequal appropriation of labor time and environmental space from the periphery by the core made possible through material flows between economically and technologically non-equivalent partners. There is, in other words, an accumulation of material and productive potential that is unequal in biophysical terms, although not readily identifiable in monetary terms. Moreover, processes of labor time-natural space appropriation are an aspect of the socio-ecological logic whereby environmental burdens tend to be unequally distributed and development trajectories continue to diverge at a global level (Hornborg forthcoming).

Undervaluation of Natural Resource Flows South to North

Differential social, economic, and political power shapes the terms of trade characterizing natural resource flows from LDCs (Hornborg 2001; Martinez-Alier 2002). Undervaluation of natural resource exports is, thus, a key mechanism of ecological unequal exchange, ultimately a consequence of variable cross-national power and advantage in international exchange relations. Externalization is a consequence of this systemic undervaluation of natural resource exports. Valuation fails to account for local environmental costs or negative externalities associated with natural resource extraction and transport, suggesting these costs are encountered at the local level within the periphery.

Further, undervaluation is less about market failures than successful appropriation of natural resources by more powerful trading partners, without internalization of the full ecological and social costs (Muradian and Martinez-Alier 2001a). Martinez-Alier and O'Connor (1999) suggest cross-national income distribution and economic valuation are not independent, thus

shaping the imposition of negative externalities. This is because the "poor sell cheap" (Martinez-Alier and O' Connor 1999:380). Therefore, environmental cost-shifting essentially entails the absence of prices in markets and a redistribution of social and environmental burdens and benefits (Martinez-Alier and O' Connor 1999). Powerful lobbies in industrialized countries strive to maintain asymmetric trade relationships enhancing domestic employment, profits, and government revenues (Arden-Clarke 1992). The result is ecological-distributional conflicts across countries not easily captured or conceptualized from a neoclassical economics perspective, which is generally optimistic about the prospects of internalizing environmental and social costs.

"Prices" are, in part, socially negotiated exchange relationships that may not necessarily reflect real material flows, including the energy and productive potential embodied in these flows and the environmental and human health costs incurred (Hornborg 1998b). Although trade appears balanced in monetary terms, the apparent confluence of impersonal market forces of supply and demand, there may nonetheless be an inequitable exchange of energy, productive potential, and sink-capacity demand among trading partners (Andersson and Lindroth 2001). Undervaluation, in turn, allows industrialized countries to increase their relative share of the world-system's total purchasing power at the expense of those providing cheap labor, energy, and raw materials (Hornborg 1998a).

Our Common Future, arguably the most well known statement on sustainable development, acknowledges the underpayment for many natural resource exports from LDCs (World Commission on Environment and Development [WCED] 1987). The report further highlights that industrialized countries have generally been more successful in achieving export product prices reflecting the costs of domestic environmental damage, passing these costs onto

consumers within importing developing nations (WCED 1987). In noting the prices of commodity exports from LDCs typically do not reflect environmental costs to the resource base the report states: “In a sense, then, poor developing countries are being caused to subsidize the wealthier importers of their products” (p. 81).

Further, exogenous factors arguably shaping monetary undervaluation of natural resource exports from LDCs include: external debt obligations, austerity requirements of structural adjustment policies, Northern import protectionism, the inability to diversify into non-primary product exports, and low revenue capture. External debt obligations, in particular, complicate disparities in economic and political power. Less developed countries are often under heavy external debt obligations and looking for increased resource exploitation to meet these obligations. This contributes not only to resource degradation as the pace of harvesting of renewable resources often outpaces natural replacement rates but inadvertently contributes to the oversupply of primary products on the world market and declining terms of trade (Muradian and Martinez-Alier 2001a). This “desperation production,” oriented towards the servicing of debt repayments, complicates efforts to internalize environmental costs in developing countries and arguably contributes to overconsumption of resources in the North, as underpricing provides few incentives for conservation efforts (Arden-Clarke 1992:126).

Most value-added processing of traded natural resources occurs in industrialized countries, contributing to low rates of revenue capture by LDCs (Arden-Clarke 1992). This further complicates, in turn, the acquisition of financial and technical resources that could be applied to more sustainable methods of commodity extraction and distribution at the local level (Arden-Clarke 1992). Further, developing countries need to diversify into non-traditional, greater value-added exports if they are to preserve their resource base and improve their position in the

world economy (Arden-Clarke 1992). This would entail achievement of vertical diversification characterized by commodity processing capturing more valued-added opportunities prior to export and horizontal diversification establishing economic enterprises unrelated to commodity production (Arden-Clarke 1992). Trade barriers in developed countries, however, complicate diversification efforts (Arden-Clarke 1992; WCED 1987). Northern protectionism makes it difficult for developing countries to reconcile the need for export-oriented growth with protection of domestic resources (WCED 1987).

As a consequence of declining terms of trade and other exogenous factors, LDCs dependent upon primary product exports can become caught in a specialization trap, wherein the structure of their exports is dominated by natural resource extraction (Ropke 1994). If this pattern remains unbroken then "free" trade essentially becomes "forced" trade for developing countries precariously situated in the world economy (Ropke 1994:15).

The Netherlands Fallacy

Ecological unequal exchange points to the geographic, temporal, and cultural discontinuities between production-consumption-accumulation and the consequent environmental side effects, analogous to the idea of the "Netherlands Fallacy." The Netherlands Fallacy is based upon the observation that the Dutch population and their average standard of living are only made possible through reliance upon imported resources (Ehrlich and Ehrlich 1990). Therefore, the Dutch population is not self-sufficient and, Ehrlich and Ehrlich suggest (1990), is arguably overpopulated relative to domestic environmental capacity (Ehrlich and Ehrlich 1990). It is a mistake in reasoning, a fallacy, to fail to appreciate that the Netherlands must draw upon the resources of other countries to support their aggregate population and its associated consumption patterns (Ehrlich and Ehrlich 1990).

Over time the Netherlands Fallacy has also come to suggest that domestic environmental conditions are not necessarily an accurate reflection of the environmental burdens engendered by domestic standards of living and rates of material consumption. A key lesson is that any particular country's environmental fate, positive or negative, is not simply the consequence of domestic factors but also its structured relations with other countries. The negative consequences of one country's environmental demands may be borne by others. This has also been referred to as the "rich-country-illusion effect" (Andersson and Lindroth 2001:120). By importing natural resources and exporting sink capacity demand and environmental costs inhabitants of industrialized countries can mistakenly perceive their lifestyles as sustainable, as their consumption rates are not tightly linked to domestic environmental conditions (Andersson and Lindroth 2001). Conversely, the rich-country-illusion effect implies LDCs are to blame for failure to sustain their domestic natural capital (Andersson and Lindroth 2001).

The Netherlands Fallacy is a reminder that to conceptualize ecological dynamics in a globalizing world it is increasingly important to examine zero-sum relations among countries and the socio-economic and environmental costs and benefits that are differentially incurred. To assume the Netherlands, for example, supports a population with a relatively high standard of living within a context of relative environmental abundance is to fail to consider the "bigger picture." Ecological unequal exchange hints at what that picture might look like.

Ecological Unequal Exchange: Conclusion and Restatement of Major Ideas

Ecological unequal exchange is characterized by the objectively asymmetric transfer of value embodied in the productive potential of energy and natural resources (Hornborg 2003). Such transfers, however, are only possible through the illusions of normatively neutral exchange through market mechanisms, misconstrued as reciprocal exchange between economically

unbalanced partners (Hornborg 2001). Market prices, therefore, are a crucial mechanism through which the core appropriates ecological value and exports waste to the periphery (Hornborg 2001).

An ecological focus upon the uneven processes underlying capital accumulation supplements rather than replaces the traditional Marxist concern with labor exploitation (Bunker 1985; Hornborg 2001, 2003). Although the environment is transformed through labor exploitation (Moore 2000), it is a mistake to conflate both labor and ecological exploitation. Conflation obscures analysis of the thermodynamic or energetic basis of industrial capitalism and the systemic flows of energy and natural resources underlying the socioeconomic metabolism of the world-system. Further, it neglects the recognition that raw materials and energy are essential components underlying the transformative capacity of industrial production (Bunker 1985).

Value, therefore, is appropriated not only through labor but the acquisition of energy and natural resources (Bunker 1985). This transfer is recognizable in biophysical terms but hidden through exclusive reference to monetary indicators, a consequence of the neoclassical economics tendency to equate exchange value with utility. This transfer of value cannot be calculated solely in terms of wages, prices, and profit (Bunker 1985). Ecological unequal exchange, therefore, can only be conceptualized by recognizing exchange value and use value do not necessarily coincide (Hornborg 1992).

Social structural relationships and institutions underpinning the accumulation of capital on a global scale shape distinctive global patterns of ecological use and degradation. International trade, a material expression of the international division of labor and flow of natural resources, shapes ecological dynamics in a systemically recognizable manner. Such dynamics transcend the overly simple domestic economic growth-environmental degradation dichotomy.

Rather, global environmental change is also conditioned by the interdependence and interaction among countries. Such interdependencies force consideration of the environmental transformations and patterns of resource use and degradation/preservation shaped by the positional and distributional dynamics within the world-system.

In contrast to the theory of comparative advantage, ecological unequal exchange focuses upon the potential zero-sum relationships resulting from the international trade of natural resources. First, industrialized countries achieve disproportionate rates of material consumption and protect their domestic environmental assets through the shifting of environmental costs to less-developed countries. Second, industrialized countries consume a disproportionate amount of environmental space or global biologically productive area at the expense of LDCs.

Ecological unequal exchange provides a framework for conceptualizing how the socio-economic metabolism or material throughput of developed countries may negatively impacts marginalized countries in the global economy by highlighting the uneven flow of energy and natural resources reinforcing disparities in production and material consumption. This inequitable appropriation of natural capital shapes both per capita affluence and poverty across the divide between developed and developing societies. This is not only complicit in driving increasing environmental demand overall but linked to the diminishing opportunities of LDCs to achieve socio-economic stability and domestic ecological protection.

It is not trade, per se, but the structure of trade that promotes dynamics of ecological unequal exchange. Based upon this theoretical tenet, trade dependency dynamics as conceptualized by dependency/world-system scholars are subsequently presented. In an effort to ground ecological unequal exchange dynamics in the broader perspective of world-systems analysis the objective is to draw-out the underlying logic of trade dependency effects and

subsequently apply these theoretical insights within the empirical analyses contained in chapters 4-6.

Trade Dependency Dynamics in the World-System

Trade dependency refers to the negative asymmetrical economic, social, and environmental processes exhibited within LDCs as a consequence of their disadvantageous bargaining position within the global economy relative to more advantageously positioned trading partners. Such processes are rooted in the global division of labor, shaping export-import interaction among countries and relations of dominance-dependence based upon commodity exchange dynamics.

Dependency suggests systemic linkages wherein the domestic class and institutional context of a country is shaped and conditioned through the development and expansion of other countries (dos Santos 1970). It can be manifested through zero-sum relations or, further, inequitable or uneven positive-sum interactions wherein the benefits accruing to the disadvantaged trading partner is tempered but not eliminated through interaction with a more economically and politically dominant country (Bornschier and Chase-Dunn 1985). Uneven positive-sum relations, in turn, facilitate increasing economic, social, and environmental disparities among trading partners over time.

Types of Trade

Not only has the volume of international trade grown since WWII but so have the different types of trade exchanged. Inter-industry trade consists of exchange across national borders between different types of industries. This conforms to the traditional view of trade as the exchange of finished products or raw materials between countries characterized by substantially different industrial structures (Held et al. 1999). The theory of comparative

advantage focuses upon and is viewed as the most relevant to inter-industry trade relations (Gilpin 1987; van Marrewijk 2002). Inter-industry trade still predominantly characterizes North-South exchange, although increasingly less so exchange between industrialized countries (Held et al. 1999).

Intra-industry trade or exchange within industries is one of the most dynamic trade-related changes in the post-WWII period and now constitutes the majority of trade between industrialized countries but only a small proportion of LDC trade activity (Held et al. 1999). Rather than exchanging very different commodities, industrialized countries increasingly trade similar semi-finished or finished manufactured products and components as a consequence of flexible production schemes and the increasing dispersement of production processes into global commodity chains (Held et al. 1999). Automobile manufacturers in the industrialized countries, for example, often subcontract out and import various components that constitute the eventual finished product, complicating efforts to specify the country of origin of many high-technology products. In addition, there has been a dramatic increase in intra-firm trade or exchange taking place entirely within a single TNC as well as inter-firm trade between TNCs cooperating through joint ventures and subcontracting relationships (Held et al. 1999).

Despite the post-WWII rise of various types of trade relations, increasing the complexity of analysis of international trade exchange, trade dependency dynamics remain a salient theoretical and empirical dimension of cross-national underdevelopment processes in general and environmental and social change more specifically. This is because the traditional view of trade as inter-industry exchange still characterizes the vast majority of LDC trade activity (Held et al. 1999). Nonetheless, LDC trade composition has changed over time as low technology

manufacturing has increased while natural resource exports, in monetary terms, have declined (Held et al. 1999).

Dimensions of Trade Dependency

World-systems analysis is typically focused upon inter-industry trade or exchange across national borders between countries possessing different industrial structures. Trade dependency, in turn, is characterized by and differentially expressed through various dimensions based upon the intensity, form, and composition of exchange relations (Rubinson and Holtzman 1981).

Table 1 outlines the dimensions of trade dependency. *Intensity* refers to the degree of trade integration into the global economy. It is a measure of trade activity, irrespective of the type of commodities exchanged or with whom. A typical of measure of intensity is trade relative to national gross domestic product (GDP).

Table 1. Trade Dependency Dimensions

Conceptual Category:	Description:
1. Intensity	Measures *activity* in trade. Refers to the amount of trade of a country relative to its national product (Trade/GDP). It indicates how much a country is integrated into the global economy or, alternatively, dependent upon trade irrespective of what commodities it trades or with whom.
2. Form	
Partner Concentration	Refers to the *variation* in export partners. Often measured by the ratio of the value of a country's exports going to its most important partner, as percentage of all exports. Higher partner concentration arguably promotes greater dependency on the conditions and activities of one particular country.
Commodity Concentration	Refers to the *variation* in the commodities a country exports. Often calculated as the percentage of a country's leading export (or three most important exports, etc.) in its total export trade. Arguably, the more concentrated in one or a few commodities the more dependent a country is on world market forces as they affect these products.
3. Composition	Refers to the kinds of *products* a country trades, a major distinction being between raw materials and manufacturing. Measures the effects of the kinds of commodities traded, irrespective of intensity or form of trade. For example, there is the Trade Composition Index measuring the predominance of exported manufactured goods relative to raw materials.

Adapted from Rubinson and Holtzman (1981).

Form of trade measures the manner in which a country is integrated into the global economy. Trade partner concentration evaluates with whom imports and/or exports are

exchanged and the degree of country reliance upon few or many trade partners. Commodity concentration refers to the degree of specialization in one or a few export commodities. High partner and/or commodity concentration arguably place LDCs in a disadvantageous bargaining position in the global economy and increasing vulnerability to dependency effects (Hirschman 1945; Galtung 1971).

Trade *composition* evaluates the types of commodities a country exports and imports irrespective of trade intensity or form. Of particular importance is the degree of processing, a continuum ranging from the exchange of unprocessed natural resources to high technology, capital-intensive manufactured products.

The Theoretical and Empirical Foundation of Trade Dependency Dynamics

The argument for trade dependency processes rests upon the assertion of power relations forged through the cross-national exchange of commodities. The theoretical and empirical foundation of these proposed power-dependence relations is generally traced to the pioneering efforts of Hirschman (1945) and Galtung (1971). Both recognized that organized and relatively enduring patterns of interaction cross-nationally have the potential to shape the unequal exchange of advantages and disadvantages among trading partners. The ideas of both have influenced successive generations of world-systems oriented researchers.

Hirschman (1945), who was interested in the explicit and strategic power-dependence posturing of countries through international trade relations, highlighted the potential non-equivalence dynamics between countries. If country “A” relies upon country “B” as the predominant market for its exports but imports from A are but a small percentage of B’s total imports then there is a relationship of non-equivalence. Country A, in turn, is arguably

disproportionately dependent upon, and therefore vulnerable to, the strategic posturing of B (Hirschman 1945).

Hirschman recognizes the positive-sum gains to be accrued through trade relations, congruent with mainstream economic theory, but suggests this implies the converse as well in that such benefits give rise to power-dependence relations wherein particular interests endeavor to realize an uneven or disproportionate share of the rewards. The benefits accrued through trade and the strategic manipulations designed to differentially shape such outcomes are two sides of the same coin, Hirschman argues. Failure to recognize such complexities is to implicitly assume the equivalence of need or benefit between trading partners (Hirschman 1945). Relations of non-equivalence, therefore, are an important foundation of power-dependence interactions.

Power-dependence relations are a particularly salient dynamic for predominantly natural resource exporting countries, Hirschman argues (1945). This follows from the proposition that it is much easier to replace or bypass a supplier of natural resources or low-tech manufacturing than it is to replace a supplier of high-tech, capital intensive manufactured products given the scarce human capital and technology required to produce the latter. Further, if B can exogenously shape the structure of A's economy in a manner highly complementary to B's import demands, but congruent with the needs of few other countries, than B can gain even greater leverage over trade relations with A over time (Hirschman 1945).

Countries characterized by domestic economic infrastructure and linkages concentrated in the export of one or a few commodities are more vulnerable to power-dependence manipulations (Hirschman 1945). In addition, the establishment of powerful vested interests domestically that benefit from export activity, often irrespective of the economy-wide benefits, the more subject will be a country to exogenous trade related manipulations (Hirschman 1945).

In an effort to avoid the reification of the state as the predominant or only actors involved in international trading relations, Hirschman suggests the power of the state is analogous to that of a labor union over its members (1945). Individual workers engage in the day-to-day activities of the workplace but it is the labor union alone that possesses the organizational and logistical capacity to influence workplace conditions. Similarly, states exhibit varying degrees of power over domestic enterprises and their transnational activities as well as the ability to influence the activities of foreign firms operating within their borders.

Just as labor unions have the capacity to call strikes and determine their length, states have the power to shape trade conditions, albeit to varying degrees. States also engage in bilateral and multilateral trade negotiations shaping the openness and structure of trade across national borders, with economically and politically dominant states arguably pursuing disproportionately favorable concessions. This is a strategic and organizational capacity few TNCs possess in and of themselves.

In turn, states largely establish the parameters of the international trading system, often within the context of supranational institutions, but TNCs and private firms lobby the state to skew the rules of the game in their favor. The persistence of protectionist policies and subsidization of American agricultural products is arguably an example of this.

Hirschman argues power-dependence processes reinforced through international trade often give large, rich countries an incentive to trade with smaller, less economically dominant countries (1945). Such interaction is characterized by non-equivalence as the imports to or exports from the smaller country are likely to consist of a much higher percentage of their total trade or GDP relative to the larger, richer country, thereby promoting disadvantageous or dependent relations for the former. As a consequence, Hirschman (1945) argues, an elementary

defensive principle of smaller trading states is to not have too large a concentration of trade with any single economically dominant country as dependence can arguably be diminished by a more even distribution of trading partners.

Galtung (1971) is the first to empirically describe the core-periphery or dominant-dependent structure characterizing global political-economic trade relations (Rubinson and Holtzman 1981). He introduces a structural theory of imperialism based upon the patterned or networked interactions expressed vertically and horizontally through cross-national trade relations and the composition or level of processing of commodities among countries nested within this hierarchy. These dynamics shape the interaction structure underlying international trade and the relative benefits accruing to countries advantageously situated within the global economy (Galtung 1971).

Vertical interaction is based upon the gap or differential level of processing of traded commodities, a reflection of the global division of labor (Galtung 1971). This division is of consequence, Galtung argues, because of the positive economic spin-off effects inherent within countries exporting complex processed commodities, a dynamic lacking within countries characterized by the export of raw materials and simple processed goods, a dynamic central to Bunker's work (1984, 1985). Vertical interaction is the major source of inequality in the global economy, Galtung argues. It is the relative absence of horizontal trade networks between disadvantaged peripheral countries, however, that perpetuates and protects such systemic relations of inequality (Galtung 1971). The lack of horizontal ties between peripheral countries reinforces their dependence upon core countries occupying the pinnacle of the vertical hierarchy.

Galtung's (1971) articulation of vertical and horizontal interaction structures enacted and reinforced through international trade shapes the value inequitably exchanged and appropriated

between countries, or inter-actor effects, and the consequences within the respective countries, the intra-actor effects. He suggests there is conflict or disharmony of objective interests between trading partners if they interact in such a manner that the gap in their true interests is increasing as a consequence of the trade relation. The inequality within the global economy need not be based exclusively upon zero-sum relationships, in other words, but may be rooted in uneven or disproportionate realization of relative benefits.

Further, relations of dependence and disharmony of interests are variable and subject to change over time. A simple perpetrator-victim scenario between countries is insufficient in describing the complexities of international trade relations. Vested interests in the core benefiting from trade, Galtung argues, must necessarily align themselves with similar vested interests in the periphery. This harmony of group interests, however, often disproportionately benefits the core country overall relative to the domestic benefits exhibited in the periphery country.

Galtung's theory of structural imperialism is based upon a model of trade relations wherein there is vertical interaction between the periphery and the core, a general lack of horizontal interaction between peripheral countries, and a complex overall harmony and disharmony of interests shaped by a relatively enduring global interaction structure. In sum, these patterned relations constrain the economic and socio-organizational options available to peripheral countries.

To empirically examine the proposed structure of international trade relations, Galtung (1971) utilizes three different measures. The trade composition index (TCI) measures the relative mix of raw materials and processed goods imported and exported from a country. A high score indicates a country is characterized by the importation of raw materials and export of processed goods, indicating its relative *vertical* position in the global economy. To examine *horizontal*

position, Galtung employs a trade commodity concentration index (TCC) evaluating the proportion of a country's three largest export commodities to total exports. Further, trade partner concentration (TPC) measures the proportion of a country's exports sent to its one most predominant trade partner.

Galtung provides evidence that countries characterized by relatively higher GDP score higher on the trade composition index, reflecting the complexity of their exports, but exhibit lower commodity and trade partner concentration. These results, he argues, reflect their dominance and relatively advantageous position within the interaction structure of international trade. Conversely, poorer countries exhibit lower trade composition index scores but higher commodity and trade partner concentration, an illustration of their relatively circumscribed position in the global economy. The consequence is a dependency of the poorer, peripheral countries upon more economically dynamic and flexible industrialized countries. Low trade composition complexity in combination with high commodity and trade partner concentration, moreover, make peripheral countries vulnerable to fluctuating world market demand and prices (Galtung 1971).

Trade composition and commodity and partner concentration processes constitute the fundamental dynamics of the global interaction structure. These systemic relations, Galtung argues, promote both the substantial inequality between countries and the relatively enduring persistence of this inequality over time.

Adopting a Wallersteinian Perspective on the Structure of the World-System

It is important to note the present study adopts a theoretical and empirical stance that is consistent with the Wallersteinian view of the structure of the world-system as composed of relatively distinct, hierarchical groupings of countries. Wallerstein asserted the world-system is

composed of a three-tiered global division of labor that exhibits a substantial geographical or spatial form drawn along the lines of interacting nation states. He argues (1974):

> A world-system is a social system, one that has boundaries, structures, member groups, rules of legitimation, and coherence. Its life is made up of the conflicting forces which hold it together by tension and tear it apart as each group seeks eternally to remold it to its advantage (347).

An alternative conceptualization is offered by Chase-Dunn (1989) who argues the core-periphery hierarchy more closely approximates a continuum rather than discrete groupings of countries. This argument is examined by Kentor (2000) who empirically derives a composite measure of position in the core-periphery hierarchy not through network analysis techniques utilizing relational data *among* countries but indicators of economic and coercive or military power exhibited as variant *domestic* attributes. Kentor's multidimensional measure of world-system position is based upon ten variables measuring economic and military power.[4] The goal is to empirically describe the core-periphery hierarchy based upon a series of multidimensional dynamics argued to enable states to obtain favorable unequal exchange relationships (Kentor 2000).

Kentor (2000) argues the terms core, semiperiphery, and periphery are ideal types and questions the value of focusing too closely upon such categorizations. He suggests that the existence of empirical groupings among countries based upon structural similarities, as is documented through network analysis techniques, does not necessarily imply a correspondence to the theoretical categories of core, semiperiphery, and periphery.

This conclusion is open to debate, however, as inferential empirical evidence suggests the relative groupings identified through network analysis techniques shape the development

[4] These variables include: GDP per capita, total GDP, total exports, global capital control, military expenditures, military exports, military global control, export commodity concentration, foreign capital dependence, and military dependence.

trajectory of similarly situated countries and these empirical results generally conform to world-system analysis expectations (see Nemeth and Smith 1985; Snyder and Kick 1979). This suggests there is some reasonable level of correspondence between the empirical groupings described through network analysis research and a priori theoretical construction.

In turn, a defining characteristic of the theorization and empirical analysis undertaken in the present study is the adoption of a Wallersteinian stance regarding the structure of the world-system and the assumption of relatively discrete strata. This stance distinguishes the analyses that follow from other, related research focused upon ecological unequal exchange processes but more oriented towards examination of the core-periphery hierarchy as a continuum (Jorgenson 2005; Jorgenson and Rice 2005).

In the present study the adoption of a Wallersteinian theoretical position fundamentally shapes the methodological inquiry. Thus, a prominent methodological stance adopted within the empirical chapters that follow is the examination of the effects of trade with the core industrialized countries. In identifying the core industrialized countries we rely upon the descriptive empirical research undertaken by scholars utilizing network analysis techniques. In turn, the core countries are delineated by their level or complexity of commodity processing relative to other, differentially situated, countries. They exhibit structural similarities that make them a distinct grouping within the global economy (see Smith and White 1992). Further, the theoretical stance that level of processing is a central determinant of position in the core-periphery hierarchy is consistent with the trade dependency arguments set forth by Hirschman (1945), Galtung (1971), and the ecological unequal exchange mechanisms identified by Bunker (1985), which are fundamentally predicated upon the power-dependence relations enacted between productive and extractive economies. In turn, we argue the Wallersteinian stance

adopted herein is appropriate as it is congruent with the overarching theoretical ideas upon which the present study is founded.

Network Analysis Studies of the Structure of the Global Economy

Galtung's analysis rests upon the examination of the trade related attributes of countries, particularly the economic division of labor illustrated by differing levels of processing of commodities, in an effort to infer the structure of the global economy and identify a mechanism of structural imperialism or exploitation. Various network analysis studies have also attempted to describe the structure of the global economy by evaluating the relational *ties* or interactions among countries (Blanton 1999; Kick 1987; Kick and Davis 2001; Mahutga forthcoming; Nemeth and Smith 1985; Smith and White 1992; Snyder and Kick 1979; Van Rossem 1996), rather than evaluating the *attributes* of countries as does Galtung (1971).

Network analysis focuses upon the structure or pattern of relationships between a country and all other countries. It is useful, therefore, for delineating organized patterns of interaction among countries and evaluating the distinct roles countries fulfill in the global economy (Mahutga forthcoming). Countries occupying a similar position in the world-system are generally characterized by similar structural relationships. Arguably, similar definable patterns of relationships exhibited by many countries, or identifiable blocks, shape similar consequent dependency relations. Countries within a particular block, exhibiting similar patterned relationships, are generally characterized by similar levels of economic development (Van Rossem 1996).

Descriptive empirical evidence of a general core-periphery structure to the global economy provides an important logical and theoretical context for dependency studies, for if such a structure does not in fact exist then the concept of dependency as a mechanism of

polarization and underdevelopment loses much of its theoretical validity (Rubinson and Holtzman 1981). It is futile, in other words, to attempt to understand the mechanisms shaping a non-existent social structure (Rubinson and Holtzman 1981).

A variety of studies based upon the evaluation of differing economic and political relationships among countries have consistently revealed a general core-periphery structure and clustering of relatively homogenous groups of countries characterized by similar patterns of cross-national relationships. One of the first is Snyder and Kick's (1979) examination of trade flows, military interventions, diplomatic relations, and conjoint treaty memberships as transnational interactions between countries. Using block modeling they combine these four dimensions and identify structural similarities or positionality among groups of countries congruent with a core/semi-periphery/periphery social structure. Using regression analysis they then provide evidence that hierarchical position is positively associated with economic growth, suggesting world-system positions are more than simply descriptive categories but shape identifiable socio-economic outcomes over time. There are, in other words, "costs" and "benefits" accruing from position in the world-system (Snyder and Kick 1979).

Nemeth and Smith (1985) focus their block modeling exclusively upon economic factors, in particular the patterns of commodity trade among countries. This conforms to the assertion raised by Galtung (1971) and others (Bunker 1985; Emmanuel 1972; Frank 1966) that unequal exchange between countries is strongly tied to levels of commodity processing. They calculate the import-export patterns of five general commodity types ranging from heavy manufacturing/high technology to raw materials and food products. They identify a core grouping of countries, consistent with dependency and world-systems expectations, tied to all other countries through trade and which are the predominant exporters of high technology goods

and importers of food products. Peripheral blocks, in contrast, are primarily tied to the global economy through trade with core countries and predominantly export low processed commodities (Nemeth and Smith 1985). Further, regression analyses reveal the hierarchical structural positions identified are correlated with economic development, income inequality, and child mortality rates, such that higher position in the world-system progressively shapes improvement on all three (Nemeth and Smith 1985).

Smith and White (1992) provide longitudinal evidence of the different roles played by distinct groupings of countries in the global economy, an exclusively trade based approach congruent with Nemeth and Smith (1985). Their analysis further substantiates the concept of a global division of labor between countries wherein capital intensive, highly processed commodities are exported between core countries and raw materials are exported South-North. Conversely, less densely connected semi-periphery and, especially, peripheral countries tend to export low processed commodities. Their results also uncover the recent decline of simple manufacturing exported from the core and its increased export from semi-peripheral countries, consistent with the new industrial division of labor thesis. Nevertheless, their analysis reveals relatively stable core, semi-periphery, and periphery groupings as measured in 1965, 1970, and 1980.

Despite the tremendous changes in the global economy over the past four decades, Mahutga (forthcoming) extends the network analysis approach of Smith and White (1992) and finds a high level of structural stability both in terms of the core-periphery divide and levels of processing between countries from 1965-2000. This stability persists despite the general rise of labor-intensive manufacturing in non-core zones of the world-system (Mahutga forthcoming). The classical dependency distinction of high-technology manufacturing-raw materials trade

dichotomy now co-exists with a low value added-high value added manufacturing dichotomy, Mahutga (forthcoming) concludes.

Overall, network analysis studies provide empirical validity of several key theoretical assumptions of dependency and world-systems theorists regarding the structure of the global economy. Nevertheless, too few studies have directly utilized these descriptive results to inferentially evaluate the uneven cross-national social and environmental outcomes shaped by these structural patterns (Kick and Davis 2001). In other words, considerable effort has been expended in empirically describing the cross-national structure of the global economy but too little effort has been devoted to assessing the empirical consequences of this structure.

Reconfiguring the Concept of Trade Partner Concentration

World-system position is most usefully identified by relational patterns between countries as identified, for example, through network analysis techniques (Mahutga forthcoming; Nemeth and Smith 1985; Smith and White 1992; Snyder and Kick 1979). Location in the world-system, moreover, is a crucial independent variable fundamentally shaping the variation displayed among countries as illustrated by trade dependency indicators.

Analysis of trade dependency effects should take into account both the variable domestic attributes *within* countries and the relational dynamics *between* countries that together shape the complex and contingent outcomes promoting overdevelopment-underdevelopment cross-nationally and divergent environmental and social outcomes. The present study attempts to address both empirically by arguing for a reconceptualization of the measurement of trade partner concentration.

Previous research typically operationalizes trade partner concentration by calculating the proportion of exports accounted for by the single largest receiving partner (Rubinson and

Holtzman 1981) or the two or three largest export partners (Dixon 1984). In contrast, this study calculates trade partner concentration as the proportion of exports to the countries at the core of the global economy, as identified through network analysis techniques. First, this produces a broader indicator that measures the degree to which a country is integrated into the global economy through exports to the most developed capitalist countries, not simply the one or few largest export partners. Second, the selection of the core countries is not arbitrarily defined but is based upon their consistent identification as the grouping or block that is most advantageously situated within the global economy.

The identification of trade partner concentration as the single largest export partner, typically a core country, largely derives from Galtung's analysis of vertical and horizontal trade relations (1971). In a post-colonial era, however, Galtung's assertion that peripheral countries are predominantly tied to only one core country is increasingly untenable (Van Rossem 1996). Further, the logic underlying trade partner concentration suggests dependency is less about one-on-one processes in particular than it is the constellation of network relations in which a country is enmeshed and from which trade related advantages and disadvantages are vertically and horizontally shaped. Upward and downward mobility in the world-system is not in relation to any one particular country, moreover, but the hierarchical assemblage of countries. The export ties between LDCs and the core, moreover, are a more appropriate conceptualization of the vertical trade dependency dynamics asymmetrically shaping cross-national social and environmental development.

The core countries are defined as those identified by Smith and White (1992) as occupying the dominant positions in the global economy based upon network analysis of international commodity trade patterns for 1980 (N=11). They are designated in table A1 in the

Appendix. The core as defined by Smith and White (1992) is congruent with the descriptive results of other network analysis studies (Blanton 1999; Mahutga forthcoming; Nemeth and Smith 1985).

From a world-systems perspective, the role occupied by core countries suggests they are ideally situated to economically dominate trade relations with LDCs. Their relative structural position should strongly influence the asymmetrical dependency dynamics argued to constrain development outcomes within those non-core countries in which they are engaged in commodity exchange. Such organized patterns of unequal exchange relations are a form of "structural power" arising out of the context of opportunities and constraints available to or impinging upon an actor (Caporaso 1978:29), or analogously to countries differentially positioned in the world-system. Evaluation of dyadic relationships cannot capture the true nature of structural power relations and are more appropriate to the evaluation of behavioral or concrete bargaining outcomes illustrative of "decisional power" enacted within but not wholly determined by structural constraints (Caporaso 1978). Structural power, moreover, is often based upon the inequitable institutional inclusion-exclusion of differing opportunity structures, an idea captured by the concept of the "mobilization of bias" (see Bachrach and Baratz 1970), a dynamic not captured from an exclusively dyadic or behavioral level of analysis.

Summary of Theoretical Propositions

Chase-Dunn (1975) notes, when examining foreign capital and trade between countries neoclassical economists see resource flows between largely unconnected societies. Marxist-oriented, dependency/world-system scholars, in contrast, see control structures shaping power-dependence relations between nonequivalent partners acting within an overarching interactive system (Chase-Dunn 1975). In turn, the theory of comparative advantage and the assertion of

unequal exchange lead to very different predictions regarding the cross-national consequences of trade relations.

In order to empirically test the theory of ecological unequal exchange we have adopted theoretical tenets from world-systems analysis in general and the assertion of trade dependency dynamics in particular. This study focuses, in particular, upon the *form* of trade relations in terms of trade partner concentration and the *composition* of exports in terms of the degree of natural resources exported while controlling for the potentially confounding effects of *intensity* or magnitude of trade integration.

In turn, the ecological unequal exchange perspective leads to the following theoretical propositions. These propositions are more fully developed in each respective empirical chapter but are include here to prefigure the theoretical claims to be subsequently examined empirically. They include:

1. *Less developed countries with a greater proportion of exports to the core countries exhibit lower consumption of environmental space.* This is a consequence of their relatively more precarious position in the global economy and their inability to transition away from largely serving as resource taps for the biocapacity and sink-capacity needs of industrialized countries.
2. *Less developed countries with a greater proportion of natural resource exports exhibit lower levels of social development.* This proposition is derived from Bunker's elaboration of the interdependent socio-organizational processes of acceleration-deceleration between productive industrialized countries and extraction-oriented LDCs.
3. *Less developed countries with a greater proportion of exports to the core countries exhibit higher levels of deforestation. In addition, less developed countries with a greater proportion of natural resource exports also exhibit higher levels of deforestation.* This is a consequence of the environmental cost-shifting underlying ecological unequal exchange. Empirically the present study attempts to illustrate that countries with the lowest consumption of forest products, typically the poorest LDCs, nevertheless have the highest deforestation rates as a consequence of their role in the global economy as natural resource exporters combined with their trade with the core.

The theory of comparative advantage does not propose that trade with the most industrialized countries is harmful for LDCs. In contrast, such trade dependency relations are

benign at worst and relatively more beneficial at best. Neoclassical economics places little emphasis upon the idea of differential development dynamics relative to position in the global economy (London and Williams 1990). Further, the principle of comparative advantage posits all countries benefit through trade with one another regardless of level of development or the divergent development levels of particular trading partners (Ragin and Delacroix 1979). Attracting exchange relations with more developed countries is, in fact, typically viewed as a positive step towards development as it facilitates the diffusion of advanced technology, more efficient and rational management practices, and LDC access to bigger markets for their exports.

Further, comparative advantage theory does not view LDC specialization in the export of natural resources as problematic but, rather, welfare enhancing as it generally conforms to their respective comparative advantages. This is particularly true of the poorest LDCs, which are often argued to possess few other trade-related options. Moreover, if all countries adhere to the principal of comparative advantage the international division of labor should, in large part, be characterized by the specialization of poor countries in natural resource exports (Ragin and Delacroix 1979). This is not based upon power-dependence relations but the most efficient utilization of relative cross-national factors of endowment. Higher export partner and export commodity concentration among LDCs, moreover, is typically viewed from a neoclassical economics perspective as nothing more than uneven factor endowments or the legacy of historical trading patterns (Dixon 1984).

In turn, the theory of comparative advantage leads to the following propositions:

1. *Less developed countries with a greater proportion of exports to the core countries will exhibit greater consumption of environmental space.* This proposition follows from the welfare enhancing benefits of international trade and the opportunities this generates for greater and more diversified consumption opportunities.
2. *Less developed countries with a greater proportion of natural resource exports will exhibit higher levels of social development.* This is a consequence of the efficiency gains

obtained through following their respective comparative advantages and the enhanced productivity procured through trade relative to a position of autarky or isolation.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

Introduction

This chapter elaborates upon research design choices relevant to the empirical analyses included in chapters 4-6. In an effort to articulate and empirically examine the uneven social and environmental processes underlying international trade, as proposed by the theory of ecological unequal exchange, the present study relies upon the application of slope dummy interaction terms. This allows for the designation of hypotheses congruent with propositions derived from the ecological unequal exchange perspective relative to the theory of comparative advantage, and it facilitates the empirical assessment of the independent contribution of key dependency variables delineated by country income level, allowing for the adjudication between these largely competing theoretical points of view.

Division of the Dataset into Income Categories

All empirical analyses in this study utilize the sample of countries listed in table A1 in the Appendix. To create slope dummy interaction terms the sample is first divided following the World Bank's income categorization of countries (WB 2002). The result is four categories delineated by gross national income (GNI) per capita for 1999. These include: Low = $755 or less; Lower middle = $756-2995; Upper middle = $2996-9265; High = $9266 or more.

This strategy was employed for three reasons. First, income categorization is based upon per capita affluence. This ostensibly serves as a proxy for capital intensiveness or productivity. Therefore, high-income countries should be more competitive within the global economy than less affluent countries and, in essence, more advantageously positioned to negotiate favorable terms of trade and avoid the asymmetrical processes posited by the theory of ecological unequal

exchange. Hornborg (2003) argues GNP is, in part, a reflection of relative terms of trade or the world market prices a country can secure for its products and services in comparison to the prices paid for goods and services of other countries. GNP is shaped by a country's position within structured, global exchange relations (Hornborg 2003). Income categorization, in turn, should produce a rough continuum from most to least economically competitive countries.

Second, the present analysis is oriented towards testing ecological unequal exchange tenets relative to the theory of comparative advantage. This methodological strategy allows for evaluating both theories without violating the internal logic of either. For example, the sample could be divided into core, semi-peripheral, and peripheral categories consistent with world-systems theorization. Neoclassical proponents, however, generally do not recognize the validity of core-periphery dynamics in this manner and, therefore, are often reluctant to recognize the validity of empirical analysis adopting such an ontology. Third, there are no network analysis studies in the research literature evaluating the positional ordering of all of the LDCs that are part of our sample, making it problematic to rely solely upon this literature in determining the categorization of countries suitable for our analysis.

The designation of non-high income countries as "less developed" is a practice common in the research literature (see Dixon 1984; Stokes and Anderson 1990). Further, the recognition that high income countries are characterized by greater levels of development and more diversified economies and, therefore, are likely excluded from the dependency effects postulated by dependency/world-systems analysis, in essence violating the theoretical scope conditions, has an established precedence in the research literature (see Dixon 1984).

Designation of the "Core" Countries

In order to calculate a reconfigured measure of trade partner concentration, the present study relies upon network analysis research by Smith and White (1992). The designation of the core countries is, therefore, based upon relational data rather than domestic attributes. The "core" is the dominant block or grouping within the global, structured exchange of commodities through international trade as measured in 1980 (Smith and White 1992), they are designated in table A1 in the Appendix.

Slope Dummy Interaction Terms

A potential methodological oversight of quantitative cross-national analysis involves treating all cases as if they are but linear variations of one another (Herkenrath 2002). Therefore, divergent processes within a subgroup of cases can be obscured in a large dataset. Slope dummy interaction terms are one technique for capturing such contingent dynamics.

Figure 5 illustrates the calculation of slope dummy interaction terms. They are created by multiplying a set of dichotomous variables measuring an underlying categorical dynamic by a single continuous or interval-level variable (Feinstein and Thomas 2002; Hamilton 1992).[5] The result is a series of new variables taking the form of either 0 or the interval-level value. In contrast to traditional intercept or dummy variable indicators that have either a 0 or 1 value, all slope dummy interaction terms created from the product of a series of dummies and an interval-level measure can be entered into a regression analysis without producing perfect multicollinearity (Hamilton 1992). This is because slope dummy terms are not necessarily a linear combination of one another, as are traditional dummy variable measures (Hamilton 1992). Slope dummy terms can exhibit strong linear relations, however, and produce multicollinearity in

[5] Examples of research using slope dummy interactions terms include Burns, Kick, and Davis 2003, Jorgenson 2004, and Shi 2003.

a regression analysis, requiring cautious observance of their effects (Hamilton 1992). Accordingly, variance inflation factor (VIF) scores for each independent variable in all models tested are reported.

Figure 5. Calculating Slope-Dummy Interaction Terms

Country	Cdist (%)	L	Lm	Um	Hi		L Cdist	Lm Cdist	Um Cdist	Hi Cdist
Afghanistan	22.2	1	0	0	0		22.2	0	0	0
Albania	77.0	0	1	0	0	→	0	77.0	0	0
Algeria	69.1	0	1	0	0		0	69.1	0	0
Angola	66.6	1	0	0	0		66.6	0	0	0
Argentina	27.0	0	0	1	0	→	0	0	27.0	0
Armenia	50.9	1	0	0	0		50.9	0	0	0
Australia	40.3	0	0	0	1		0	0	0	40.3
Austria	69.7	0	0	0	1	→	0	0	0	69.7
Azerbaijan	58.4	1	0	0	0		58.4	0	0	0

Note: Slope-dummy interaction terms are calculated by multiplying or "interacting" a series of dichotomous variables measuring an underlying categorical dynamic by a single interval-level variable. The result is a new set of variables characterized by either a 0 or the interval-level value.
Cdist = Distribution of exports to core countries (% of total exports)
L = Low income countries; Lm = Lower-middle income countries; Um = Upper-middle income countries; Hi = High income countries

One strategy for utilizing slope dummy terms is to first conduct a *k-1* test for statistically significant differences in slopes. This involves entering into a regression model the original continuous variable and the k-*1* slope dummy variables created from this variable and the categorical variable of interest (Burns et al. 2003). A statistically significant coefficient for any slope dummy indicates the slope for that term differs significantly from the excluded category (Burns et al. 2003). Second, a *contextual* test is conducted wherein all of the slope dummy terms are included in a regression run, but the original continuous variable is excluded, to evaluate the relative contribution of each slope dummy to explaining variation in the dependent variable, controlling for all other independent variables in the analysis (Burns et al. 2003). Results from the contextual analysis can then be interpreted in combination with the previous results obtained from the k-1 test.

By running both k-1 and contextual slope dummy tests it is possible to evaluate: (1) if the slopes are significantly different from one another, and (2) the relative contribution of each slope dummy interaction term to explaining variation in the dependent variable, controlling for other appropriate independent variables. In this analysis slope dummy interaction terms, based upon the strategy outlined above, are employed to model potential ecological unequal exchange relationships.

Hierarchical Regression Analysis

Included in the analyses that follow a number of explanatory and control variables in the regression models to account for relative variance in the dependent variable, guard against spurious relationships, and to examine the stability of parameter estimates and patterns of statistical significance among the independent variables. Further, hierarchical regression is utilized to examine the relative partitioning of the variance accounted for in the dependent variable among the baseline, control, and explanatory independent variables, rather than simply attempting to construct the most parsimonious model possible. Consistent with this approach, relevant independent variables identified through previous research are first enter into the regression analyses (Field 2005). Baseline variables suggested from previous research are entered sequentially in the order of their importance in accounting for variation in the dependent variable; explanatory and control variables are then subsequently incorporated into the analysis (Field 2005). This method of producing a series of simultaneous analyses upon the same dependent variable allows for the evaluation of the consecutive effect of different sets of independent variables upon variance in the dependent variable.

As a check upon problematic multicollinearity among predictor variables, we report variance inflation factor (VIF) values in addition to standardized and unstandardized coefficients

and standard errors in all regression models. Multicollinearity exists when there are strong correlations between two or more independent variables (Field 2005). As Stine notes (1995), VIF values indicate the degree to which multicollinearity among independent variables increases the variance of a slope estimate. Greater multicollinearity among predictor variables, as indicated by higher VIF values, is problematic because it makes both partial coefficients and slope estimates increasingly sensitive to measurement error (Blalock 1979). Multicollinearity does not result in biased coefficient estimates but does increase the standard error and therefore decrease the certainty or degree of confidence that can be placed upon the reliability of the coefficient estimates. Further, as the standard errors of the b-coefficients increase as a consequence of multicollinearity it can bias the resulting statistical significance tests (Field 2005).

There is no well-defined critical VIF value beyond which multicollinearity is a clearly defined problem (Field 1995; Stine 1995). Field (2005) and Chatterjee and Price (1991) argue VIF values of 10 or higher highlight problematic multicollinearity and Hoffman (2004) suggests VIF values of 9 or higher are indicative of problematic multicollinearity. In the research literature there exist varying opinions on critical VIF values. Shandra et al. (2004, 2005), for example, view VIF values of 10 or more as indicating unacceptable multicollinearity whereas Ehrhardt-Martinez (1998) takes a more conservative position and suggests values higher than 4 are problematic. In the present study we consider VIF values of 6-7 as illustrative of problematic multicollinearity. This position is consistent with the majority of quantitative cross-national research in sociology that subscribes to a more conservative stance but typically does not identify a well-defined VIF cut-off value beyond which multicollinearity is considered problematic.

Despite the lack of a well-defined cut-off point in terms of a critical VIF value, there are several classical features or symptoms of multicollinearity that highlight potential problems.

First, high standard errors are a common symptom of multicollinearity and indicate that coefficient estimates are imprecise and likely to vary across different samples (Hamilton 1992). Second, a situation wherein the addition or deletion of an independent variable across successive regression models produces substantial changes in the estimated regression coefficients is a common symptom (Hamilton 1992). Third, standardized regression coefficients greater than or less than 1 provide a warning of excessive multicollinearity.

None of the regression analyses that follow in chapters 4-6 exhibit these classical symptoms of excessive multicollinearity. Further, when preliminary analysis has indicated VIF values beyond 6-7 we have taken steps, outlined in the respective chapters, to address potential problems.

CHAPTER FOUR

ENVIRONMENTAL SPACE IN THE WORLD-SYSTEM

Introduction

The environment serves three vital functions for human populations (Dunlap and Rosa 2000:800-801): 1) it is a "supply depot" providing renewable and non-renewable resources; 2) it acts as a "waste repository" absorbing the byproducts of human consumption and economic activity; and, 3) it provides suitable "living space" for human populations, including housing, transportation, and other activities. Environmental problems are the result of human activity negatively impacting the ability of ecological systems to sustain any or all three functions (Dunlap and Rosa 2000). Over the past 50 years humans have altered global ecological systems more rapidly and extensively than in any comparable period of time in human history (MEA 2005). Such changes are largely the consequence of increasing demand for food, fresh water, timber, fiber, and fuel (MEA 2005).

Environmental space is a concept oriented towards evaluation of the change in the capacity of the environment to provide for these three functions over time. It recognizes that at any particular point in time there are limits to the human induced pressures upon the Earth's ecological services that can be sustained without inducing irreversible damages (Hille 1997; Opschoor 1995; Sachs, Loske, and Linz 1998). The concept builds upon the industrial metabolism perspective by focusing upon the flows of material, energy, and waste supporting human social organization (Sachs 1999).

From an ecological unequal exchange perspective, cross-national appropriation of environmental space enhances the socio-economic and environmental opportunities of industrialized countries, at the expense of LDCs. Such uneven dynamics are recognizable in the

flow of resources and energy underlying, and whose magnitude is obscured by, the flow of monetary exchange values in the world-system (Hornborg 2003). Environmental space is one way of conceptualizing such systemic material relations in a manner not easily captured through purely monetary measurements.

Further, there is increasing evidence industrialized countries inequitably appropriate both global natural resources and the sink-capacity or waste assimilation properties of ecological systems. This appropriation is one mechanism underpinning the enormous disparity in production and consumption patterns and standards of living cross-nationally.

Research Problem and Statement of Purpose

This chapter examines empirically one key question: does international trade create uneven access to global environmental space relative to country income position? The ecological footprint is utilized as a of the potential zero-sum properties related to international trade and environmental space. We build upon previous studies examining the driving forces of ecological footprint demand (Jorgenson 2003; York et al. 2003) and those highlighting the contingent dynamics promoting and constraining demand according to relative position in the global economy (Jorgenson 2004, 2006; Jorgenson and Rice 2005). Methodologically the present study extends beyond the existing literature by evaluating the affect of exports to the core industrialized countries upon environmental consumption by country income level. To examine contingencies within the data we divide countries into low, lower middle, upper middle, and high-income categories. Regression analysis is employed using slope dummy interaction terms to test for differential impacts of international trade relative to country income level.

Defining Environmental Space

Environmental space encompasses the stocks of natural resources and sink capacity or waste assimilation properties of ecological systems supporting human social organization.[6] It focuses upon the flows of material, energy, and industrial waste between human societies and ecological systems through the chain of extraction, production, consumption, and disposal (Sachs 1999). Ecological unequal exchange argues industrialized countries are increasingly appropriating both global natural resources and the sink capacity of ecological systems (Martinez-Alier 2002). They are, in short, disproportionately utilizing global environmental space, constraining present and future utilization opportunities of LDCs.

Trade between economically imbalanced partners is one mechanism shaping cross-national disparities over access to environmental space (Andersson and Lindroth 2001). Further, access is becoming increasingly zero-sum as global ecological systems are straining to accommodate the demands of human social organization.

Improvements in technology and social organization arguably expand both the types of resources available and the productivity of existing resources over time, thus expanding available environmental space (OECD 1997; Opschoor 1995). Therefore, some researchers argue economic growth is not fundamentally constrained by environmental space limits (OECD 1997). Others attach a normative dimension to the concept, however; arguing it is useful for illustrating the inequitable access of industrialized countries to ecological services at a global scale, given the presumed finite limits of environmental space (Daniels 2002; McLaren 2003; Sachs 1999). Sachs (1999), for example, suggests the concept of environmental space can serve as a regulative principle in defense of greater entitlement of LDCs to the use of the global commons.

[6] This concept is also referred to as "environmental utilization space" (OECD 1997), "environmental capacity" (McLaren 2003), and "eco-space" (Opschoor 1995).

Environmental space, in sum, is intended to conceptualize the increasingly complex tradeoffs regarding access to natural resources and sink-capacity. Whether such constraints are short-term tensions or long-term patterns of inequitable environmental utilization remains a topic of debate. Arguably, LDCs require greater consumption of environmental resources to improve the social and economic context for the vast majority of their residents (Sachs et al. 1998), an assertion few researchers take issue with.

The Ecological Footprint: A Review of the Literature

The Ecological Footprint of Nations provides one strategy for operationalizing the concept of environmental space. It is a measure of the biologically productive area required to satisfy the consumption of renewable natural resources and absorption of carbon dioxide waste of a given population, based on prevailing technology and management practices (Chambers et al. 2002).

A growing body of social science research has examined the driving forces of cross-national ecological footprint demand; concluding economic and population dynamics are the primary driving factors (Jorgenson 2003; York et al. 2003). A neglected aspect of this research, however, concerns the relationship between the structural dimensions of international trade as it both facilitates and constrains cross-national ecological footprint consumption. Such disparities in access to environmental space is relevant to broader discussions concerning global environmental change, the continuing development challenges facing LDCs, and considerations of cross-national environmental injustice.

The ecological footprint is composed of six subcomponents: cropland, forest, grazing land, fisheries, energy, and built-up land. Calculation includes domestic resource production plus imports from abroad minus exports to other countries. Exports do not constitute part of a

country's footprint demand but are added to the calculation of importing countries. The ecological footprint, therefore, is based upon a trade balance approach and is sensitive to a nation's demand regardless of the origin of the natural resources consumed.

Consumption within each subcomponent is summed and divided by world average productivity to produce an adjusted figure comparable across countries (Chambers et al. 2002). The overall footprint figure consists of the sum of the adjusted calculations of each of the subcomponent areas, expressed as global hectares of consumption per capita.[7] Because it measures demand relative to both domestic and global biocapacity, it is a reasonable approximation of the cross-national flow of hectares of productive area (Andersson and Lindroth 2001).

Based upon footprint calculations, human societies currently consume more renewable natural resources than can be sustained indefinitely (Wackernagel et al. 2002). Global demand exceeds regenerative capacity by as much as 20 percent (Wackernagel et al. 2002). Overshoot of biological capacity is maintained in the short-term by drawing down or degrading natural capital faster than natural replacement rates. Progressive depletion of groundwater, fisheries, forests, and other large-scale ecological disturbances are, in part, a consequence of natural resource overshoot. Global overshoot began in the 1980s and has been increasing steadily (Loh and Wackernagel 2004). Global biocapacity changes with the amount of productive area available and its average yield (Loh and Wackernagel 2004), but for nearly 20 years it has not changed as fast as consumption demand, despite greater efficiency of resource use or dematerialization in many industrialized countries.

Population, affluence (GDP per capita), percentage of the population composed of nondependents (ages 15-65), and urbanization are the driving forces of national ecological

[7] One hectare is approximately 2.47 acres.

footprint demand (York et al. 2003).[8] Research supports therefore both a human ecology perspective, focused upon population dynamics, as well as a neo-Marxist or treadmill of production perspective focused upon economic production (York et al. 2003).

Political rights, civil liberties, and state environmentalism, variables drawn from ecological modernization theory, are not significantly related to national ecological footprint demand (York et al. 2003). Equally notable, research does not uncover an environmental Kuznets curve (EKC) or inverted-U relationship between either GDP per capita or urbanization and footprint consumption (York et al. 2003). There does not appear to be a decoupling, in absolute terms, of environmental demand relative to affluence or urbanization despite the fact the industrialized countries are the most environmentally efficient per unit of economic output (York et al. 2003; York, Rosa, and Dietz 2005).

Further research using per capita ecological footprint demand reveals a strong causal link between countries at the core of the world-system and higher footprint demand (Jorgenson 2003). Utilizing path analysis, Jorgenson (2003) finds position in the core of the world economy is causally linked with the highest per capita footprints, followed by the semi-periphery and periphery. Beyond this direct effect, world system position influences literacy rates and urbanization, which, in turn, promote per capita footprint consumption. Domestic income inequality is negatively correlated with footprint demand (Jorgenson 2003). Subsequent research using slope dummy interaction terms reveals the affects of urbanization is more pronounced in the core, a consequence of extensive consumer markets and maintenance of the built infrastructure, while greater income inequality is positively associated with footprint demand in the core but negatively associated in the other zones of the world economy (Jorgenson 2004).

[8] York et al. (2003) use the total national ecological footprint score (per capita footprint multiplied by total population). This allows them to assess the independent contribution of population.

Separating the various forms of relative international power, Jorgenson (2005) finds economic (GDP per capita) and military (expenditures per soldier) power is positively correlated with per capita footprint consumption. Export volume (% of GDP) is negatively correlated with footprint demand.

Cross-National Uneven Appropriation of Environmental Space

Developed countries typically utilize relatively greater proportions of the sink-capacity of the global commons. Global warming, for example, is primarily a consequence of the carbon emissions of industrialized countries. Their use of fossil fuels threatens the assimilative capacity of the global environment and arguably precludes the ability of LDCs to follow a similar trajectory, within the confines of the global environment. Martinez-Alier (2002) suggests this imbalance is equivalent to a "carbon debt" in which the North has made use of a disproportionate amount of environmental services without monetary payment or compensation (p. 229).

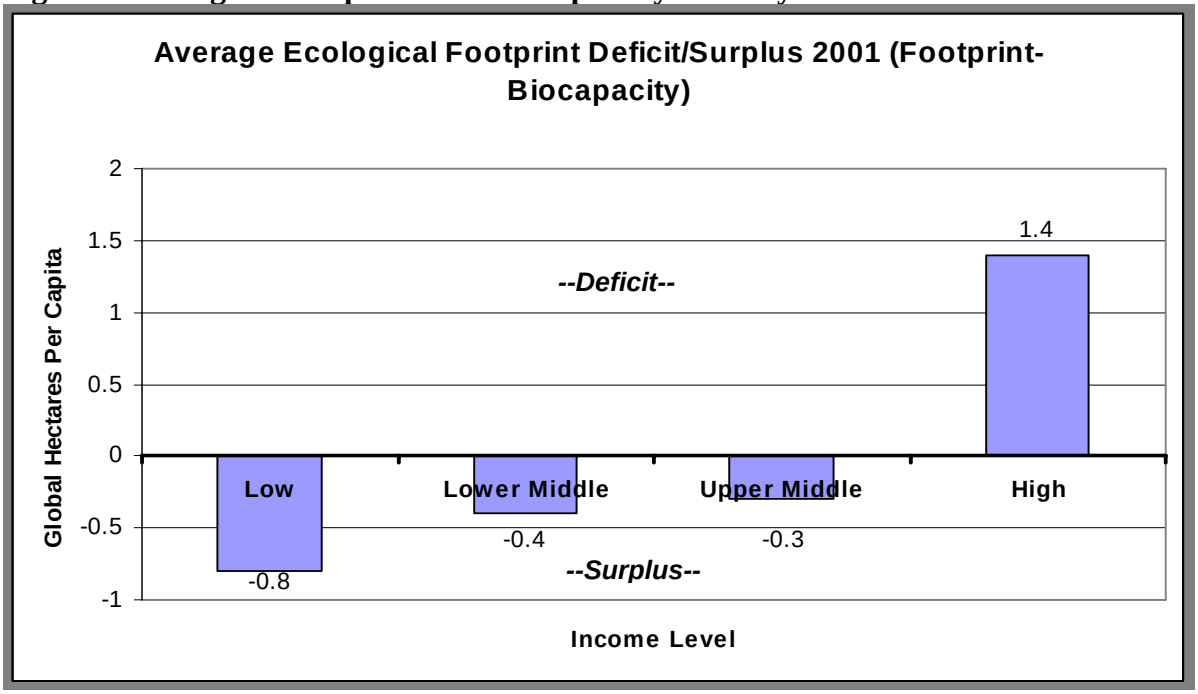
In terms of the supply of environmental resources, researchers have adopted materials flow analysis to chart the movement of natural resources by weight to evaluate the degree of export from the periphery, revealing that even as prices decline the movement of resources to industrialized countries generally continues to increase (Giljum and Eisenmenger 2004; Giljum and Muradian 2003; Muradian and Martinez-Alier 2001a). For example, the movement of non-renewable resources from South-North, particularly minerals and fuels, increased dramatically between the mid-1970s and mid-1990s, even as prices declined (Muradian and Martinez-Alier 2001a). Further, Northern imports of semi-processed metals generally exhibit steady increases in demand rather than a de-linking of Northern economies and Southern non-renewable exports (Muradian and Martinez-Alier 2001b).

The cross-national uneven appropriation of environmental space or biocapacity is not necessarily problematic, per se, unless it enhances the socio-economic and environmental opportunities of some countries at the expense of others. Such zero-sum dynamics complicate the pursuit of intra-generational equity underlying the concept of sustainable development.

Many nation-states, particularly the industrialized countries, have an ecological footprint greater than the natural capital stock available domestically. These countries are argued to be exhibiting an ecological deficit in that their use of bioproductive area must necessarily be appropriated from abroad. Countries run an ecological deficit because of high population density, high consumption rates, or both. The United States has an ecological footprint in 2000 of 9.6 hectares per capita relative to a domestic biocapacity of 4.6 hectares per capita (Venetoulis, Chazen, and Gaudet 2004), arguably appropriating resources from other countries to meet consumption demands.

Figure 6 highlights the average ecological footprint deficit or surplus per capita by country income level. High-income countries, on average, consume 1.4 hectares per capita more than are available domestically, running an ecological deficit. Conversely, low income countries are characterized by an average ecological surplus of .8 hectares per capita, consuming much less than the biologically productive area originally located within their borders. Lower and upper middle-income countries are also characterized by ecological surpluses. Core countries, as identified by Smith and White (1992), are running the largest average deficit as a group. They are not illustrated in figure 6 but analysis reveals the core consume 1.9 hectares per capita more than are available domestically, clearly running an ecological deficit. In general, much of the global per capita demand for renewable natural resources illustrated in figure 6 is a consequence of the environmental consumption of high-income countries, and in particular the core countries.

Figure 6. Ecological Footprint Deficit/Surplus by Country Income Level



Data source: Loh and Wackernagel 2004. Calculated by: total per capita footprint demand - total per capita domestic biocapacity = deficit/surplus. Biocapacity refers to usable biologically productive area. Negative numbers represent an ecological surplus. Positive numbers represent an ecological deficit. Analysis is based upon countries listed in table A1 in the Appendix.

Ecological unequal exchange suggests the patterns illustrated in figure 6 reflect the fact that high income countries utilize LDCs as resource taps in order to subsidize their own rates of material consumption, in the process arguably constraining resource consumption elsewhere. Jorgenson and Rice (2005), for example, find evidence LDCs with relatively greater trade with more economically powerful trading partners are characterized by lower per capita ecological footprints. This suggests factors in addition to domestic economic development, population dynamics, and urbanization shape material consumption outcomes. In particular, structured trade relations among countries shape differential appropriation of environmental space.

The degree to which lower footprint consumption in LDCs translates into negative social welfare outcomes remains an empirical question. The ecological footprint measures resource flows but not human wellbeing directly. However, there is evidence countries exhibiting lower

per capita footprint demand are characterized by higher levels of organic water pollution and, consequently, higher infant mortality rates (Jorgenson and Burns 2004). Further, not all countries exhibiting high footprint demand are characterized by high rates of social development but countries exhibiting low footprint demand are universally mired in poverty (Andersson and Lindroth 2001).

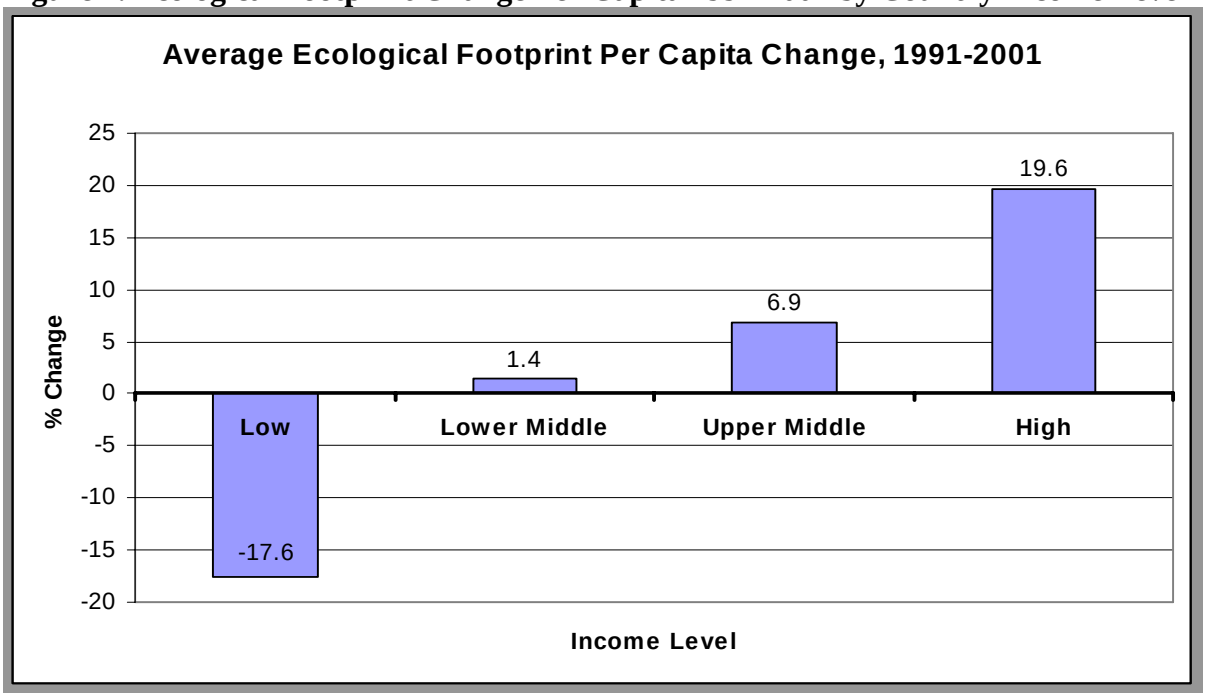
Arguably, poverty reduction and increasing social wellbeing is predicated upon greater consumption than characterizes many LDCs at present. The cross-national appropriation of environmental space or biocapacity within a context of global overshoot raises difficult questions about the trade-offs necessary to achieve broad-based sustainable development. If high income and, especially, core countries protect their domestic environments and satisfy their consumptive demands through reliance upon renewable and non-renewable resources from LDCs it may complicate equitable movement towards sustainable development and an acceptable standard of living in the periphery. This raises the difficult question of whether industrialized countries need to reduce their consumptive demands in order for broad-based sustainable development to be a realistic option.

From 1961 to 1999 South Korea, for example, transitioned from a low to comparatively high footprint demand subsequent to rapid industrialization (Wackernagel et al. 2004). In turn, domestic biocapacity declined by approximately 50 percent over this period and South Korea currently exhibits an ecological deficit whereby domestic consumption significantly outweighs domestic biocapacity (Wackernagel et al. 2004). South Korea's rise in footprint demand and decline in biocapacity, moreover, is only compensated for through a steep rise in imports of natural resources (Wackernagel et al. 2004). The degree to which other countries can follow a

similar development trajectory, pursuing industrialization concurrent with the importation of natural resources, remains an empirical question.

The uneven appropriation of environmental space, moreover, may be increasing over time. Figure 7 presents the average per capita ecological footprint change from 1991 to 2001 by country income level. Over the decade the average per capita footprint demand within low-income countries declined by 17.6 percent. Population growth is arguably a significant aspect of this decline, but declining footprint demand nevertheless raises questions regarding parallel processes of declining social welfare and food security within low-income countries. Conversely, high, upper middle, and lower middle-income countries are characterized by increasing per capita footprint demand from 1991-2001. This effect is especially pronounced in high-income countries, a 19.6 percent average per capita increase.

Figure 7. Ecological Footprint Change Per Capita 1991-2001 by Country Income Level



Data source: Loh and Wackernagel 2004. Analysis is based upon the countries listed in table A1 in the Appendix.

There is more efficient utilization of natural resources within industrialized countries wherein they produce more with less (see York et al. 2005). But these efficiency gains appear relative and not absolute (York et al. 2005). Therefore, on average industrialized countries are becoming more efficient in utilizing environmental resources even as their absolute levels of natural resource throughput continues to increase. For example, research finds increasing cross-national per capita ecological footprint demand from 1991-2001 is driven by GDP per capita growth and growth in service-based economic activity, while manufacturing activity and export intensity are negatively correlated with footprint change (Jorgenson and Burns 2005). This result is contrary to neoclassical economic suggestions concerning the environmentally beneficial relationship between economic growth and movement to service-based industries (Jorgenson and Burns 2005). Rather, as industrialized countries engage in economic growth and movement to service-based industries they may concurrently rely increasingly upon international trade in order to meet natural resource consumption requirements (Jorgenson and Burns 2005), a dynamic exemplified by South Korea's industrialization (Wackernagel et al. 2004).

Regression Analysis Methodology

Ordinary least squares (OLS) regression with listwise deletion is conducted to examine a series of quantitative cross-national analyses incorporating data on the 148 countries for which values on the dependent variable are available for the most recent date, 2001. To maximize available data, we allow sample sizes to vary among tested models.

Dependent Variable

Ecological footprint per capita, 2001 is a comprehensive measure of natural resource consumption. Data source: Loh and Wackernagel 2004. It is based upon six components:

1. *Cropland*--for the cultivation of food, animal feed, fiber, oil crops, and rubber.
2. *Grazing land*--for producing meat, hides, wool, and milk.

3. *Forest*--for harvesting timber, fuelwood, and wood fiber for paper.
4. *Fishing*--for consumption of fish and other marine products.
5. *Built-up land*--for accommodating infrastructure for housing, transportation, and industrial production.
6. *Energy*--a calculation for the area required to sequester carbon emissions produced primarily from fossil fuel use (coal, oil, and natural gas); includes an additional calculation for nuclear power and hydroelectric use.

Main Explanatory Variable

Distribution of exports to the core industrialized countries (% of total exports)—annual average 1997-1999 is a measure of the degree to which a country is integrated into the global economy through exports to the most developed capitalist countries. Data source: IMF *Direction of Trade Statistics* CD-Rom (2003). This variable is averaged over a three-year period to avoid anomalous fluctuations present in any particular year. The core countries identified by Smith and White (1992) are congruent with those identified through similar network analysis research (Blanton 1999; Mahutga forthcoming; Nemeth and Smith 1985).

Proportion of exports to the core industrial countries is the key explanatory variable introduced in this chapter to test claims of ecological unequal exchange. These countries occupy the central or dominant position in the global economy as identified through network analysis of international commodity trade patterns for 1980 (Smith and White 1992).

Examination of exports to these 11 countries is not based upon their domestic attributes but their relative position in the interaction structure encompassing global trade relations. This dominant structural position, from a world-systems perspective, influences the asymmetrical or unbalanced flow of different commodities underlying arguments for unequal exchange. They are ideally positioned to potentially dominate less economically powerful countries. Ecological unequal exchange suggests they are also the countries most likely to impose environmental burdens and constraints upon others. From a neoclassical economics perspective, these countries

are the most developed, and hence, most advantageous countries for LDCs to trade with, as they possess the most efficient and cleanest technology and management practices.

The core countries represent just 12.2 percent of total world population in 2000 but account for 69.5 percent of world gross domestic product.[9] Their average ecological deficit is 1.9 global hectares per capita in 2001, greater than the average for all high-income countries illustrated previously in figure 6. In addition, of the total hectares of global biocapacity consumed by the 148 countries in the sample, these 11 countries account for 37.2 percent of total demand in 2001.

Control Variables

GDP per capita, (PPP, current international $) 1999 measures the annual market value of all final goods and services produced domestically. Data source: World Bank *WDI 2002* CD-Rom.[10] This variable is often utilized as a proxy for level of economic development. This variable is included as previous research indicates it is the driving factor of cross-national ecological footprint demand (Jorgenson 2006; Jorgenson and Rice 2005; York et al. 2003).

Urban population (% total population) 1999 is included as previous research indicates it is positively associated with footprint demand (Jorgenson 2004, 2006; Jorgenson and Rice 2005; York et al. 2003). Data source: World Bank *WDI 2002* CD-Rom.

Exports of goods and services (% of GDP)—annual average 1997-1999 is included as a measure of export intensity. Data source: World Bank *WDI 2004* CD-Rom. This variable is included to control for volume of exports relative to GDP. Previous research suggests export

[9] Data are measured in constant 1995 U.S. dollars and obtained from World Bank 2004.
[10] Missing data from World Bank 2002 were supplemented with data obtained from the *World Factbook 2000 (CIA 2000)*. Supplemental data covered the following countries: Afghanistan, Bosnia, Cuba, Iraq, North Korea, Liberia, Libya, Myanmar, Serbia-Montenegro, and Somalia.

intensity is negatively correlated with footprint demand (Jorgenson 2006). This variable is average over a three-year period to avoid anomalous fluctuations present in any particular year.

Export commodity concentration 1990-1995 is included to control for potential effects related to form of trade integration. It is calculated as the percent of total exports accounted for by the single largest export, based upon the largest 3-digit SITC (revision 2) export category. Data for any particular country range from 1990-1995. Data source: United Nations *International Trade Statistics Yearbook*, Volume 1, various years. Dependency theory posits export commodity concentration is detrimental to the development of LDCs as it inhibits their ability to compete effectively in the global economy (London and Williams 1990).

Inward foreign direct investment (FDI) stocks (% of GDP) 1999 is included as a measure of foreign capital integration. Data source: UNCTAD *World Investment Report 2001*. Foreign direct investment (FDI) is the acquisition of a lasting interest in the productive assets of another country. A country's outflow and inflow of FDI signal the degree of foreign influence over its domestic economy.

World-system/dependency arguments frequently suggest FDI integration into LDCs can have negative economic and social consequences. One conceivable dimension of ecological unequal exchange in turn is the effect of FDI. This assertion is beyond the scope of this paper, but FDI is included in the analysis to control for this potential.

Gross domestic investment (% of GDP) 1999 is included as a control for domestic outlays on additions to the fixed assets of an economy plus net changes in inventory levels. Data source: World Bank *WDI 2002* CD-Rom. This variable is included as previous research examining dependency effects of FDI generally control for domestic investment as this is viewed as having

a positive or counterbalancing effect upon the negative consequences of foreign capital integration.

Regression Diagnostics

Natural log transformations were performed on the ecological footprint, GDP per capita, proportion of exports to the core, FDI, and export commodity concentration variables because of evidence of non-normal distributions. In addition, preliminary analysis revealed GDP per capita was highly correlated with urban population (r = .780). This produced multicollinearity in preliminary regression runs. Therefore, urban population was residualized by regressing this variable upon GDP per capita. The unstandardized residuals were then saved as the new urban population (residualized) variable. This allows for the evaluation of the affects of urban population upon the dependent variable entirely independent of GDP per capita. Consistent with standard practice, VIF values of 6-7 or higher are viewed as evidence of problematic multicollinearity. None of the independent variables in our reported regression models violate this standard or acceptable tolerance levels. Further, Cook's distance and DFBETA values did not highlight overly influential outliers.

Hypotheses[11]

Given that many neoclassical economists reject a strict conception of ecological carrying capacity and, ultimately, the possibility of environmental space constraints, the neoclassical perspective does not necessarily envision increasing footprint demand in industrialized countries as necessarily problematic. We do expect, however, that neoclassical proponents would predict rising footprint demand in LDCs as a consequence of the comparative advantages tied to export activity. This follows from the hypothesized gains in social welfare rooted in greater material

[11] We do not define hypotheses for upper middle-income countries because we anticipate less well-defined results or, in other words, outcomes that are a blending of both lower middle and high-income countries.

consumption as a consequence of efficiency gains through engagement in international trade, consistent with Ricardo's original argument (1951 [1817]). In this chapter the following hypotheses are examined:

Ecological unequal exchange:
1. Greater proportion of exports to core countries is *negatively* correlated with ecological footprint demand in low and lower middle-income countries.

Comparative advantage theory:
2. Greater proportion of exports to core countries is *positively* correlated with ecological footprint demand in low and lower middle-income countries.

Results and Discussion[12]

Table 2 includes a descriptive summary of the key variables in the ecological footprint regression analysis, delineated by country income position.[13] Ecological footprint demand increases in a linear fashion with country income. The greatest consumption among high-income countries is an ecological footprint of 9.9 global hectares per capita, a figure that is 33 times the smallest consuming low-income country. Low-income countries exhibit the smallest average proportion of exports to the core. Lower middle and upper middle-income countries have roughly equivalent average proportions while high-income countries exhibit the highest exports to the core. Further, low-income countries are the least integrated into the global economy through export intensity and FDI. Commodity concentration, on average, is highest among low-income countries, declining in a linear manner with country income.

Table 3 includes the ecological footprint 2001 regressed on a series of baseline and alternative dependency variables. Model 1 in table 3 is the baseline model, with each successive model incorporating the slope dummy interaction terms and additional control variables in a

[12] All F-tests for the models reported in table 3 are statistically significant at the .001 level and are therefore not reported in the text.
[13] Tables A2 and A3 in the Appendix include descriptive statistics and bivariate correlations for all of the variables in the analyses in this chapter.

Table 2. Descriptive Summary of Key Variables in the Ecological Footprint Analysis

Low Income	Mean	Median	Min.	Max.	S.D.
Ecological Footprint Per Capita 2001 (global hectares)	.98	.90	.30	3.30	.44
Proportion of Exports to the Core (% of total exports)	45.3	44.0	8.7	97.7	19.1
Exports (% of GDP)	28.1	24.4	.57	70.1	16.1
FDI (% of GDP)	35.8	14.9	.20	661.9	91.8
Export Commodity Concentration (largest export as % of total exports)	33.1	23.6	1.10	92.6	23.4
Lower Middle Income					
Ecological Footprint Per Capita 2001 (global hectares)	1.9	1.6	.90	4.40	.92
Proportion of Exports to the Core (% of total exports)	52.3	52.1	7.9	93.7	19.7
Exports (% of GDP)	35.1	32.3	12.0	75.9	14.6
FDI (% of GDP)	23.4	19.3	.40	57	16.2
Export Commodity Concentration (largest export as % of total exports)	22.2	18.2	2.70	97.8	19.2
Upper Middle Income					
Ecological Footprint Per Capita 2001 (global hectares)	2.9	2.6	1.30	6.90	1.2
Proportion of Exports to the Core (% of total exports)	52.2	49.4	23.3	92.5	17.1
Exports (% of GDP)	40.4	37.9	8.5	110.2	23.3
FDI (% of GDP)	30.6	21.9	4.4	90.9	22.3
Export Commodity Concentration (largest export as % of total exports)	20.9	11.1	3.40	85.7	21.3
High Income					
Ecological Footprint Per Capita 2001 (global hectares)	5.9	5.4	3.8	9.9	1.7
Proportion of Exports to the Core (% of total exports)	59.7	56.2	39.2	92.8	13.0
Exports (% of GDP)	37.4	34.6	10.5	84.7	18.1
FDI (% of GDP)	25.5	20.5	1.0	108.3	22.8
Export Commodity Concentration (largest export as % of total exports)	14.6	9.3	3.6	94.7	18.5

hierarchical manner. Model 1 highlights the strong association of GDP per capita with ecological footprint demand and the moderate relationship of urbanization. These results are consistent with previous research (Jorgenson 2006; Jorgenson and Rice 2005; York et al. 2003).

Model 2 includes a k-1 test for the non-homogeneity of slopes for the slope dummy interaction terms created by multiplying income level (a set of dummy variables) by proportion of exports to the core (a continuous level variable). High-income is the excluded category. Including the k-1 test after controlling for the variables in the baseline model provides a more conservative test of non-homogeneity of slopes, as a considerable degree of variance has already been accounted for. A significant coefficient for any of the three slope dummies indicates that term has a slope statistically different from or non-homogenous with the excluded category (i.e., high-income countries) (Burns et al. 2003; Hamilton 1992).

Model 2 illustrates the low, lower middle, and upper middle-income categories are non-homogenous or non-parallel to the high-income category. This result is strongest for low-income countries. The results illustrated in model 2 substantiate the utility of dividing the sample into discrete categories on the proportion of exports to the core variable. It does not, however, provide information on the relative contribution of each slope dummy to explaining variance in the dependent variable. Accordingly, a contextual analysis is conducted to evaluate the income level specific effects.

Model 3 includes each of the slope dummies for the proportion of exports to the core variable. Low and lower middle-income countries with a greater proportion of exports to the core exhibit lower ecological footprint demand overall. The results suggest a negative progression from upper middle to low income countries, with the strength of the relationship increasing in a linear manner, although the upper middle and high-income categories are not statistically significant. Inclusion of the slope dummies weakens the effect of GDP per capita and increases the variance accounted for in the dependent variable overall. Another notable result is the effect of urbanization weakens from that observed in the baseline model.

Table 3. Ecological Footprint 2001 by Exports to Core Countries

Independent Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	[-4.289] (.211)	[-3.153] (.444)	[-3.153] (.444)	[-2.535] (.437)	[-2.621] (.436)	[-2.516] (.510)
GDP per capita (ln)	.883*** [.591] (.025) *1.000*	.715*** [.476] (.055) *5.226*	.715*** [.476] (.055) *5.226*	.606*** [.391] (.054) *5.516*	.642*** [.416] (.054) *5.551*	.626*** [.408] (.059) *6.414*
Urbanization (residualized)	.119** [.00621] (.002) *1.000*	.082* [.00437] (.002) *1.078*	.082* [.00437] (.002) *1.078*	.078* [.00409] (.002) *1.085*	.067 [.00348] (.002) *1.098*	.066 [.00343] (.002) *1.112*
Proportion of Exports to Core (%)--Low Income Countries		-.285** [-.0086] (.003) *7.639*	-.214*** [-.0064] (.002) *3.286*	-.283*** [-.0081] (.002) *3.467*	-.285*** [-.0083] (.002) *3.481*	-.288*** [-.0084] (.002) *3.754*
Proportion of Exports to Core (%)--Lower Middle Income Countries		-.203** [-.0061] (.002) *3.619*	-.132* [-.0040] (.002) *2.451*	-.146** [-.0042] (.002) *2.485*	-.175** [-.0051] (.002) *2.524*	-.187*** [-.0054] (.002) *2.589*
Proportion of Exports to Core (%)--Upper Middle Income Countries		-.128** [-.0047] (.002) *1.894*	-.070 [-.0025] (.002) *2.641*	-.070 [-.0025] (.002) *2.628*	-.086 [-.0030] (.002) *2.688*	-.088 [-.0031] (.002) *2.753*
Proportion of Exports to Core (%)--High Income Countries			.066 [.00214] (.003) *4.610*	.111 [.00343] (.002) *4.627*	.078 [.00239] (.002) *4.731*	.078 [.00238] (.002) *4.910*
Proportion of Exports to Core (%)—Main Effect (All Countries)		.052 [.00214] (.003) *2.915*				
Exports (% of GDP)				.080* [.00327] (.002) *1.135*	.099* [.00405] (.002) *1.376*	.098* [.00396] (.002) *1.377*
Inward FDI Stock (% of GDP) (ln)					-.048 [-.0348] (.029) *1.289*	-.039 [-.0285] (.029) *1.292*
Gross Domestic Investment (% of GDP)					-.008 [-.0009] (.005) *1.241*	-.008 [-.0009] (.005) *1.250*
Export Commodity Concentration (ln)						-.021 [-.0177] (.034) *1.334*
Sample Size	147	142	142	135	133	129
Adjusted R^2	.790	.813	.813	.827	.835	.836
Note: First number reported is the standardized coefficient, unstandardized coefficient in brackets, standard error in parentheses, VIF in italics; *p<.05 **p<.01 ***p<.001 (two-tailed tests); ln = natural log transformation						

The results illustrated in model 3 support an ecological unequal exchange interpretation as it suggests proportion of exports to the core countries, a measure of trade partner concentration, has unique effects upon utilization of environmental space, as measured by the ecological footprint, relative to country income level. Economic integration through exports to the core has uneven consequences upon environmental consumption. In general, this is consistent with the argument that trade with economically dominant partners is associated with declining environmental space utilization.

Model 4 includes a control for export intensity. This variable is statistically significant but only weakly correlated with ecological footprint demand. Further, model 5 illustrates the inclusion of FDI and gross domestic investment has little impact upon the dependent variable and it does not substantially temper the effect of core exports across the income categories. Their inclusion, however, strengthens the relationship of the lower middle-income slope dummy. Urbanization, in contrast, drops from statistical significance. The FDI variable is only weakly related to footprint demand in table 1 and never statistically significant. Across all countries in the database, foreign direct investment accounts for little of the variation in the dependent variable.

Model 6 includes a control for export commodity concentration. Controlling for export commodity concentration is a particular concern for low and lower middle income countries as they are typically characterized by a lack of export diversity. Inclusion of this variable, however, does not substantially alter the effect of the baseline or political-economic variables in the table.

The results in table 3 illustrate that each of the income slope dummies is uniquely related to environmental demand. Of particular note, however, is the negative correlation between consumption demand in the low and lower middle-income categories and greater proportion of

exports to the core industrialized countries. Arguably, this highlights zero-sum environmental consumption outcomes related to the structural patterns of international trade and position in the global economy.

Accordingly, the empirical evidence supports hypothesis #1, which proposes that greater proportion of exports to core countries is negatively correlated with ecological footprint demand in low and lower middle income countries. Overall, the results in table 3 contradict hypothesis #2 and the argument that a greater proportion of exports to the core is associated with increasing environmental demand in low and lower middle income countries.

Conclusion

The argument that international trade influences disproportionate cross-national utilization of global renewable natural resources is examined. Such uneven dynamics are relevant to the consideration of inequitable appropriation of environmental space in particular and processes of ecological unequal exchange in general. Using OLS regression with slope dummy interaction terms, the effects of trade upon environmental consumption, as measured by per capita ecological footprint demand for 2001, delineated by country income levels is analyzed. Based upon data for 148 countries, analyses reveal low and lower middle-income countries characterized by a greater proportion of exports to the core industrialized countries exhibit lower environmental consumption. These results remain statistically significant over a series of regression models controlling for alternative political-economic factors. Support is found for the ecological unequal exchange argument that international trade shapes inequitable access to global environmental space, a result contradicting the theory of comparative advantage. International trade appears to shape uneven utilization of global environmental space by constraining consumption in low and lower middle-income countries.

The empirical results build upon previous research but move beyond by evaluating the effects of export structure upon divergent cross-national footprint demand. Our analysis is relevant to considerations of sustainable development as the results suggest trade with core countries is associated with greater polarization rather than convergence of environmental consumption cross-nationally.

CHAPTER FIVE

THE EXPORT OF NATURAL RESOURCES AND SOCIAL DEVELOPMENT

Introduction

Ecological unequal exchange encompasses more than simply uneven environmental cost-shifting and appropriation of environmental space. It is also conceptualized as a mechanism shaping the underdevelopment of resource-exporting LDCs (Bunker 1985; Hornborg 2001). Underdevelopment is characterized by a disadvantageous position in the world-economy and the subsequent lack of economic leverage in exchange relations with other countries. Rather than lagging behind or simply needing to "catch-up" with industrialized nations, the existence of underdeveloped countries helps facilitate the economic development of dominant countries in the first place (Frank 1966).

Research Problem and Statement of Purpose

The sociological literature on cross-national social development includes numerous insightful theoretical and empirical contributions. Nevertheless, few studies directly incorporate natural resource exports as an explicit independent variable to account for the variance in social development outcomes, despite the numerous studies incorporating world-systems insights. This chapter seeks to overcome this limitation. The regression analyses reported in this chapter incorporate a measure of natural resource exports, with and without the calculation of fuels included. Incorporation of such a measure is logically supported by the theoretical arguments underlying the assertion of ecological unequal exchange among countries. In other words, if natural resource exports are linked in a substantive manner to the socio-organizational acceleration of industrialized countries and deceleration in the periphery (Bunker 1984, 1985;

Bunker and Ciccantell 2005) then it is probable such effects obtain even after controlling for other relevant variables.

Slope dummy interaction terms are calculated to test for the differential effects of natural resource exports upon social development by country income level. This strategy is oriented towards explicitly testing insights based upon the idea of ecological unequal exchange. In particular, it allows for the evaluation of the unique effects of natural resource exports upon social development patterns as they vary by country income level.

Delineating the complex and often contradictory consequences of international trade dependency expressed at different structural positions within the global economy provides insights into the prospects of improving social wellbeing cross-nationally but, particularly, contributing to the social situation of populations of less developed countries. Further, it allows for the development and refinement of theoretical scope conditions suitable to a more nuanced understanding of the impact of trade within different contexts.

This chapter begins with an overview of trade dependency and its theorized effects upon social development, discussing the main theoretical and empirical conclusions derived from the sociological literature to date. Next, the methodological strategy is outlined. OLS regression analysis is then conducted utilizing two different measures of social development. First, the Human Development Indicator (HDI) is examined. This is arguably the most well-known and frequently used indicator of social development. Second, the Human Wellbeing Index (HWI) is incorporated as a dependent variable. This is a newer and more broadly constructed measure. The HDI is a measure more oriented towards the assessment of fundamental or basic needs whereas the HWI recognizes social development as a more encompassing concept.

Definition and appropriate empirical assessment of social development resists scholarly consensus (London and Williams 1988). It is not uncommon, therefore, for researchers to run parallel analyses using more than one dependent variable measure (see London and Williams 1988, 1990; Ragin and Bradshaw 1992). Doing so allows for the evaluation of the degree to which the effects of an explanatory variable changes depending upon the social development measure selected (London and Williams 1988). Further, if the results of parallel analyses obtained on different measures of social development are mutually supportive or congruent this, in turn, enhances confidence in the validity of the findings (London and Williams 1988). In the conclusion section the results illustrated in the regression analyses are outlined and the implications as they relate to the juxtaposition of the theory of comparative advantage and arguments of unequal exchange through trade are highlighted.

Trade Dependency and Social Development

Trade dependency refers to the negative asymmetrical economic, social, and environmental processes manifested in LDCs as a consequence of their disadvantageous position in the structural hierarchies of exchange within the global economy. Such processes are rooted in the global division of labor, shaping export-import interaction among countries and relations of relatively enduring dependence largely based upon commodity exchange dynamics.

Dependency refers to a situation wherein the socio-economic development of a country is shaped by and conditioned through the socio-economic expansion and change of other countries. It is a variable and multi-dimensional process. Dependency relations are neither nonexistent nor are they absolute and static. The nature, extent, and temporal continuity of dependency relations are, rather, a persistent empirical question.

A long research tradition in world-systems analysis posits the production and reproduction over time of dependency relations shaped through international trade and its disadvantageous impact upon social wellbeing in LDCs. This research tradition is united by the insistence that in order to understand uneven cross-national social wellbeing outcomes it is necessary to consider both the structure and the structural consequences of trade relationships.

Conventional wisdom suggests economic growth within LDCs promotes greater social wellbeing or mass welfare. There is considerable "slippage," however, between economic development within peripheral countries and social wellbeing outcomes (Stokes and Anderson 1990:63), suggesting the association is not as linear or unproblematic as conventional wisdom would imply. Slippage occurs when economic development does not lead to the expected improvement in mass welfare. Such suboptimal outcomes are arguably linked to complex domestic and world-system dynamics.

Trade dependency processes arguably impact social wellbeing *indirectly* through the suppression and conditioning effects upon economic growth. Trade dependency also impacts social wellbeing *directly* by shaping the domestic economic, political, and social institutional contexts within peripheral countries. Such direct trade dependency processes may influence the slippage between economic development that does occur and social wellbeing. This is not to deny the importance of economic growth for improving mass welfare, but it highlights the complexities of social wellbeing outcomes within a global economy wherein countries are linked through hierarchical interaction structures.

Empirical Studies Examining Social Development: A Review of the Literature

Empirical Research Utilizing the Physical Quality of Life Index

There is a clear and consistent link between economic growth and social development (Stokes and Anderson 1990). Nonetheless, the correspondence between economic growth and genuine improvement in social wellbeing has been elusive for many LDCs (Huang 1995; London and Williams 1988; Stokes and Anderson 1990). In the dependency/world-systems literature, the transition from an empirical focus upon economic growth to a focus upon social development directly was prompted by the increasing recognition of the slippage whereby the former does not necessarily lead to the latter (Ragin and Bradshaw 1992). At times there exists an ostensible contradiction between general economic growth and the distribution of social resources (London and Williams 1988). This necessitates the evaluation of patterns of cross-national social development irrespective of or holding constant economic growth outcomes.

Previous studies employ a number of indicators of social development. Of particular relevance, however, is the research literature utilizing the Physical Quality of Life Index (PQLI). The PQLI is a composite measure based upon the unweighted average of infant mortality rate, life expectancy at age one, and literacy rate, and is developed by Morris (1979). Previous research focused upon the PQLI is salient to the analysis presented in this chapter, moreover, as the PQLI is commonly referred to as the precursor to the United Nations Human Development Index (HDI). Both are composite measures based upon similar underlying indicators, and the creation of the HDI in 1990 has largely supplanted the use of the PQLI in the research literature.[14] Greater scores on both measures indicate higher levels of human development. We organize this review of previous research around the scholarly dialogue that arose in response to

[14] The HDI is based upon four indicators: life expectancy at birth, adult literacy rate, school enrollment, and standard of living as indicated by gross domestic product (GDP) per capita.

studies utilizing the PQLI as well as more contemporary research employing the HDI. This provides a framework for deriving the appropriate model specifications undertaken in the regression analyses that follow and for comparing the results of this chapter with previous social development studies.

The Human Wellbeing Index has yet to be incorporated into the scholarly literature, arguably a consequence of its more recent creation. In turn, when empirically examining the HWI the models are derived from the previous results obtained using the PQLI as well as the HDI.

In one of the earliest studies directly examining cross-national social development, Dixon (1984) evaluates the effect of export partner and export commodity concentration on the provision of basic needs 1960-1980 in a sample of LDCs. Basic needs is operationalized through a variation of the PQLI. Dixon's research illustrates neither export partner concentration, defined as the two largest trading partners, nor export commodity concentration has an appreciable direct impact upon basic needs provision (1984).

Moon and Dixon (1985) incorporate an explicit examination of political processes and their influence upon social development. They suggest wealth is the most powerful explanation for aggregate social development. However, the discrepancy or gap between wealth and welfare performance is influenced by state-level political processes (Moon and Dixon 1985). Their results illustrate democratic processes have a beneficial impact upon the PQLI across a sample of 116 countries. So too does level of state strength, defined as central government expenditures as a percent of GNP, among leftist ideological ruling regimes only. In other words, state capacity to act is necessary though not sufficient but interacts with ideological orientation of the ruling party to shape beneficial social development outcomes (Moon and Dixon 1985). Subsequently, Frey

and Al-Roumi (1999) find democracy is positively associated with improvement in PQLI level in separate cross-sectional analyses covering 1970, 1980, and 1990. They suggest democracy serves to focus the public agenda and state actions on improvements in social wellbeing (Frey and Al-Roumi 1999).

As London and Williams (1988) note, Moon and Dixon's research (1985) is compelling but neglects to control for exogenous dependency-oriented impacts. In an attempt to model both internal and external factors shaping social development, London and Williams (1988) examine levels of investment dependence or FDI and political protest within LDCs. Results illustrate FDI negatively impacts beneficial change over time in the PQLI; level of political protest has no significant effect (London and Williams 1988). In subsequent research, London and Williams (1990) further illustrate the negative effect of FDI and also the negative impact of commodity concentration on level of basic needs provision as measured by the PQLI concurrent with the positive influence of democracy.

Ragin and Bradshaw (1992) construct a trade-based composite measure of dependency based upon four indicators: percentage of raw materials exports, export commodity and partner concentration, and import partner concentration. Utilizing a series of panel analyses, they illustrate trade dependency is negatively correlated with beneficial change in social development, as measured by a composite indicator based upon infant mortality, calorie consumption, protein consumption, and life expectancy, a variant of the PQLI. Of note, their analysis highlights trade dependency has a stronger and more consistent harmful impact upon social development than it does on economic growth, particularly among LDCs. Their research is one of the first longitudinal studies to highlight the negative social development impacts of trade dependency,

but interpretation of their results is complicated by the composite construction of their trade dependency explanatory variable.

The research of Wimberley and Bello (1992) constitutes one example of the direct examination of LDC natural resource exports upon a measure of social development. Utilizing a panel analysis ranging from 1967-1985, they illustrate reduction in non-fuel natural resource exports promotes food consumption. Further, they reveal it is change in natural resource exports rather than level at a given point in time that affects food consumption. Conversely, level of investment dependence or FDI penetration reduces food consumption. Based upon the finding that preexisting levels of natural resource exports do not affect change in food consumption combined with the strong negative influence of level of FDI, they reason the effects of investment dependence have surpassed trade dependence in importance over time.

Empirical Research Utilizing the Human Development Index

Huang's research (1995) is the only study directly evaluating the effect of natural resource exports upon the HDI. Utilizing a sample of 69 LDCs, he highlights the negative association between primary product exports and HDI level for 1987, holding constant state strength, sectoral disarticulation or the juxtaposition of economic sectors exhibiting different rates of development, fertility rate, and private debt as a ratio of GDP. The relationship is moderately strong. Of note, his research does not find commodity concentration and FDI to be significantly associated with the HDI at the .05 level. In turn, Sharma and Gani (2004) find FDI inflows as a percent of GDP to be positively correlated with the HDI when utilizing a pooled cross-sectional analysis of LDCs over the period 1975-1999, although the result is not statistically significant at the .05 level. Despite the non-significance, they conclude FDI contributes to enhancement of human development in LDCs.

Subsequent research by Wickrama and Mulford (1996) highlights the positive association of democracy upon improvement in the level of the HDI in 1990 and the negative association of sectoral disarticulation, among a sample of developing countries. Utilizing slope dummy interaction terms, their research further illustrates sectoral disarticulation has the most substantial negative impact within the least democratic countries. They conclude democracy suppresses the harmful effects of disarticulation upon social wellbeing within LDCs (Wickrama and Mulford 1996).

Roberts (2005) incorporates consideration of the impact of global civil society as measured by the number of country ties to international non-governmental organizations (INGOs) and its impact upon change in the HDI 1980-2000 among a sample of 65 LDCs. He illustrates a positive correlation between number of INGO ties and improvement over the period on the HDI. This result is net the effects of FDI, gross domestic investment, and level of democracy. In contrast to previous research, Roberts does not find a statistically significant relationship between democracy and social development (2005). Further, he argues civil society organizations provide the capacity, coordination, and network ties or social capital for effective collective action promoting improvement in human development.

Sectoral Disarticulation and Cross-National Social Development

Based upon the work of Amin (1974, 1976), sectoral disarticulation is defined distorted economic changes characterized by: 1) The juxtaposition of domestic economic sectors exhibiting substantially different levels of development and worker productivity; 2) Domestic economic sectors characterized by weak or non-existent mutually beneficial linkages, inhibiting the autocentric or self-sustaining economic growth characteristic of more industrialized economies; and, 3) The lack of correspondence between domestic production and consumption

patterns such that workers do not generally consume the products they make nor does economic growth and production stimulate domestic consumption patterns overall.

Sectoral disarticulation is a consequence of "extraversion" or an external economic orientation wherein peripheral countries are overly reliant upon exports for external markets and inward foreign capital (Amin 1976). This reliance distorts the domestic economic structure so that the most dynamic sectors produce primarily for export, and these leading enterprises are often financed by foreign capital (Gallagher, Stokes, and Anderson 1996). As a consequence, other sectors of the economy tend to stagnate, becoming characterized by low wages and low levels of worker productivity (Gallagher et al. 1996).

Disarticulation, therefore, impedes the expansion of the societal division of labor and blocks the developmental benefits inherent in a more complex and internally connected economy (Delacroix and Ragin 1981). Sectoral disarticulation, in particular, produces few beneficial linkages between export and non-export sectors of the economy and few ownership discontinuities in the predominant export industries (Delacroix and Ragin 1981).

A number of studies show sectoral disarticulation directly impedes social development (Breedlove and Armer 1996; Gallagher et al. 1996; Huang 1995; Stokes and Anderson 1990; Wickrama and Mulford 1996) and is negatively associated with economic growth (Delacroix and Ragin 1981). Further, disarticulation is theorized to mediate or intervene between dependency factors and social development such that dependency promotes disarticulation which then impedes social development (Breedlove and Armer 1996) or, alternatively, acts as a contextual or conditioning variable exacerbating the negative effects of dependency, rather than an intervening influence (Breedlove and Armer 1997).

Stokes and Anderson (1990) suggest sectoral disarticulation accounts for much of the "slippage" between economic growth and beneficial social development outcomes in LDCs. This is because disarticulation produces a "distorted" form of economic growth (Stokes and Anderson 1990:63). Their analysis reveals disarticulation negatively impacts beneficial improvement in child mortality rates, crude death rates, and secondary school enrollment, holding constant level of economic development. Moreover, the impact of disarticulation is the most pronounced in the poorest countries in their sample.

Debt Dependency and Cross-National Social Development

Bradshaw and Huang (1991) point to the changing structure of global capitalism over time and suggest dependency takes multidimensional forms exhibiting period-specific effects, an argument many dependency/world-system scholars support (see, for example, Chase-Dunn 1989). Further, they argue foreign investment and trade were the most salient or substantial forms of dependency in the 1960s and 1970s but the dependency effects of foreign debt have become more prominent in the 1980s and 1990s.

Research examining developing countries illustrates foreign debt has a negative impact upon economic growth (Bradshaw and Huang 1991; Bradshaw and Wahl 1991) but it does not appear to have a *direct* impact upon social development as measured by the PQLI. Foreign debt, in turn, may have an indirect impact upon social development through suppression of economic growth in LDCs. Further, Bradshaw and Huang (1991) also illustrate FDI negatively impacts the PQLI while state intervention is positively associated, both results in turn support a dependency argument. Their analysis does not examine the potential effects of trade dependency, however.

In sum, there is considerable empirical evidence that cross-national social development is impacted by dependency factors. There is a complex and, at times, contradictory record of the

relative importance of the different dimensions of dependency. In the empirical analyses below measures of trade, investment, and debt dependency are included in an attempt to delineate among these different factors. Variables drawn from human ecology theory, neoclassical economics, neo-institutionalism, and state-centered approaches are included as appropriate to control for factors previous research illustrates are important explanatory considerations. Similar to Huang's analysis (1995), the present study includes natural resource exports as an explanatory variable. In contrast to Huang, however, the differential impact of natural resource exports, delineated by country income position, are examined. Further, natural resource exports with and without fuels included in the calculation are included in the analyses.

Regression Analysis Methodology

Two different dependent variable measures are utilized in the analyses below. First, the Human Development Index (HDI) is examined. Second, the analyses are repeated with the Human Wellbeing Index (HWI). We incorporate two different composite indicators to evaluate the potential changes in social development observed when using a more narrowly constructed indicator such as the HDI versus a broader indicator as embodied in the HWI.

The narrow focus of the HDI is both a strength and weakness. It is a strength in that it contributes to an easier understanding of the what the HDI actually measures but it is a weakness as it may neglect to measure some aspects social development that are salient considerations. Conversely, it is more difficult to easily conceptualize just what the HWI is measuring but its broader construction encompasses more of the complexities underlying social development.

OLS regression with listwise deletion is employed to examine a series of quantitative cross-national analyses. The countries in the sample are listed in table A1 in the Appendix. To maximize available data, sample sizes are allowed to vary among tested models.

Dependent Variables

The Human Development Index 2003 is based upon the unweighted average of three dimensions: a long and healthy life, knowledge, and standard of living. These three dimensions are operationalized through four indicators:

1. Long and Healthy Life--life expectancy at birth.
2. Knowledge--adult literacy rate (two-thirds weight) and school enrollment as measured by gross enrollment ratio for primary, secondary, and tertiary schools (one-third weight).
3. Standard of Living--gross domestic product (GDP) per capita, measured in purchasing power parity rates (in U.S. $).

Data source: United Nations Development Programme [UNDP] (2005). The HDI ranges from 0-100. Higher values indicate greater human development.

The Human Wellbeing Index 1999 was created to measure the degree to which members of a society are "able to determine and meet their needs and have a large range of choices to meet their potential (Prescott-Allen 2001:5). Data source: Prescott-Allen 2001. Figure 8 outlines the components of the HWI. They include, in succession from broad to concrete, five dimensions, nine total elements, and 36 indicators (Prescott-Allen 2001). The HWI calculation is composed of the unweighted average of the five dimensions, these include: health and population, wealth, knowledge, community, and equity. The data collected for the indicators represent the years 1996-1999. Congruent with the HDI, the HWI ranges from 0 to 100 and higher values represent greater human wellbeing.

Prescott-Allen (2001) argues the HDI is intended to measure distance from deprivation or the most basic social needs whereas the HWI is intended to measure distance from fulfillment and is thus conceptualized as a broader, more encompassing conception of social development. As a consequence, the two present contrasting views of human wellbeing.

Figure 8. Calculation of the Human Wellbeing Index

Human Wellbeing Index (HWI)
What it is: Average of indices of health and population, wealth, knowledge, community, and equity.

It is divided into 5 dimensions &, further, 9 total elements (elements are subsumed under dimensions):

1. **Health & Population Dimension**
    a. Health
    b. Population
2. **Wealth Dimension**
    a. Household wealth
    b. National wealth
3. **Knowledge Dimension**
    a. Knowledge
4. **Community Dimension**
    a. Freedom & governance
    b. Peace & order
5. **Equity Dimension**
    a. Household equity
    b. Gender equity

Hierarchy is as follows: **DIMENSIONS, Elements, indicators**

1. **Health & Population Dimension** What it is: lower of health index & population index
    a. Health: 1 indicator—healthy life expectancy at birth
    b. Population: 1 indicator—total fertility rate
2. **Wealth Dimension** What it is: average of household wealth index & national wealth index
    a. Household wealth (average of needs & income scores; total of 3 indicators):
        i. Needs = food sufficiency indicator & basic services indicator (% of population with access to safe water & basic sanitation.)
        ii. Income = GDP per capita (PPP)
    b. National wealth (weighted average scores for 3 subelements: size of economy, inflation & underemployment [inflation & unemployment], & debt [external & public].)
        i. Size of economy = GDP per capita
        ii. Inflation & unemployment = lower of inflation rate or unemployment rate
        iii. Debt = 1) external debt: lowest score of debt service as a % of exports, debt service as a % of GNP, or ratio of short term debt to international reserves. 2) Public debt & deficit: average score of gross public debt as a % of GDP & central government deficit/surplus as a % of GDP
3. **Knowledge Dimension** What it is: weighted average of education score & communication score
    a. Education score: average score of 2 indicators—1) primary & secondary school enrollment & 2) tertiary school enrollment (students per 10,000 people)
    b. Communication score: Average score of 2 indicators—1) telephone access within the population; 2) internet users per 10,000 persons
4. **Community Dimension** What it is: lower of freedom & governance & peace & order index
    a. Freedom and governance: Average score of 4 indicators—1) political rights rating; 2) civil liberties rating; 3) press freedom rating; 4) corruption perceptions index
    b. Peace and order: Average of peace score & crime score—1) peace score = lower score of deaths from armed conflicts per year and military expenditure as a % of GDP; 2) crime score = average of scores for homicide rate and for other violent crimes (rape, robbery, & assault)
5. **Equity Dimension** What it is: average of household equity index and gender equity index
    a. Household equity: based on 1 indicator—ratio of richest to 20% income to poorest 20% income
    b. Gender equity: Average of 3 indicators—1) gender and wealth (ratio of male income to female income); 2) gender and knowledge (difference between male & female school enrollment rates); 3) gender and community (% of women in parliament)

For example, as conceptualized by the HDI the disparities in human wellbeing between countries are relatively modest (Prescott-Allen 2001). The HWI illustrates greater disparities between countries and performance scores for many countries are consistently lower relative to their HDI performance score (Prescott-Allen 2001), both of which rank countries on a 0-100 continuum.

The HDI and HWI are included together in the present chapter to evaluate the potential variance between the two regarding the effects of trade dependency dynamics and cross-national social development. Such variance provides a more nuanced assessment of ecological unequal exchange tenets relative to comparative advantage theory.

Human Development Index Model Specification

In an effort to specify appropriate regression models the explanatory variables found to be the most significant predictors of level of the PQLI and the HDI within the research literature are included in the analysis. The analysis then proceeds with the testing of potential baseline variables drawn from previous research, included in table 5. The appropriate control variables identified in table 5 are subsequently incorporated into an analysis incorporating slope dummy interaction terms measuring natural resource exports delineated by country income position, included in tables 6 and 7. Proportion of natural resource exports is the main explanatory variable introduced in this chapter, oriented towards evaluating ecological unequal exchange dynamics. A measure of natural resource exports without and with fuels included in the underlying calculation is included in tables 6 and 7, respectively. After introducing the baseline and slope dummy interaction terms, alternative dependency measures are incorporated in a hierarchical manner to further evaluate the stability and statistical significance of the slope dummies and their impact upon social development.

Main Explanatory Variable

Natural resource commodity exports (% of GDP)--annual average1997-1999 is included to examine ecological unequal exchange tenets relative to the theory of comparative advantage. Data source: United Nations *Commodity Yearbook 1995-2000,* Volume 1 (UNCTAD 2003). The data are averaged over a three-year period to avoid anomalous fluctuations in the data present in any particular year. An indicator including and excluding fuels is examined. The indicator excluding fuels is based upon the sum of agricultural raw materials, food, and minerals, ores, and metals as a percent of GDP. The indicator including fuels is based upon the sum of agricultural raw materials, food, minerals, ores, and metals, and fuels as a percent of GDP.[15] This strategy was selected because calculating a fuels only indicator drops numerous countries from the analysis because they are not applicable or do not export fuels. This is problematic because it substantially lowers the degrees of freedom, an issue that is particularly relevant when utilizing slope dummy interaction terms.

Many previous studies evaluating cross-national social development exclude oil-exporting LDCs from the analysis as a matter of course (see, for example, Gallagher et al. 1996; Roberts 2005; Stokes and Anderson 1990; Wickrama and Mulford 1996); suggesting they introduce an atypical, anomalous element into the sample. The present study includes oil-exporting LDCs because these countries may manifest some of the most substantial ecological unequal exchange dynamics. Dividing this variable into a non-fuels and fuels version may highlight interesting social development dynamics that many other previous studies have neglected.

[15] Classification of commodities is based upon the United Nations Standard International Trade Classification, Revision 2 (SITC, Rev. 2). Agricultural raw materials is based upon: SITC section 2 (less divisions 22, 27, 28 and groups 233, 244, 266, and 267); Food is based upon: the sum of SITC section 0, section 1, section 4, and division 22; Minerals, ores, and metals is based upon: the sum of SITC divisions 27, 28, 68, and item 522.56; Fuels is based upon: SITC section 3.

Baseline Control Variables

Economic freedom 1999 is included as a measure of the degree of supportive institutional structures and policies in-place supporting free market economic activity. Data source: the Heritage Foundation report, *2002 Index of Economic Freedom*. This variable is included to more comprehensively evaluate comparative advantage arguments concerning the effects of international trade. Many neoclassical economists suggest it is not simply trade that has positive cross-national social development consequences but trade within institutional contexts supporting market activity. Research by Grubel (1998), for example, illustrates greater economic freedom is positively associated with improved performance on the HDI among a sample of countries at all development levels.

The Heritage Foundation index is based upon the assessment of restrictive/liberal dimensions of an economy in ten areas: trade policy, fiscal burden (taxes and government expenditures), government intervention in the economy, monetary policy, banking and finance regulations, capital flows and foreign investment regulations, wage and price controls, protection of property rights, regulations encountered in starting a business (including labor and environmental), and informal market activity. Countries are evaluated in each area and the average scores are summed to produce an overall score ranging from 1 (least free) to 5 (most free).[16]

Research from environmental economics suggests LDCs integrated into the global economy primarily through exports of natural resources exhibit slower economic growth (Atkinson and Hamilton 2003; Auty 1997, 2001; Gylfason 2001; Sachs and Warner 2001) and lower rates of physical, human, and natural capital development (Atkinson and Hamilton 2003) relative to other developing countries. In the environmental economics and development

[16] We have reverse coded the index from the original to ease interpretation.

literature this is now referred to as the “resource curse hypothesis.” It is considered a “paradoxical but seemingly robust” finding (Atkinson and Hamilton 2003:1793) and a “reasonably solid fact” (Sachs and Warner 2001:837).

It is a persistent contradiction or paradox from a neoclassical economics perspective because mainstream economists expect resource abundant economies to possess comparative advantages enhancing social and economic welfare relative to resource-poor countries. Natural capital assets, in other words, should promote short run economic growth and long-term domestic investment in other productive assets, including physical and human capital (Atkinson and Hamilton 2003), contributing to social and economic development.

The natural resource curse literature in environmental economics includes a number of ad hoc explanations attempting to reconcile these anomalous findings with theoretical expectations. The most prominent explanation forwarded is the suggestion that the rent or profits from resource endowments are not being sufficiently reinvested in other forms of physical and human capital to insure the accumulation of a range of societal assets or wealth over time. Explanations for the lackluster socio-economic development of resource exporting LDCs in the environmental economics literature, in turn, generally focuses upon potentially distorted domestic natural resource, public expenditure, and macroeconomic policies within the affected countries. Such explanations are notable for what is left unconsidered—the exogenous factors shaping the historical development trajectory of LDCs reliant upon natural resource exports.

A measure of economic freedom is included to control for institutional context. Statistically significant trade dependency effects that obtain even after controlling for free-market institutional quality supports the argument that natural resource exporting LDCs are subject to ecological unequal exchange dynamics. Further, this supports the assertion that the

focus of the natural resource curse hypothesis literature within environmental economics is misplaced and cannot account for this seemingly paradoxical situation without reference to exogenous factors.

Democracy 2000 controls for potential political regime effects upon social development. A composite measure of democracy included in the Polity IV Project developed by Marshall and Jaggers (2002) is included in the analyses. This index of democracy ranges from –10 representing a fully autocratic regime to +10 representing a fully democratic. It evaluates competitiveness of political participation, openness and competitiveness of executive recruitment, and constraints on the chief executive. Previous research has illustrated the importance of level of democracy for shaping beneficial social development outcomes (Frey and Al-Roumi 1999; London and Williams 1990; Moon and Dixon 1985; Wickrama and Mulford 1996) while research by Roberts (2005) fails to find a statistically significant effect.

International non-governmental organization (INGO) ties 2000 (number per million population) assess the degree of integration into global civil society and domestic social capital network capacity available to address social development issues. It includes the number of INGOs of which a country is a member, whether directly or indirectly through the presence of organization members within the country. Data source: Union of International Associations *Yearbook of International Organizations,* Volume 2. Previous research by Roberts (2005) suggests there is a positive association between number of INGO ties and beneficial change on the HDI from 1980-2000 within a sample of 65 LDCs.

Central government expenditures (% of GDP)--annual average 1995-1997 is a measure of state strength, generally considered a prerequisite for beneficial state intervention to improve social development. Data source: U.S. Department of State *World Military Expenditures and*

Arms Transfers, various years. This variable is average over a three-year period to avoid anomalous fluctuations in the data present in any particular year. Previous research suggests central government expenditures, an aspect of state-level political processes, is positively correlated with improved social development (Moon and Dixon 1985).

Age structure (% of total population aged 14 years or younger) 1999 is included to evaluate factors derived from human ecology theory in sociology. Data source: World Bank *WDI 2002* CD-Rom. Human ecologists stress the importance of population dynamics in shaping social organization (Humphrey and Buttel 1982). These forces include population size, growth, density, and age structure as factors shaping societal challenges and opportunities. Later generations of human ecologists developed the POET model to articulate the interrelated mechanisms shaping societies (Duncan 1961). This model sketches the push and pull or equilibrium/disequilibria between population (P), social organization (O), the environment (E), and technology (T) as the fundamental forces influencing society. Age structure is included as a control variable because proportion of the population under 14 years of age is arguably a burden upon the social infrastructure negatively affecting social development. This is particularly true of LDCs as they are generally characterized by younger populations and less resources to devote to social development improvement.

A limited body of previous research illustrates population dynamics potentially have an impact upon cross-national social wellbeing. Huang (1995) highlights the negative association between fertility rates and level of the HDI across a sample of LDCs. Further, Wickrama and Mulford (1996) examine the impact of population growth upon level of the HDI across a sample of LDCs. Their research does not illustrate a statistically significant relationship, however. Age structure is included as a control variable rather than fertility rate, as does Huang (1995), because

it is arguably a more valid measure of the immediate impact of population burden upon social development in a cross-sectional analysis as is conducted in this chapter.

Urban population (% of total population) 1999 is included to further assess theoretical insights drawn from human ecology. Data source: World Bank *WDI 2002* CD-Rom. Previous research examining cross-national social development has not incorporated urbanization as a relevant explanatory variable. Theoretical tenets from human ecology theory suggest urbanization may promote social development as a consequence of the Durkheimian concept of dynamic density. As human communities, on any scale, experience population growth there is typically a process of structural differentiation whereby an increasingly complex variety of communications, contacts, social exchanges, and roles evolve, partly as an adaptive response to consequent resource scarcity and other challenges (Humphrey and Buttel 1982). These adaptations, a dynamic response to increasing population density, often promote a greater range of adaptive mechanisms (Humphrey and Buttel 1982). It is anticipated that urbanization, drawn from the human ecology perspective, positively influences social development as a consequence of dynamic density, thus shaping the development of resources and logistical capacity to address social wellbeing concerns. This relationship may be contingent upon country income position, however, as over-urbanization in the poorest LDCs may actually promote decreasing social development as a consequence of increasing population growth and density amid inadequate social and economic infrastructure.

Dependency Control Variables

Distribution of exports to the core (% of total exports)--annual average 1997-1999 is a measure of the degree to which a country is integrated into the global economy through exports to the most developed capitalist countries. This variable is included to control for trade partner

concentration. Data source: Data source: IMF *Direction of Trade Statistics* CD-Rom (2003). This variable is averaged over a three-year period to avoid anomalous fluctuations present in any particular year.

Exports of goods and services (% of GDP)--annual average 1997-1999 is included as a measure of export intensity or aggregate export integration into the global economy. Data source: World Bank *WDI 2004* CD-Rom.

Inward foreign direct investment (FDI) stocks (% of GDP) 1999 is included as a measure of foreign capital integration. Data source: UNCTAD *World Investment Report 2001*. World-system/dependency arguments suggest FDI integration into LDCs can have negative social development consequences. One conceivable dimension of ecological unequal exchange is the effect of FDI integration. This assertion is beyond the scope of this paper, but FDI is included to control for its possible effects. Some previous research illustrates a statistically significant negative correlation between FDI and social development within LDCs (Bradshaw and Huang 1991; Breedlove and Armer 1996) while other research fails to uncover a significant negative relationship (Huang 1995).

Gross domestic investment (% of GDP) 1999 is included as a control for domestic outlays on additions to the fixed assets of an economy plus net changes in inventory levels. Data source: World Bank *WDI 2002* CD-Rom. This variable is included as previous research examining dependency effects of FDI stocks generally control for domestic investment as this is viewed as having a positive or counterbalancing effect upon the potential negative consequences of foreign capital integration.

Sectoral (structural) disarticulation is included to control for the effects of distorted economic organization as a consequence of extraversion. A higher score indicates greater

disarticulation. Data source: Calculated from data collected from World Bank *WDI 2002* CD-Rom. Data range from 1990-1995 (a single year within that period). Sectoral disarticulation is calculated by taking the sum of the absolute difference between a sectors share of labor force (employment) and that sectors contribution to GDP (value added as a % of GDP) across the three major sectors of the economy: agriculture, industry, and services (Breedlove and Armer 1996, 1997; Stokes and Anderson 1990; Wickrama and Mulford 1996). Previous research highlights the negative association of sectoral disarticulation and HDI level (Huang 1995; Wickrama and Mulford 1996) and alternative measures of social wellbeing (Breedlove and Armer 1996, 1997; Gallagher et al. 1996; Stokes and Anderson 1990).

Total debt service (% of GNI) 1999 is a measure of debt dependency. Data source: World Bank *WDI 2002* CD-Rom. Research illustrates debt-oriented dependency factors may negatively impact social development (Bradshaw and Wahl 1991; Huang 1995).

Human Wellbeing Index Model Specification

Given the lack of previous research utilizing the HWI to draw upon, the procedure outlined previously for developing appropriate baseline models for the HDI is repeated. The baseline and dependency variables previously outlined are included in the subsequent analysis incorporating the HWI with the exception of the democracy, age structure, and total debt service variables. These variables, or very similar approximations, are indicators that are an aspect of the HWI calculation.

Because the indicator data composing the HWI range from 1996-1999, some of the independent variables previously outlined were collected at an earlier point in time to preserve an appropriate time ordering. These variables include the following:

1. Natural resource commodity exports (% of GDP) 1995-1996. Data source: United Nations *Commodity Yearbook 1995-2000,* Volume 1 (UNCTAD 2003).

2. Economic freedom 1995. Data source: the Heritage Foundation report, *2002 Index of Economic Freedom*.
3. Democracy 1995. Data source: Marshall and Jaggers 2002.
4. INGO ties 1994. Data source: Union of International Associations *Yearbook of International Organizations,* Volume 2 (1994).
5. Central government expenditures (% of GDP) 1993-1995. Data source: U.S. Department of State (2000) *World Military Expenditures and Arms Transfers, 1998.*
6. Urban population (% of total population) 1995. Data source: World Bank *WDI 2002* CD-Rom.
7. Distribution of exports to the core industrialized countries (% of total exports)—annual average 1993-1995. Data source: IMF *Direction of Trade Statistics* CD-Rom (2003).
8. Exports of goods and services (% of GDP)—annual average 1993-1995. Data source: World Bank *WDI 2004* CD-Rom.
9. Inward foreign direct investment (FDI) stocks (% of GDP) 1995. Data source: UNCTAD *World Investment Report 2005*.
10. Gross domestic investment (% of GDP) 1995. Data source: World Bank *WDI 2002* CD-Rom.

Regression Diagnostics

Natural log transformations were applied to the natural resource exports, INGO ties, FDI, sectoral disarticulation, and total debt service variables because of evidence of non-normal distributions. Consistent with standard practice, VIF values of 6-7 or higher are viewed as evidence of problematic multicollinearity. None of the independent variables in our reported regression models violate this standard or acceptable tolerance levels. Further, examination of Cook's distance and DFBETA values did not identify any overly influential outlying cases.

Hypotheses

The indirect and direct effects of trade dependency processes are mediated by position in the global economy. It is expected, therefore, that the negative consequences of the various dimensions of trade intensity, form, and composition to generally be most forcefully expressed at lower levels of the periphery. Broad period-specific alterations in modes of production in the global economy and the particular outcome under examination, however, may not always conform to such a simplistic model. Nonetheless, based upon the tenets of trade dependency

outlined in chapter two, it is expected that the export of natural resources from non-high income countries negatively impacts level of social development as measured by the HDI and HWI. Further, the poorest countries, the low and lower middle-income groups, are hypothesized to be the most substantially impacted.

Conversely, the theory of comparative advantage argues the export of natural resources benefits the poorest countries and contributes to both economic growth and social development. Many LDCs do not yet possess the human capital, physical capital and technology, and investment capital to engage in sophisticated domestic manufacturing. In many cases, they do possess natural resource assets, and low wage labor, and therefore possess a relative comparative advantage in these areas. The positive effect of natural resource exports, therefore, should be the most recognizable among the poorest countries, the low and lower middle income categories.

Based upon the tenets of ecological unequal exchange and the theory of comparative advantage, the following hypotheses are tested in this chapter:[17]

Ecological unequal exchange:

1. Greater proportion of natural resource exports is *negatively* correlated with level of social development in low and lower middle-income countries.

Comparative Advantage Theory:

2. Greater proportion of natural resource exports is *positively* correlated with level of social development overall, but the positive effect is the strongest within low and lower middle-income countries.

Human Development Index Results and Discussion

Table 4 includes a descriptive summary of the variables included in the regression analyses examining the HDI, delineated by country income level.[18] Some of the notable patterns include the contrast between income levels and the human ecology variables. Urbanization is

[17] We do not define hypotheses for upper middle-income countries because we anticipate less well-defined results or, in other words, outcomes that are a blending of both lower middle and high-income countries.

[18] Tables A4-A7 in the Appendix include descriptive statistics and bivariate correlations for all variables included in the analyses contained in this chapter.

Table 4. Descriptive Summary of Key Variables in the Human Development Index Analysis

Low Income	Mean	Median	Min.	Max.	S.D.
Human Development Index 2003	.51	.50	.28	.77	.13
Urbanization (% of total population)	34.6	32.8	6.1	69.7	15.2
Age Structure (% of pop. 14 years or less)	41.1	43.4	18.3	49.8	7.2
Economic Freedom	2.2	2.1	1.0	3.4	.51
Natural Resource Exports, Non-Fuel (% of GDP)	9.5	6.8	.53	40.5	9.1
Natural Resource Exports, Including Fuels (% of GDP)	13.6	8.3	.50	59.5	13.4
Sectoral Disarticulation	63.9	64.7	15.7	126.8	31.7
Total Debt Service (% of GNI)	5.5	3.7	.43	36.2	5.8
Lower Middle Income					
Human Development Index 2003	.74	.75	.50	.85	.076
Urbanization (% of total population)	53.9	56.1	17.1	76.3	16.2
Age Structure (% of pop. 14 years or less)	31.8	34.1	16.2	43.9	8.7
Economic Freedom	2.6	2.9	1.15	3.63	.67
Natural Resource Exports, Non-Fuel (% of GDP)	8.3	6.8	.13	33.4	6.9
Natural Resource Exports, Including Fuels (% of GDP)	13.3	10.6	2.0	54.4	10.9
Sectoral Disarticulation	34.6	29.4	3.8	103.0	24.9
Total Debt Service (% of GNI)	5.9	6.2	.61	13.7	3.4
Upper Middle Income					
Human Development Index 2003	.79	.80	.56	.90	.078
Urbanization (% of total population)	71.0	74.1	41.1	91.1	14.6
Age Structure (% of pop. 14 years or less)	28.7	29.4	16.8	43.3	7.7
Economic Freedom	3.1	3.1	1.05	3.88	.59
Natural Resource Exports, Non-Fuel (% of GDP)	6.1	4.4	.20	18.5	5.3
Natural Resource Exports, Including Fuels (% of GDP)	12.7	7.0	.90	56.4	12.5
Sectoral Disarticulation	33.6	32.5	7.3	88.7	18.9
Total Debt Service (% of GNI)	8.1	8.4	1.8	16.1	3.6
High Income					
Human Development Index 2003	.92	.94	.84	.96	.029
Urbanization (% of total population)	77.4	77.4	50.3	97.5	12.5
Age Structure (% of pop. 14 years or less)	19.4	18.3	14.4	32.6	4.4
Economic Freedom	3.7	3.8	2.9	4.2	.31
Natural Resource Exports, Non-Fuel (% of GDP)	4.1	3.3	.20	13.9	3.3
Natural Resource Exports, Including Fuels (% of GDP)	8.2	4.1	.20	38.8	9.5
Sectoral Disarticulation	16.0	10.0	3.7	73.8	16.8
Total Debt Service (% of GNI)	---	---	---	---	---

substantially greater among the high and upper middle-income countries. Inversely, low-income countries, on average, are characterized by a substantially greater percentage of the population 14 years of age or younger.

On average, economic freedom increases in a positive and linear manner with country income level. Consistent with dependency/world-system assertions, non-fuel primary product exports as a percent of GDP is inversely related to country income level. On average, low and lower middle income countries exhibit roughly equivalent reliance upon non-fuel natural resource exports.

Consistent with dependency/world-system thought, sectoral disarticulation is clearly more pronounced in low income countries. Surprisingly, however, lower middle and upper middle income countries are characterized by roughly equivalent average sectoral disarticulation.

Table 5 includes a series of hierarchical models from which are derived the baseline model. The baseline model is then included with a series of political-economic variables and the natural resource exports slope dummies in tables 6 and 7. The human development index 2003 is the dependent variable. Higher values indicate greater human development.

Model 1 includes the variables drawn from the human ecology perspective. The results illustrate urbanization is significant and positively correlated with the dependent variable. Age structure, in turn, exhibits a strong negative correlation with the human development index. Countries with a larger proportion of their population 14 years of age or younger tend to be characterized by lower levels of human development. Both variables account for a considerable amount of variation in the dependent variable.

Table 5. Human Development Index by Baseline Variables

Independent Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Constant	[.900] (.042)	[.916] (.048)	[.913] (.051)	[.913] (.053)	[.834] (.058)
Urbanization	.360*** [.00295] (.000) *1.740*	.365*** [.00299] (.000) *1.743*	.370*** [.00303] (.000) *1.805*	.370*** [.00303] (.000) *1.912*	.329*** [.00267] (.000) *2.100*
Age Structure	-.639*** [-.0112] (.001) *1.740*	-.647*** [-.0113] (.001) *1.836*	-.648*** [-.0112] (.001) *2.173*	-.648*** [-.0112] (.001) *2.175*	-.624*** [-.0107] (.001) *2.210*
State Strength--Central Government Expenditures (% of GDP)		-.024 [-.0004] (.001) *1.187*	-.028 [-.0004] (.001) *1.188*	-.028 [-.0004] (.001) *1.334*	-.019 [-.0003] (.001) *1.424*
Democracy			-.006 [-.0001] (.001) *1.379*	-.006 [-.0001] (.001) *1.493*	-.055 [-.0016] (.001) *1.825*
Non-Governmental Organizational Ties (ln)				.000 [.00002] (.007) *1.546*	-.025 [-.0036] (.007) *1.681*
Economic Freedom					.147** [.03579] (.013) *2.389*
Sample Size	141	139	129	129	126
Adjusted R^2	.837	.838	.841	.840	.850
Note: First number reported is the standardized coefficient, unstandardized coefficient in brackets, standard error in parentheses, VIF in italics; *p<.05 **p<.01 ***p<.001 (two-tailed tests); ln = natural log transformation					

Models 2 and 3 include measures of central government expenditures and level of democracy. In contrast to previous research (Moon and Dixon 2005), our results do not find state intervention, in terms of central government expenditures, is a significant predictor of social wellbeing. Similarly, democracy is not significantly correlated with the dependent variable, in contrast to previous findings (Wickrama and Mulford 1996). These divergent results are likely the consequence of our decision to include urbanization and age structure in our baseline model, both of which remain strongly correlated with the human development index in models 2 and 3.

INGO ties are included in model 4. In contrast to previous research evaluating change in the HDI over time (Roberts 2005), our results do not illustrate this is a significant predictor of human development examined in a cross-sectional manner.

Model 5 includes a measure of economic freedom. The results illustrate economic freedom is statistically significant and positively correlated with the human development index. Countries with greater economic freedom tend to exhibit greater human development, consistent with findings illustrated by Grubel (1998). The inclusion of this variable does not substantially alter the previous findings illustrated in models 1-4, although both the urbanization and age structure variables weaken in strength slightly.

Based upon the overall results contained in table 5, urbanization, age structure, and economic freedom are included as the baseline model in tables 6 and 7 that follow. These three variables account for a considerable amount of variation in the human development index, and their inclusion in the regression analyses should provide for a conservative test of the effect of natural resource exports upon the human development index.

In tables 6 and 7 an identical analytical strategy is followed, incorporating slope-dummies for the non-fuel primary products export variable in table 6 and the primary product exports including fuels in table 7. A k-1 test for non-homogeneity of slopes within a model including the baseline variables previously identified is conducted. Next, a contextual test incorporating the slope dummies and the baseline variables is run to assess the degree of variance accounted for by each income category slope dummy. The remaining models consist of the inclusion of additional dependency and political-economic variables in a hierarchical manner, primarily as controls to further assess the relative effects of the slope dummies and the baseline variables upon the dependent variable.

The k-1 test illustrated in model 1, table 6, shows that only the low income slope dummy is significantly different from or non-homogenous with the excluded category, high income countries. This effect is moderately strong and significant at a .01 level. This suggests low-income countries are unique in terms of the effect of non-fuel primary product exports upon the dependent variable relative to the other income categories.

Model 2 is the contextual test with the slope dummy for high-income countries included in the analysis. In contrast to model 1 wherein the effect of each slope dummy is interpreted in relation to the excluded category, model 2 evaluates the relative contribution of each slope dummy to variance in the dependent variable, controlling for the other independent variables in the analysis. The results illustrated in model 2 reveal low-income countries with a greater proportion of non-fuel primary product exports have a lower HDI score. This effect is significant at the .001 level. Inclusion of the slope dummies weakens the effects of each of the baseline variables, but each remains statistically significant in the direction exhibited in table 5. Of particular note, the effect of the economic freedom measure declines by approximately 50 percent and is now significant at the .05 rather than the .01 level, in contrast to the results illustrated in table 5.

The results of model 2 support an ecological unequal exchange interpretation. Low-income countries with greater non-fuel natural resource exports exhibit lower social development. This effect is not strong but it is statistically significant controlling for economic freedom or market-oriented institutional structure and policies. Also of note is, first, that the lower-middle and upper middle-income slope dummies are not statistically non-homogenous from high-income countries and, second, that neither category exhibits a statistically positive relationship between non-fuel natural resource exports and human development. The prevailing

Table 6. Human Development Index by Natural Resource Exports--Non-Fuel

Independent Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Constant	[.821] (.047)	[.821] (.047)	[.812] (.049)	[.782] (.049)	[.752] (.053)	[.898] (.059)	[.923] (.072)
Urbanization	.296*** [.00242] (.000) *2.040*	.296*** [.00242] (.000) *2.040*	.287*** [.00235] (.000) *2.087*	.265*** [.00220] (.000) *2.170*	.269*** [.00222] (.000) *2.162*	.206*** [.00173] (.000) *2.393*	.199** [.00159] (.000) *2.270*
Age Structure	-.538*** [-.0093] (.001) *2.099*	-.538*** [-.0093] (.001) *2.098*	-.535*** [-.0092] (.001) *2.156*	-.520*** [-.0089] (.001) *2.211*	-.523*** [-.0099] (.001) *2.317*	-.463*** [-.0079] (.001) *2.564*	-.467*** [-.0081] (.001) *2.050*
Economic Freedom	.085* [.0205] (.010) *1.850*	.085* [.0205] (.010) *1.852*	.084* [.02009] (.010) *1.930*	.101* [.02446] (.011) *1.976*	.095* [.0234] (.011) *2.072*	.075 [.01922] (.012) *2.220*	.068 [.01845] (.015) *1.874*
Natural Resource Exports-Non-Fuel (% of GDP) (ln)--Low Income Countries	-.250** [-.0415] (.014) *7.270*	-.147*** [-.0244] (.007) *1.932*	-.151*** [-.0249] (.008) *2.172*	-.176*** [-.0290] (.008) *2.319*	-.164*** [-.0269] (.008) *2.482*	-.195*** [-.0319] (.008) *2.336*	-.182** [-.0253] (.009) *2.507*
Natural Resource Exports-Non-Fuel (% of GDP) (ln)--Lower Middle Income Countries	-.028 [-.0055] (.013) *4.236*	.058 [.01151] (.007) *1.408*	.061 [.01286] (.008) *1.402*	.036 [.00752] (.008) *1.558*	.039 [.00816] (.008) *1.707*	.014 [.00290] (.008) *1.636*	.033 [.00576] (.011) *2.287*
Natural Resource Exports-Non-Fuel (% of GDP) (ln)--Upper Middle Income Countries	-.058 [-.0154] (.013) *2.415*	.006 [.00167] (.010) *1.349*	.012 [.00324] (.010) *1.352*	-.020 [-.0055] (.011) *1.603*	-.021 [-.0055] (.011) *1.720*	-.014 [-.0036] (.011) *1.645*	.022 [.00479] (.015) *2.723*
Natural Resource Exports-Non-Fuel (% of GDP) (ln)--High Income Countries		.053 [.01716] (.013) *1.572*	.051 [.01644] (.013) *1.595*	.033 [.01058] (.013) *1.653*	.033 [.0105] (.014) *1.897*	.000 [.00014] (.013) *1.830*	
Natural Resource Exports-Non-Fuel (% of GDP) (ln)—Main Effect (All Countries)	.098 [.01708] (.013) *5.385*						
Proportion of Exports to the Core (% of Total Exports)			.025 [.00024] (.000) *1.184*	.008 [.00008] (.000) *1.217*	.013 [.00013] (.000) *1.257*	.029 [.00029] (.000) *1.231*	.065 [.00058] (.000) *1.273*
Exports (% of GDP)				.096** [.00101] (.000) *1.298*	.074* [.00077] (.000) *1.522*	.103** [.00110] (.000) *1.291*	.101* [.00095] (.000) *1.448*
Inward FDI Stock (% of GDP) (ln)					.014 [.00261] (.007) *1.687*		
Gross Domestic Investment (% of GDP)					.048 [.00139] (.001) *1.346*		

Table 6. Continued

Sectoral Disarticulation (ln)						-.162*** [-.0346] (.009) *2.024*	-.190*** [-.0414] (.011) *1.520*
Total Debt Service (% of GNI) (ln)							-.013 [-.0031] (.012) *1.499*
Sample Size	135	135	131	129	128	121	96
Adjusted R^2	.869	.869	.870	.877	.876	.888	.839
Note: First number reported is the standardized coefficient, unstandardized coefficient in brackets, standard error in parentheses, VIF in italics; *p<.05 **p<.01 ***p<.001 (two-tailed tests); ln = natural log transformation							

view in neoclassical economics is that LDCs often have a comparative advantage in natural resource exports. This perspective generally denies the existence of negative social development consequences based upon LDC reliance upon natural resource exports, except within a context of domestic corruption and narrow rent seeking behaviors. Inclusion of the economic freedom measure is intended to control for this concern. This positive relationship is arguably a consequence of greater integration into the global economy based upon comparative advantage. In contrast, models 1 and 2 suggest LDCs reliant upon a greater proportion of non-fuel primary product exports as a percent of GDP not only do not illustrate a higher level of social development but are, as is the case with low income countries, characterized by lower levels of human development.

Model 3 includes proportion of exports to the core, across all countries in the dataset. In contrast to the results found for the ecological footprint, distribution of exports to the core does not appear to be a significant predictor of the human development index. Model 4 illustrates export intensity is weakly correlated with human development. Greater export integration is positively correlated with social development as measure by the HDI. Non-fuel primary product exports, a measure of export composition relative to size of the economy, remains negatively correlated with the dependent variable despite the inclusion of export intensity.

Model 5 includes controls for FDI stock and gross domestic investment. Neither is a significant predictor of the dependent variable nor does their inclusion temper the effect of non-fuel natural resource exports within low-income countries. Model 6 includes a control for sectoral disarticulation. Previous research illustrates sectoral disarticulation is negatively correlated with level of social development across LDCs; as sectoral disarticulation increases the level of social development declines (Breedlove and Armer 1996; Gallagher et al. 1996; Huang 1995; Stokes and Anderson 1990; Wickrama and Mulford 1996). Our results are congruent with previous research as sectoral disarticulation is negatively correlated with human development across all of the countries in the dataset. With the inclusion of sectoral disarticulation, the economic freedom measure drops from statistical significance.

Model 7 includes a control for the potential effect of debt dependency. Many natural resources exporting LDCs are also characterized by high levels of external debt. None of the high-income countries in the dataset have values on this variable. The high-income countries, as a consequence, are essentially excluded from analysis as a result, reflected in the substantially lower number of cases in model 7. Similar to previous research that fails to uncover a direct negative correlation between debt dependency and social development (Bradshaw and Huang 1991), a significant correlation with the human development index is also not detected. Of particular note, inclusion of total debt service does not appreciably weaken the negative effect of non-fuel primary products among low-income countries. In addition, controlling for external debt strengthens the negative association of sectoral disarticulation upon the dependent variable.

Table 7 includes slope dummy variables based upon the interaction of country income level and primary product exports including fuels (% of GDP). Model 1 illustrates that, congruent with the results reported in table 6, only the low-income category is significantly non-

Table 7. Human Development Index by Natural Resource Exports--Including Fuels

Independent Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Constant	[.834] (.047)	[.834] (.047)	[.819] (.049)	[.790] (.050)	[.755] (.052)	[.907] (.062)	[.903] (.074)
Urbanization	.259*** [.00210] (.000) *2.316*	.259*** [.00210] (.000) *2.316*	.250*** [.00203] (.000) *2.351*	.258*** [.00212] (.000) *2.411*	.260*** [.00213] (.000) *2.422*	.193*** [.00160] (.000) *2.919*	.219*** [.00175] (.001) *2.456*
Age Structure	-.569*** [-.0098] (.001) *2.269*	-.569*** [-.0098] (.001) *2.269*	-.567*** [-.0098] (.001) *2.332*	-.515*** [-.0088] (.001) *2.849*	-.508*** [-.0087] (.001) *2.823*	-.477*** [-.0081] (.001) *3.240*	-.461*** [-.0080] (.001) *2.575*
Economic Freedom	.088* [.02121] (.010) *1.846*	.088* [.0212] (.010) *1.846*	.088* [.02113] (.010) *1.917*	.083 [.0204] (.011) *2.119*	.062 [.01509] (.012) *2.382*	.047 [.01203] (.012) *2.423*	.049 [.0135] (.015) *1.728*
Natural Resource Exports-Including Fuel (% of GDP) (ln)--Low Income Countries	-.224** [-.0328] (.011) *6.215*	-.091 [-.0133] (.008) *2.789*	-.089 [-.0130] (.008) *3.148*	-.178** [-.0260] (.010) *4.682*	-.199** [-.0288] (.010) *5.018*	-.168** [-.0242] (.010) *5.316*	-.178 [-.0218] (.013) *6.243*
Natural Resource Exports-Including Fuel (% of GDP) (ln)--Lower Middle Income Countries	.000 [-.00006] (.010) *3.506*	.112** [.01949] (.007) *1.916*	.117** [.02108] (.008) *1.984*	.054 [.00964] (.009) *2.802*	.039 [.00687] (.009) *2.968*	.057 [.0101] (.010) *3.245*	.044 [.00664] (.013) *4.192*
Natural Resource Exports-Including Fuel (% of GDP) (ln)--Upper Middle Income Countries	-.022 [-.00453] (.010) *2.382*	.073 [.01502] (.008) *1.801*	.078 [.01593] (.009) *1.815*	-.001 [-.0001] (.011) *2.695*	-.013 [-.0028] (.011) *2.859*	.044 [.00919] (.011) *3.267*	.023 [.00399] (.015) *4.322*
Natural Resource Exports-Including Fuel (% of GDP) (ln)--High Income Countries		.081* [.01955] (.010) *1.822*	.080 [.01908] (.010) *1.848*	.038 [.00960] (.012) *2.229*	.041 [.01034] (.012) *2.320*	.048 [.01206] (.012) *2.494*	
Natural Resource Exports-Including Fuel (% of GDP) (ln)—Main Effect (All Countries)	.106* [.01955] (.010) *3.097*						
Proportion of Exports to the Core (% of total)			.035 [.00034] (.000) *1.165*	.012 [.00012] (.000) *1.239*	.013 [.00012] (.000) *1.261*	.032 [.00032] (.000) *1.234*	.074 [.00066] (.000) *1.264*
Exports (% of GDP)				.100* [.00103] (.000) *1.893*	.071 [.00072] (.000) *2.053*	.090* [.00093] (.000) *1.844*	.128* [.00119] (.001) *1.928*
Inward FDI Stock (% of GDP) (ln)					.042 [.00763] (.007) *1.565*		
Gross Domestic Investment (% of GDP)					.063 [.00185] (.001) *1.254*		

Table 7. Continued

Sectoral Disarticulation (ln)						-.143*** [-.0301] (.009) *2.060*	-.168** [-.0366] (.011) *1.566*
Total Debt Service (% of GNI) (ln)							-.035 [-.0079] (.012) *1.622*
Sample Size	137	137	133	131	130	123	97
Adjusted R^2	.871	.871	.873	.878	.880	.886	.836
Note: First number reported is the standardized coefficient, unstandardized coefficient in brackets, standard error in parentheses, VIF in italics; *p<.05 **p<.01 ***p<.001 (two-tailed tests); ln = natural log transformation							

homogenous with the excluded category, high-income countries. In contrast to non-fuel primary product exports, however, the contextual test reported in model 2 does not reveal a statistically significant negative relationship between the low-income slope dummy and the dependent variable. Also of note, natural resource exports are positively associated with human development in lower middle and high-income countries, controlling for the baseline variables. Interpretation of this result is complicated, however, by the fact that the k-1 test reported in model 1 did not reveal a statistically significant difference of slopes for lower middle-income countries. As a consequence, natural resource exports may be positively correlated with the HDI in both lower middle and high-income categories but it cannot be asserted with confidence that these results are significantly unique to each income category.

With the inclusion of proportion of exports to the core in model 3 the positive effect of high-income natural resource exports drops from statistical significance at the .05 level. The baseline variables remain significantly associated with human development, exhibiting effect sizes throughput table 7 congruent with the results reported in table 6.

The inclusion of export intensity in model 4 changes the relative effects of the slope dummies. Primary product exports (including fuels) within low-income countries are now significantly correlated with human development at the .01 level. This relationship is moderately

strong and negative. Similar to the results illustrated in table 6, low-income countries with a greater proportion of natural resource exports exhibit lower social development. The positive effect exhibited by lower middle-income countries weakens and drops from statistical significance, as does the measure of economic freedom.

Model 5 includes controls for FDI and gross domestic investment. Their inclusion strengthens the effect size of the low-income slope dummy slightly, and export intensity becomes no longer statistically significant at the .05 level. Model 6 includes the control for sectoral disarticulation. Consistent with the result illustrated in table 6, sectoral disarticulation is negatively correlated with human development across all of the cases at the .001 level. This effect strengthens with the inclusion of the total debt service variable in model 7. Also of note, the inclusion of controls for sectoral disarticulation and debt dependency do not temper the negative correlation of natural resource exports from low-income countries and human development.

Arguably, the failure of lower middle and upper middle-income countries to be characterized by a significant positive association between natural resource exports and human development, as illustrated in tables 6 and 7, may be also be indicative of ecological unequal exchange dynamics. Many of the primary product exports from these countries contribute to natural capital loss, localized environmental degradation, and the accumulation of human health hazards, particularly as it concerns the mining sector. The results of tables 6 and 7 suggest there may be few social development benefits that accrue to offset such negative externalities. Of particular importance, despite the fact that economic freedom is positively correlated with the human development index across the dataset, as freedom increases so does human development,

the negative and lackluster effect of primary product exports upon level of human development remains statistically significant.

Human Wellbeing Index Results and Discussion

In an effort to provide some contrast to the results obtained utilizing the human development index, the analysis next turns to a consideration of the effect of natural resource exports upon a broader measure of social development. There is little precedent in the academic literature to draw upon in developing appropriately specified regression models when utilizing the Human Wellbeing Index (HWI). In table 8 urbanization, state strength, INGO ties, and economic freedom are included as independent variables in an effort to construct a baseline model, for subsequent incorporation in tables 9 and 10.[19] As the results of table 8 illustrate, all four are statistically significant predictors of HWI score and all are positively correlated with improving human wellbeing; Inclusion of each variable, illustrated in model 4, accounts for a substantial amount of variation in the HWI. Of particular note, urbanization and economic freedom are strongly associated with the dependent variable. In tables 9 and 10 these variables are included as the baseline model and then the natural resource export slope dummies and relevant political-economic variables are incorporated in succession, congruent with the analytical strategy illustrated previously in tables 6 and 7.

Model 1 of table 9 reveals the low-income slope dummy is strongly non-homogenous with the high-income category slope at the .001 level.[20] In addition, the lower middle and upper middle income slopes are also significantly non-parallel, a result not obtained for any of the k-1 tests examining variation in the HDI. The results suggest the positive human wellbeing benefits

[19] Descriptive summaries and bivariate correlations of all variables included in the HWI analyses are reported in tables A6 and A7 in the Appendix.

[20] The INGO ties variable is excluded from the subsequent regression runs because in preliminary analyses it does not reach statistical significance in any of the models but its inclusion inflates the VIF scores among several independent variables.

Table 8. Human Wellbeing Index by Baseline Variables

Independent Variables	Model 1	Model 2	Model 3	Model 4
Constant	[3.932] (2.949)	[-1.939] (3.761)	[-35.82] (6.815)	[-36.21] (6.631)
Urbanization	.744*** [.700] (.052) *1.000*	.711*** [.659] (.053) *1.094*	.521*** [.483] (.057) *1.551*	.407*** [.373] (.055) *1.661*
State Strength--Central Government Expenditures (% of GDP)		.157** [.305] (.111) *1.094*	.165** [.320] (.100) 1.094	.188*** [.362] (.093) *1.093*
Non-Governmental Organization Ties (ln)			.338*** [6.864] (1.198) *1.448*	.132* [2.786] (1.378) *1.968*
Economic Freedom				.379*** [10.817] (1.898) *2.052*
Sample Size	145	138	138	132
Adjusted R^2	.551	.590	.668	.716

Note: First number reported is the standardized coefficient, unstandardized coefficient in brackets, standard error in parentheses, VIF in italics; *p<.05 **p<.01 ***p<.001 (two-tailed tests); ln = natural log transformation

of reliance upon non-fuel natural resource exports as a percent of GDP are considerably less for LDCs than for high-income countries as a group. Concerning the baseline variables, urbanization, state strength, and economic freedom are all positively correlated with the HWI. As urbanization, state strength, and economic freedom increase across the dataset so does improvement in human wellbeing.

A contextual test is reported in model 2 of table 9. The results illustrate low-income countries with a greater proportion of non-fuel primary product exports exhibit lower levels of human wellbeing. Of note, this result is the inverse of that illustrated by high-income countries as a group. Higher levels of human wellbeing characterize high-income countries with a greater proportion of non-fuel natural resource exports. This result supports an ecological unequal exchange interpretation. The divergent outcomes between low and high-income countries are arguably tied to the differing domestic attributes and variant positions in the global economy.

Table 9. Human Wellbeing Index by Natural Resource Exports Non-Fuel

Independent Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	[-1.743] (5.682)	[-1.717] (5.681)	[3.092] (6.375)	[.526] (6.983)	[.770] (7.557)	[37.484] (9.671)
Urbanization	.306*** [.280] (.054) *2.035*	.306*** [.280] (.054) *2.034*	.238*** [.220] (.057) *2.293*	.221*** [.206] (.060) *2.388*	.211*** [.198] (.056) *2.423*	.144** [.136] (.051) *2.666*
State Strength--Central Government Expenditures (% of GDP)	.129** [.248] (.087) *1.213*	.129** [.248] (.087) *1.213*	.152*** [.294] (.089) *1.264*	.170*** [.330] (.097) *1.440*	.126** [.248] (.096) *1.622*	.064 [.130] (.090) *1.826*
Economic Freedom	.242*** [6.912] (1.753) *2.216*	.241*** [6.897] (1.754) *2.219*	.266*** [7.573] (1.747) *2.265*	.278*** [8.283] (1.909) *2.388*	.268*** [8.128] (1.826) *2.484*	.192*** [6.025] (1.676) *2.641*
Natural Resource Exports-Non-Fuel (% of GDP) (ln)--Low Income Countries	-.811*** [-14.42] (2.270) *9.579*	-.172** [-3.060] (1.211) *2.729*	-.213** [-3.791] (1.248) *2.961*	-.204** [-3.700] (1.343) *3.177*	-.140* [-2.558] (1.309) *3.525*	-.183** [-3.289] (1.133) *3.680*
Natural Resource Exports-Non-Fuel (% of GDP) (ln)--Lower Middle Income Countries	-.484*** [-10.31] (2.035) *5.374*	.049 [1.050] (1.306) *2.214*	.057 [1.289] (1.360) *2.195*	.080 [1.786] (1.531) *2.741*	.114 [2.584] (1.497) *2.966*	.046 [1.062] (1.341) *3.176*
Natural Resource Exports-Non-Fuel (% of GDP) (ln)--Upper Middle Income Countries	-.289*** [-8.343] (1.923) *2.610*	.105 [3.022] (1.740) *2.137*	.123* [3.603] (1.747) *2.129*	.140* [4.076] (1.934) *2.587*	.167** [4.853] (1.857) *2.799*	.110* [3.103] (1.614) *3.029*
Natural Resource Exports-Non-Fuel (% of GDP) (ln)--High Income Countries		.324*** [11.383] (2.406) *2.755*	.336*** [11.783] (2.401) *2.824*	.342*** [11.841] (2.503) *3.037*	.437*** [15.362] (2.459) *3.356*	.321*** [11.016] (2.252) *3.979*
Natural Resource Exports-Non-Fuel (% of GDP) (ln)—Main Effect (All Countries)	.443*** [11.357] (2.405) *5.170*					
Proportion of Exports to the Core (% of Total Exports)			-.080 [-.0837] (.046) *1.176*	-.068 [-.0730] (.049) *1.200*	-.045 [-.0486] (.047) *1.269*	-.029 [-.0321] (.041) *1.284*
Exports (% of GDP)				-.027 [-.0339] (.062) *1.438*	.012 [.01503] (.065) *1.761*	.040 [.05058] (.056) *1.810*
Inward FDI Stock (% of GDP) (ln)					-.152*** [-3.749] (1.072) *1.296*	-.132*** [-3.390] (.973) *1.321*
Gross Domestic Investment (% of GDP)					.093* [.311] (.147) *1.317*	.114** [.400] (.131) *1.295*

Table 9. Continued

Sectoral Disarticulation (ln)						-.283*** [-7.230] (1.392) *2.743*
Sample Size	131	131	127	122	120	110
Adjusted R^2	.777	.777	.789	.790	.825	.881
Note: First number reported is the standardized coefficient, unstandardized coefficient in brackets, standard error in parentheses, VIF in italics; *p<.05 **p<.01 ***p<.001 (two-tailed tests); ln = natural log transformation						

Despite the fact non-fuel primary product exports are, on average, a much smaller proportion of total GDP among high-income countries than among low, high income countries are nonetheless more inclined to be characterized by positive social development outcomes as a consequence of reliance upon non-fuel natural resource exports. The slope dummy effect for lower middle and upper middle-income countries is non-significant.

Model 3 includes a control for proportion of exports to the core. When controlling for this measure, the positive slope dummy effect for upper middle-income countries reaches statistical significance at the .05 level. The inverse effects characterizing the low and high-income slope-dummies strengthen. Model 4 controls for export intensity. This measure is not a significant predictor of level of human wellbeing. This result is incongruent with the effect of export intensity upon level of the human development index, illustrated in tables 6 and 7. In these previous analyses export intensity is consistently and positively, albeit weakly, correlated with HDI score.

Model 5 includes controls for FDI and gross domestic investment. In contrast to the HDI cross-sectional models, FDI is negatively associated with the HWI measure at a statistically significant level. Across all cases in the dataset, greater proportion of FDI stock (as a % of GDP) is correlated with lower human wellbeing. Gross domestic investment is significant and positively correlated with the dependent variable. Inclusion of these two measures strengthens the positive effects of the upper middle and high-income slope dummies but weakens the effect

of non-fuel natural resources among low-income countries on the dependent variable. Model 6 includes a control for the potential influence of sectoral disarticulation. Consistent with the results from the cross-sectional HDI models, sectoral disarticulation is statistically significant and negatively associated with human wellbeing. The effect of this measure is moderately strong and significant at the .001 level. Inclusion of sectoral disarticulation weakens the effect of state strength, which drops from statistical significance.

Table 10 includes an identical analytical set-up as table 9 but includes slope dummies for primary product exports with fuels included. The k-1 test in model 1 illustrates each of the slope dummy categories is significantly non-homogenous with the high-income category, similar to the results obtained in table 9. Of particular note, low-income countries are strongly non-parallel with the high-income category. Each of the baseline variables is statistically significant and positively associated with the HWI.

Model 2 includes the slope dummy contextual test, controlling for the baseline measures. The low-income slope dummy is statistically significant and negatively correlated with the HWI. The effect for the low-income slope is considerably stronger than was obtained in table 8. In addition, the lower middle and upper middle-income slopes are also statistically significant and negatively correlated with the dependent variable. The high-income slope dummy is weakly correlated with human wellbeing but fails to reach statistical significance. Together, these results are in sharp contrast to the results obtained in table 9, which illustrated the inverse negative and positive associations between the low and high-income slope dummies. The contextual test in table 10 illustrates non-high income countries with a greater proportion of primary product exports, including fuels, have considerably lower scores on the HWI. These negative effects, moreover, are moderate to strong despite controlling for economic freedom, which remains

Table 10. Human Wellbeing Index by Natural Resource Exports--Including Fuels

Independent Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	[2.600] (6.168)	[2.602] (6.168)	[6.410] (6.369)	[12.884] (6.614)	[9.754] (7.243)	[47.514] (8.720)
Urbanization	.340*** [.311] (.056) *2.200*	.340*** [.311] (.056) *2.200*	.272*** [.254] (.058) *2.419*	.282*** [.269] (.054) *2.390*	.258*** [.246] (.054) *2.477*	.254*** [.247] (.050) *3.062*
State Strength--Central Government Expenditures (% of GDP)	.206*** [.400] (.088) *1.193*	.206*** [.400] (.088) *1.194*	.232*** [.456] (.086) *1.225*	.117** [.235] (.092) *1.597*	.123** [.246] (.091) *1.603*	.049 [.100] (.079) *1.743*
Economic Freedom	.269*** [7.764] (1.700) *2.004*	.269*** [7.763] (1.699) *2.003*	.267*** [7.718] (1.587) *2.074*	.203*** [6.196] (1.727) *2.422*	.228*** [7.024] (1.790) *2.606*	.098* [3.131] (1.630) *3.084*
Natural Resource Exports-Including Fuel (% of GDP) (ln)--Low Income Countries	-.452*** [-7.147] (1.740) *7.015*	-.450*** [-7.114] (1.206) *3.370*	-.460*** [-7.291] (1.178) *3.538*	-.551*** [-8.866] (1.246) *4.534*	-.467*** [-7.533] (1.352) *5.455*	-.507*** [-8.096] (1.153) *6.184*
Natural Resource Exports-Including Fuel (% of GDP) (ln)--Lower Middle Income Countries	-.207** [-3.778] (1.540) *4.122*	-.205** [-3.745] (1.199) *2.500*	-.166** [-3.133] (1.202) *2.581*	-.273*** [-5.122] (1.358) *3.952*	-.203** [-3.954] (1.473) *4.441*	-.261*** [-5.381] (1.284) *4.603*
Natural Resource Exports-Including Fuel (% of GDP) (ln)--Upper Middle Income Countries	-.184** [-3.977] (1.454) *2.614*	-.182** [-3.943] (1.381) *2.356*	-.133* [-2.893] (1.354) *2.471*	-.221** [-4.937] (1.533) *3.553*	-.161* [-3.607] (1.637) *4.152*	-.213*** [-4.646] (1.415) *4.993*
Natural Resource Exports-Including Fuel (% of GDP) (ln)--High Income Countries		.001 [.03659] (1.775) *2.561*	.088 [2.551] (1.866) *2.663*	.122 [3.787] (2.066) *3.334*	.184* [5.715] (2.258) *4.083*	.096 [2.934] (1.873) *4.474*
Natural Resource Exports-Including Fuel (% of GDP) (ln)—Main Effect (All Countries)	.001 [.03141] (1.775) *2.978*					
Proportion of Exports to the Core (% of total)			-.058 [-.0605] (.044) *1.141*	-.062 [-.0668] (.042) *1.163*	-.047 [-.0508] (.043) *1.203*	-.031 [-.0355] (.037) *1.238*
Exports (% of GDP)				.175*** [.224] (.062) *1.796*	.160** [.205] (.066) *2.037*	.198*** [.257] (.056) *2.181*
Inward FDI Stock (% of GDP) (ln)					-.088* [-2.249] (1.098) *1.429*	-.080* [-2.160] (.941) *1.435*
Gross Domestic Investment (% of GDP)					.050 [.167] (.139) *1.336*	.053 [.195] (.124) *1.327*

Table 10. Continued

Sectoral Disarticulation (ln)						-.249*** [-6.456] (1.290) *2.946*
Sample Size	130	130	125	119	118	107
Adjusted R^2	.775	.775	.804	.843	.848	.910
Note: First number reported is the standardized coefficient, unstandardized coefficient in brackets, standard error in parentheses, VIF in italics; *p<.05 **p<.01 ***p<.001 (two-tailed tests); ln = natural log transformation						

positive and statistically significant. Of particular note, the significant positive association between non-fuel natural resource exports and human wellbeing within high-income countries disappears when fuels are included in the calculation.

When utilizing the HDI as a dependent variable, there was little variance between the results obtained with and without fuels included in the natural resource export measures. The HWI is a broader measure, however. The results in model 2 illustrate that when considering a more encompassing measure of social development there may be a greater distinction between the effect of natural resource exports with and without a fuels calculation included.

Models 3 and 4 include controls for proportion of exports to the core and export intensity. In contrast to the results obtained in table 9, export intensity is statistically significant and moderately correlated with the dependent variable when controlling for natural resource exports that include fuels. This effect is substantially stronger than in any previous models examining the human development index. Arguably, export integration may be positively correlated with social development when utilizing a broader measure of wellbeing and controlling for the ostensibly negative effects of primary product exports, including fuels. A central neoclassical economics argument suggests greater LDC export integration is an important mechanism of social and economic development (UNCTAD 2004). The results in table 10, however, suggest the positive benefits of export intensity may depend in important respects not upon simply the degree of export integration into the global economy but the structure or composition of export intensity.

Model 5 includes a control for FDI and gross domestic investment. Inward FDI stock is negatively correlated with the dependent variable and statistically significant, but the effect is weak. This is in contrast to the result illustrated in table 9. When including non-fuel primary product exports in the regression models the negative effect of FDI is substantially stronger. It is possible that the moderate negative effect obtained between FDI and human wellbeing in table 9 is an artifact of not controlling for the negative effects of fuels. Model 6 includes a control for sectoral disarticulation. Congruent with previous results highlighted in this chapter, disarticulation has a negative and statistically significant association with social development.

Conclusion

Since the end of World War II trade has grown more rapidly than world income and today constitutes an important link between most nations of the world (Held et al. 1999). Within this context, it is increasingly important to sort through the divergent arguments regarding the consequences of international trade relations for social development outcomes. The challenge of moving beyond the current impasse consists of theorization and empirical analysis sensitive to the contingent dynamics between international trade and social development at variable country positions in the global economy.

Few studies directly examine the export of natural resources as an explicit independent variable impacting level of social development in a systematically contingent, and uneven manner. Previous research has often relied upon measures of the form of trade integration, including partner and commodity concentration, and export intensity or magnitude of trade integration. Such trade dependency measures have often been associated with negative social development outcomes within LDCs in previous research (Ragin and Bradshaw 1992), in

addition to evidence that investment dependence also has negative impacts upon social wellbeing (London and Williams 1988, 1990).

Natural resource exports, with and without fuels included, is analyzed in the chapter. Bunker's work, in particular, suggests natural resource extractive economies are linked in a substantive manner to the socio-organizational acceleration and increasing complexity of industrialized countries but deceleration, simplification, and progressive underdevelopment of the periphery (1984, 1985). Accordingly, the theory of ecological unequal exchange proposes that LDCs with a greater proportion of natural resource exports will be characterized by lower levels of social development net the effects of appropriate baseline factors and alternative dependency measures.

This theoretical expectation is at odds with that derived from the theory of comparative advantage. Many LDCs are not characterized by abundant human, physical, and investment capital and therefore possess comparative advantages not in the export of sophisticated manufacturing but the export of natural resources. The theory of comparative advantage suggests, in turn, that many LDCs will benefit through the export of natural resources, contributing to social development. This effect, moreover, should be the most recognizable in the poorest countries as they typically have few other options than to engage in natural resource extractive activities for export. Accordingly, the theory of comparative advantage proposes that LDCs with a greater proportion of natural resource exports will be characterized by greater levels of social development; particularly low and lower middle income countries.

Regression analysis utilizing slope dummy interaction terms illustrates low-income countries with a greater proportion of natural resource exports are characterized by lower levels of social development as measured by the Human Development Index (HDI). This effect obtains

regardless of whether fuels are included or excluded in the calculation. This result is statistically significant and moderately strong net the effects of urbanization, age structure (proportion of the population under 14 years of age), level of economic freedom, and inclusion of appropriate alternative dependency variables, including sectoral disarticulation. Of note, sectoral disarticulation is negatively correlated with social development across the entire sample, consistent with previous research (Breedlove and Armer 1996; Gallagher et al. 1996; Huang 1995; Stokes and Anderson 1990; Wickrama and Mulford 1996).

As a contrast to the more narrowly constructed HDI, empirical analysis in this chapter also incorporates a broader indicator of social development as embodied in the Human Wellbeing Index (HWI). Results obtained utilizing the HWI highlight the differential impact of including fuels in the calculation of natural resource exports.

Examining the non-fuel calculation illustrates low-income countries with a greater proportion of natural resource exports exhibit lower levels of social development. Conversely, upper middle and high-income countries with a greater proportion of natural resource exports exhibit higher levels of social development, as measured by the HWI. This positive effect is particularly strong among high-income countries. This dichotomy is net the statistically significant and positive effects of urbanization, state strength, economic freedom, and the negative effects of FDI and sectoral disarticulation across the entire sample.

Thus, the poorest countries, those the theory of comparative advantage suggests should typically benefit from natural resource extraction, are those characterized by lower levels of social development as a consequence of their natural resource extraction-oriented integration into the global economy. Conversely, the richest countries, those the theory of comparative advantage suggest should benefit the least from the export of natural resources as their comparative

advantages lie elsewhere, are those characterized by higher levels of social development. This situation becomes even more curious when one considers that these results are net the positive and moderately strong association of economic freedom across the entire sample. Higher levels of social wellbeing characterize countries with more open, market-oriented institutional structures and policies.

From an ecological unequal exchange perspective, these empirical results are suggestive of the contingent, dominance-dependence relations underlying exchange relations within the global economy. Industrialized countries are more advantageously positioned to not only engage in the most dynamic economic activities within the global economy but benefit disproportionately even from the export of primary products relative to low income countries. This is likely a consequence of greater economies of scale, subsidization of extractive activities, and more efficient technologies in the developed countries. Further, low-income countries appear to exhibit deceleration as a consequence of their extraction-oriented role in the global economy, consistent with the theorization of Bunker (1984, 1985; see also Bunker and Ciccantell 2005). Economic freedom, in turn, may promote social development, as Grubel (1998) notes, but it may be subject to important theoretical scope conditions not appropriately recognized or specified by neoclassical economists. Whatever the impact of economic freedom within the poorest countries in the world, for example, its effect does not appear substantial enough to offset the negative effect of non-fuel natural resource exports upon social development.

In contrast to the results obtained with the HDI, including fuels in the calculation of natural resource exports substantially alters the effects observed when utilizing the HWI as a measure of social development. Low, lower middle and upper middle-income countries with a greater proportion of primary product exports exhibit lower levels of social development when

fuels are included in the calculation. This negative impact is particularly strong among low-income countries. Further, the positive impact observed among high-income countries drops from statistical significance when including fuels. These effects are net the positive relationship of urbanization, state strength, economic freedom, and export intensity and the negative relationship of FDI and sectoral disarticulation upon social wellbeing.

The empirical results illustrated in this chapter primarily support the ecological unequal exchange proposition that natural resource exports are associated with lower social development outcomes within LDCs. This effect only holds among low-income countries, however, when employing the HDI as an indicator of social wellbeing and when examining non-fuel natural resource exports in combination with the HWI. There is evidence this relationship is relevant to low, lower middle, and upper middle income countries when evaluating the impact of natural resource exports with fuels included in the calculation in combination with examination of the HWI. There is limited support for the theory of comparative advantage as economic freedom is consistently and positively correlated with social development across the entire sample.

CHAPTER SIX

ENVIRONMENTAL COST-SHIFTING AND DEFORESTATION

Introduction

A conundrum hints at the existence of environmental cost-shifting: nations with higher levels of natural resource consumption often experience lower domestic levels of natural resource degradation, a process referred to as the "consumption/environmental degradation paradox" (Jorgenson 2003, 2006; Jorgenson and Rice 2005). From an ecological unequal exchange perspective, the key to this puzzle is the recognition that the export of natural resources from LDCs to industrialized countries supports the consumption requirements of the latter at rates of exchange promoting environmental degradation within the former.

Environmental costs, in terms of disruptive human and ecological outcomes, are encountered during the extraction, production, and distribution of natural resources. Such costs are externalized to the extent they are not reflected in the price received on the world market and are therefore borne by the exporting country.

As developed countries import environmentally intensive primary products, at declining terms of trade, local environmental and health concerns within exporting LDCs are sold cheaply on the world market (Martinez-Alier 2002). In this manner, industrialized countries exploit the periphery for natural resources, even as elite classes within peripheral countries exploit domestic environmental assets in search of economic growth through export-oriented exchange.

In the colonial era processes of environmental cost-shifting were overt and explicit. In the contemporary global economy mechanisms of market exchange complicate the conceptualization of cross-national ecological-distributional conflicts. International trade, arguably, is central to cost-shifting dynamics. Trade lengthens the links between consumption and its environmental

consequences (Andersson and Lindroth 2001). The ecological implications of international trade, in turn, can be difficult to recognize as the global export-import of natural resources obscures responsibility for the environmental effects of production and consumption (Andersson and Lindroth 2001). This lengthening or globalization of the links between consumption and its consequences tends to promote the "rich country illusion effect" (Andersson and Lindroth 2001). In other words, by importing natural resources and exporting sink capacity demand inhabitants of industrialized countries mistakenly perceive their lifestyles as sustainable as their consumption rates are not tightly linked to domestic environmental conditions (Andersson and Lindroth 2001).

The idea of environmental cost-shifting challenges prevailing conceptions that the core industrialized countries are increasingly characterized as "environmental states." Environmental states are those engaging in the institutionalization of environmental protection through enactment of state policies and politics (Mol and Buttel 2002). The ecological modernization perspective, a theory increasingly prominent in environmental sociology, focuses upon the increasing embeddedness of ecological rationality in social practices and institutional developments, particularly within industrialized countries (Mol and Spaargaren 2000; Mol 2002). Moreover, globalization is argued to be crucial for the diffusion of ecologically modern social organization and technology beyond the most industrialized countries (Weidner 2002). The implication, in turn, is that such processes of institutionalization translate into real-world progress towards addressing environmental problems. Undoubtedly this is the case in some respects. But, the assertion of environmental cost-shifting suggests a more rigorous examination of the cross-national ecological impact of industrialized countries is necessary as it illustrates that what appear to EKC patterns could be artifacts of cost-shifting dynamics.

The assertion of environmental cost-shifting is rejected, moreover, by many conservative economists advocating unbridled free market neoliberal globalization. Taylor (2002), for example, suggests the world is already on a sustainable trajectory with the exception of those places that have yet to embrace Western capitalism. He argues that rather than overshoot there is an increasing abundance of natural resources (Taylor 1993). Free and competitive markets facilitate technological advances whereby new resources are discovered and existing resources are utilized more efficiently (Taylor 1993). Global natural resources are not created by nature, and therefore fixed and finite, but procured through the application of human knowledge and technology whereby resources that were once useless are molded into useful commodities (Taylor 1993). Moreover, reducing consumption in the industrialized countries is not only unnecessary but it would actually harm LDCs (Taylor 2002). This is because economic growth, knowledge, and technology expand in a parallel manner to create and discover new materials and resources for human utilization, contributing even to standards of living well beyond the developed countries (Taylor 2002).

Conversely, from an ecological unequal exchange perspective the increasing capacity of industrialized countries to preserve their domestic environmental assets may, in part, be rooted less in greater environmental institutionalism and embrace of environmental rationality than in their ability to shift or displace the negative consequences of natural resource consumption. Failure to internalize environmental costs suggests industrialized countries subsidize their levels of resource consumption at the expense of LDCs. They achieve, in effect, disproportionate consumption rates while shifting environmental costs to exporting countries. This allows industrialized countries to decrease pressure on domestic environmental assets and protect or even enhance their own domestic environmental conditions while increasing natural resource

consumption. In contrast to a “race to the bottom” in environmental standards worldwide, ecological unequal exchange suggests a polarization of environmental conditions or a “stuck at the bottom” scenario within many LDCs (Muradian and Martinez-Alier 2001a).

Research Problem and Statement of Purpose

To empirically document the existence of environmental cost-shifting dynamics at a cross-national scale requires more than simply the descriptive illustration of the consumption/environmental degradation paradox. This provides face validity for the idea of cost-shifting processes but the overall imperative in the research literature is for specification and examination of particular mechanisms whereby environmental cost-shifting is enacted through international trade.

This chapter seeks to empirically illustrate that countries with the lowest consumption of forest products, typically the poorest LDCs, are characterized by higher deforestation rates as a consequence of their role in the global economy as natural resource exporters combined with their trade with the core. This examination includes analysis of the structure of trade in terms of export composition and export partner concentration.

This examination is relevant to consideration of the theory of comparative advantage relative to tenets drawn from the ecological unequal exchange perspective. The export of natural resources, including timber products, is argued to constitute the relative comparative advantage of LDCs. Engaging in export-oriented activity, therefore, should represent a minimization of opportunity costs and enhancement of economic development. Further, trade with the core industrialized countries arguably promotes the most advantageous diffusion of advanced technology and management practices and provides access to large external markets. Overall, the theory of comparative advantage suggests many LDCs integrated into the global economy

through natural resource exports and trade with the core should experience enhanced economic productivity and greater acquisition of the capacity to reforest and manage forest reserves in a rational, cost-effective manner, relative to more economically isolated LDCs.

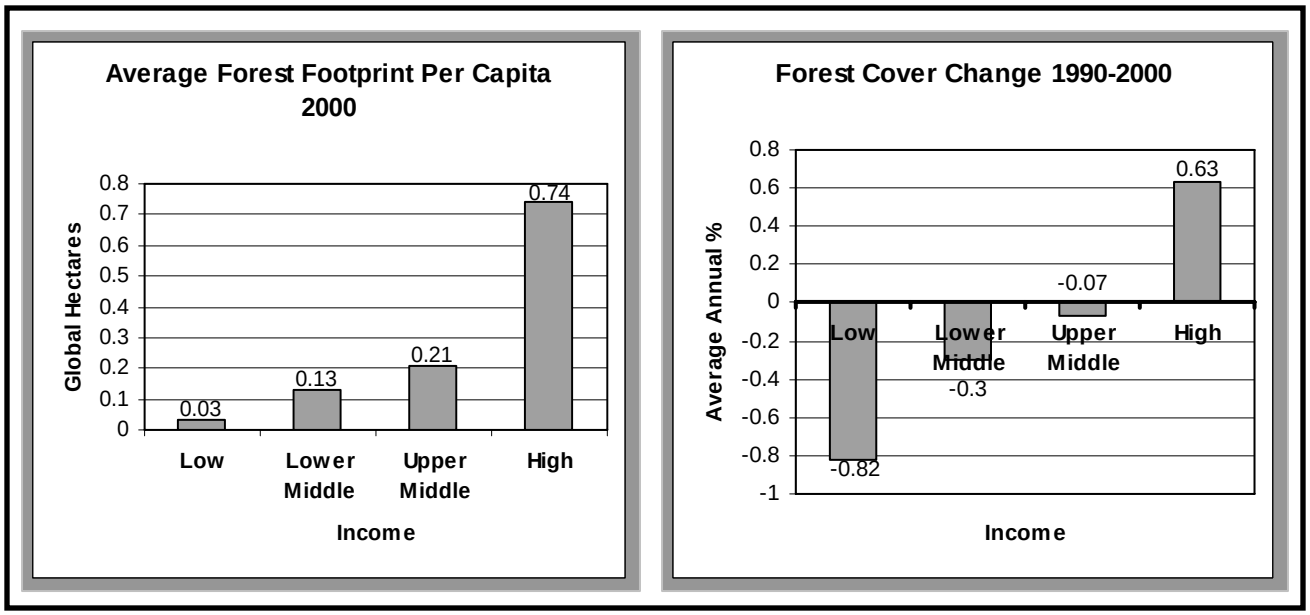
Conversely, the theory of ecological unequal exchange posits natural resource exporting LDCs are typically the most disadvantageously positioned countries in the global economy. They are the least flexible in response to changing market demands and the most vulnerable to the fluctuations of world market prices for commodities. Further, they are least able to capture the beneficial socio-economic spin-off effects associated with natural resource endowments, including the transformation of natural capital assets into sustained welfare-enhancing physical and human capital assets. In turn, many LDCs integrated into the global economy as natural resource taps for industrialized countries are characterized by socio-organizational deceleration and erosion of domestic environmental resources.

Deforestation and Environmental Cost-Shifting

Figure 9 highlights the consumption/environmental degradation paradox in relation to deforestation.[21] The average consumption of forest products, or forest footprint, in the high-income countries is .74 hectares per capita in 2000. This is 24 times the average per capita demand in low-income countries and approximately 6 times the demand within lower middle-income countries. Despite the significantly greater consumption within high income countries, declining forest cover (deforestation) from 1990-2000 is the most pronounced in the low-income countries, an annual average loss of .82 percent, and upper middle income countries, an annual

[21] Data are from Venetoulis, Chazen, and Gaudet 2004. Forest cover change data are from the United Nations Food and Agriculture Organization publication, *State of the World's Forests 2003.* Analysis is based upon the 127 countries listed in table A1 in the Appendix with data available on both variables and that have at least 4% of their total land area in forest cover, to avoid anomalies related to distinct forest cover processes in desert countries (see Burns, Kick, and Davis 2003). Two non-desert countries, Macedonia and Serbia-Montenegro, are excluded from the analysis because of missing forest cover change data.

Figure 9. Forest Consumption and Cover Change by Income Level



Note: Figure is based upon non-desert countries only (forest area > 4% of total land area), N = 127; Forest footprint is a calculation of total wood, wood fibre, and pulp consumption (excluding fuelwood). A global hectare is one hectare of biologically productive space adjusted for world average productivity. Forest cover change positive values indicate reforestation; Negative values indicate deforestation.

average loss of .07 percent over the decade. High-income countries are characterized, on average, by reforestation from 1990-2000.

The forest consumption and cover change patterns illustrated in figure 9 demonstrates that countries with the lowest consumption of forest products are characterized by the greatest rates of deforestation. Conversely, countries characterized by significantly greater demand for forest products are experiencing, on average, reforestation. Figure 9 highlights dynamics both within and between world-system positions. For example, deforestation is the highest in the periphery but it is unlikely domestic forest product demand is the driving force; rather, it is between world-system position distributional processes enacted through international trade that shapes the uneven consumption and degradation of forest products in the world-system.

Of note, uneven deforestation rates are linked to a number of other subsequent environmental issues. For example, deforestation contributes to loss of biodiversity, erosion of topsoil, desertification, and watershed degradation (Burns et al. 1994).

The consumption/environmental degradation paradox highlighted in figure 9 may be partially explained through reference to greater capacity for reforestation, better governance of natural resource assets, and more efficient technology in high-income countries. Ehrhardt-Martinez (1998), for example, suggests the absence of net deforestation in developed countries is largely the result of reforestation efforts and regrowth. Conversely, it may also reflect the fact that economically dominant countries are able to maintain high rates of consumption of forest products by drawing upon the undervalued resources of LDCs, shifting the environmental costs. Jorgenson (2006), for example, finds evidence LDCs with relatively greater overall exports sent to more economically developed countries experience greater rates of deforestation from 1990-2000, net population, economic, state environmentalism, and other relevant variables. This research is significant because it establishes a direct link between the structure of international exchange and environmental transformation. In particular, the domestic attributes of the countries that LDCs trade with is relevant to considerations of deforestation within LDCs (Jorgenson 2006).

Factors Driving Cross-National Deforestation: A Review of the Literature

Deforestation has been hypothesized to emanate from three sources; these include population dynamics, modernization forces, and dependency effects (Ehrhardt-Martinez 1998; Inman 1992). This review of the research literature begins with a focus upon previous studies evaluating the contingencies and dependency relations linked to position in the world-system and both the level of deforestation and the differential dynamics driving deforestation (Burns et al.

1994, 2003, 2006; Kick et al. 1996; Jorgenson 2006). This literature is directly relevant to the analyses presented in this chapter, and our efforts are substantially informed by and attempt to extend the line of inquiry. Subsequently, the focus is upon previous research oriented towards examining the demographic and socio-economic causes of forest cover change (Ehrhardt-Martinez 1998; Ehrhardt-Martinez, Crenshaw, and Jenkins 2002; Inman 1992; Rudel 2002).

Research by Burns et al. (1994) is one of the first attempts to evaluate the distinct factors shaping deforestation by country position in the world-system and an empirical focus beyond simply forest cover change among LDCs. They delineate positional "deforestation profiles" or domestic social and cross-national political-economic dynamics differentially shaping deforestation rates among countries at different levels of development (p. 223). Examining forest cover change from 1965-1990, their results indicate that level of deforestation is highest in the semi-periphery. This is presumably a consequence of the potential upward mobility of semi-peripheral countries in the global economy and both the willingness to deforest for short-term export earnings combined with the increasing technological capacity to do so (Burns et al. 1994; Kick et al. 1996).

Burns et al. (1994) highlight deforestation from 1965-1990 is approximately 5 times greater in the semi-periphery than the periphery. However, subsequent research focused upon the 1990-2000 period reveals this ratio has changed dramatically as the greatest deforestation is now occurring in the periphery of the world-system (Burns et al. 2003, 2006). This result is congruent with the forest cover change dynamics illustrated previously in figure 9. Descriptive evidence that contemporary deforestation rates are now greater among the poorest countries rather than the upper middle income or semi-periphery challenges the assumption of an underlying inverted-U or environmental Kuznets curve (EKC) relationship between level of development and

deforestation. This is significant as it suggests countries may not be able to easily grow out of or transition through a period of deforestation on the path to development only to recoup such losses at a later point in time.

The burgeoning rates of deforestation among peripheral countries may in part be a consequence of relatively higher population growth (Burns et al. 2003). Clearing of forest area to accommodate increased agricultural or ranching activities, often destined for eventual export, is an additional factor. Further, it may be influenced by trade liberalization over the past several decades and a widening gap cross-nationally in environmental regulations (Burns et al. 2003). Such dynamics shift the cost-benefit ratio of capital towards environmentally damaging practices within the poorest countries (Burns et al. 2003). Further, progressively greater deforestation among the poorest countries may be attributable to unequal exchange and the externalization of consumption based environmental impacts by industrialized countries (Burns et al. 2003; Jorgenson 2003), as suggested in figure 9.

Not only does *level* of deforestation covary by position in the global economy but the *dynamics* promoting deforestation do as well (Burns et al. 1994, 2003). Population growth has a direct impact upon deforestation only in the core but an indirect effect through promotion of rural encroachment across all world-system positions (Burns et al. 1994). Growth in secondary education is associated with declining deforestation within the semi-periphery directly and through its tendency to temper rural encroachment (Burns et al. 1994). Moreover, growth in services and manufacturing is associated with declining deforestation in the periphery (Burns et al. 1994).

In a follow-up study, Kick et al. (1996) examine deforestation 1965-1990 incorporating slope-dummy interaction terms, including indicators of forest product imports and exports across

world-system positions. Their analysis illustrates exports of forest products from the core in 1985 is fifteen times the monetary value of forest product exports from the semi-periphery, which in turn is twice that of the periphery. Surprisingly, core countries also import substantially more wood products relative to non-core areas. Somewhat paradoxically, however, forest product exports are significantly associated with deforestation among peripheral countries but positively correlated with reforestation among the core countries, despite the substantially greater levels of forest products exports from core countries (Kick et al. 1996).

It has long been recognized that core countries benefit disproportionately from the export of sophisticated manufactured products, but this result further suggests they may even benefit disproportionately from the export of some natural resources (Kick et al. 1996). This dichotomy, Kick et al. (1996) suggest, is a consequence of the vastly greater resources within the core to reforest as well as government programs mandating reforestation. The periphery, in contrast, typically lacks such resources and is primarily oriented towards mass raw materials export in exchange for foreign capital (Kick et al. 1996). Further, rural population growth promotes deforestation across world-system positions net the effects of total population change, which independently shapes deforestation outside the periphery (Kick et al. 1996).

To capture differential dynamics shaping deforestation 1990-2000 by country position in the world-system, Burns et al. (2003) utilize slope dummy interaction terms to model the contingent effects of percent urban population, age structure or proportion of the population under 14 years of age, and GDP per capita. Their research illustrates the positional or zone specific impact of urbanization upon deforestation is strongest in the periphery and semi-periphery, while percent of the population composed of adults, the most economically active segment, is only significantly related to deforestation in semi-peripheral countries (Burns et al.

2003). GDP per capita positively correlates with reforestation in the semi-core and semi-periphery countries.

Of relevance to dependency/world-systems research, debt dependency within LDCs is theorized to contribute to forest loss (Inman 1992; Kahn and McDonald 1995). External debt, in combination with the structural adjustment requirements imposed by supranational lenders, tends to foster increasing export-oriented natural resource extractive activities designed to facilitate loan repayment (Inman 1992). Previous research illustrates both level of debt (Inman 1992; Kahn and McDonald 1995) and increased debt over time (Inman 1992) is associated with forest cover change patterns. Research by Ehrhardt-Martinez et al. (2002), however, fails to uncover a statistically significant association between debt and deforestation.

In an explicit attempt to examine the ecological unequal exchange dynamics underlying international trade and deforestation, Jorgenson (2006) constructs a weighted index measuring the degree to which a country exports to more economically developed countries. The results illustrate less developed countries with higher proportions of exports sent to more economically developed countries experience greater rates of deforestation from 1990-2000, net population, economic, state environmentalism, and other relevant factors (Jorgenson 2006). This research is significant as it corroborates the unequal exchange tenet that cross-national exchange between economically non-equivalent partners can have uneven negative effects, an assertion the theory of comparative advantage generally discounts. In particular, the structure of LDC exports in terms of the attributes of receiving countries is linked to domestic forest loss within LDCs. This lends support to the suggestion that the consumption/environmental degradation paradox is shaped through international trade.

Researchers typically approach the empirical examination of deforestation by incorporating a number of general theoretical perspectives into an analysis even as they disproportionately emphasize a particular theoretical point of view. The studies reviewed above, for example, incorporate explanatory factors drawn from various theoretical origins but pursue an overarching dependency/world-systems analytical framework (Burns et al. 1994, 2003, 2006; Jorgenson 2006; Kick et al. 1996). Next, previous research more oriented towards the neo-Malthusian and modernization perspectives are reviewed in order to further derive a series of control variables to be incorporated in the regression analyses that follow.

The neo-Malthusian perspective points to the population-based factors driving forest cover change. As Ehrhardt-Martinez (1998) notes, the proximate causes of deforestation can be attributed to the clearing of land for expanded agricultural and livestock activities, harvesting of timber for economic exchange, and the building of roads and expansion of urban areas. Such proximate factors, however, are driven by underlying aggregate-level processes (Ehrhardt-Martinez 1998), of which population characteristics are a central dimension.

Population growth typically increases human pressure upon forest resources and contributes to forest loss (Ehrhardt-Martinez 1998; Inman 1992; Rudel 1989; Rudel and Roper 1997). Deforestation is tied to more than simply aggregate population size, as rural population pressures in particular encroach upon forest reserves, contributing to deforestation within LDCs (Burns et al. 1994; Ehrhardt-Martinez et al. 2002; Inman 1992; Kick et al. 1996).

The modernization perspective focuses upon such dynamics as economic growth and sectoral change, urbanization, and educational levels as key factors shaping forest cover change. Economic growth is theorized to contribute to forest loss by providing enhanced capital assets that can be subsequently invested in agricultural, mining, and timber extraction, all of which are

potentially detrimental to forest reserves within LDCs (Rudel 1989). Research suggests increasing economic growth per capita is positively associated with deforestation within LDCs (Capistrano and Kiker 1995; Ehrhardt-Martinez 1998) as is level of GDP per capita (Rudel 1989). Other research, however, suggests the positive effect of economic growth or change in GDP per capita upon deforestation is disproportionately strong within the semi-core and semi-periphery, or the middle ranges of the world-system (Burns et al. 2003).

Level of and change in the ratio of the population residing in urban areas is also positively associated with forest loss (Ehrhardt-Martinez 1998). Of note, research highlights a curvilinear or inverted-U relationship between level of urbanization and rate of deforestation among a sample of LDCs (Ehrhardt-Martinez 1998; Ehrhardt-Martinez et al. 2002). Forest loss increases concurrent with urbanization until a moderate level is reached wherein forest loss relative to increasing urbanization begins to decline. This result, however, is contradicted by research by Burns et al. (2003, 2006) examining deforestation among a sample of countries of all development levels, 1990-2000. Their results illustrate a negative progression whereby urbanization increasingly impacts forest loss at lower levels of the international hierarchy, particularly within peripheral countries. Further, Jorgenson (2006) fails to find an EKC relationship between urbanization or GDP per capita change and deforestation 1990-2000 among a sample of LDCs.

Based upon the previous studies reviewed, the analyses below include a number of control variables consistently found to be significant predictors of forest cover change. These include variables derived from the neo-Malthusian, economic modernization, and dependency/world-systems perspectives. Further, the analysis incorporates two main explanatory variables intended to model potential ecological unequal exchange dynamics. These include a

measure of non-fuel natural resource exports and proportion of exports to the core countries. Arguably, both shape the uneven cross-national consumption of forest products and change in forest cover illustrated in figure 9 and provide inferential evidence of environmental cost-shifting.

Regression Analysis Methodology

Dependent Variable

Forest cover change 1990-2000 (annual average % change). Data source: Food and Agricultural Organization of the United Nations (FAO) publication *State of the World's Forests 2003*. Data indicate rate of gain or loss in percent of the remaining forest area each year within the given period. Negative values indicate deforestation over the period whereas positive values indicate reforestation.

Main Explanatory Variables

Natural resource commodity exports-non-fuel (% of GDP)--annual average1988-1990 is included to examine ecological unequal exchange tenets relative to the theory of comparative advantage. Data source: United Nations *Commodity Yearbook 1995-2000*, Volume 1 (UNCTAD 2003). The data are averaged over a three-year period to avoid anomalous fluctuations in the data present in any particular year. This indicator is based upon the sum of agricultural raw materials, food, and minerals, ores, and metals as a percent of GDP.[22]

Previous research has examined the export of forest products specifically and confirmed the rate of change in wood exports is significantly associated with deforestation in the periphery but reforestation in the core (Kick et al. 1996), while other research has failed to uncover a

[22] Classification of commodities is based upon the United Nations Standard International Trade Classification, Revision 2 (SITC, Rev. 2). Agricultural raw materials is based upon: SITC section 2 (less divisions 22, 27, 28 and groups 233, 244, 266, and 267); Food is based upon: the sum of SITC section 0, section 1, section 4, and division 22; Minerals, ores, and metals is based upon: the sum of SITC divisions 27, 28, 68, and item 522.56.

significant relationship between level of forest product exports and forest loss among a sample of LDCs (Ehrhardt-Martinez et al. 2002; Rudel 1989). Ehrhardt-Martinez (1998) has examined the broader categorization of natural resource exports, of which wood exports are but one dimension, and concludes that rate of change in primary product exports among a sample of LDCs is not significantly associated with deforestation.

The present study endeavors to conduct a more detailed examination of natural resource exports than Ehrhardt-Martinez (1998) by utilizing slope dummy interaction terms that allow for contingent effects among LDCs rather than examining the generic impact across LDCs as a whole. Further, evaluating the potential impact of natural resource exports upon deforestation, above and beyond a focus on the export of forest products more specifically, can contribute to a more comprehensive conceptualization of ecologically unequal exchange. First, deforestation among LDCs may in part be the consequence not simply of the export of forest products per se but the export of other natural resources that necessitate or encourage the clearing of forest reserves. Soybeans or beef exports from LDCs, for example, are often increasingly promoted to the detriment of forest areas. Second, the evaluation of the broader categorization of natural resource exports is more congruent with Bunker's nomothetic argument concerning the acceleration-deceleration of industrialized and extractive oriented LDCs (1984, 1985). The examination of forest product exports among LDCs could potentially illuminate the ideographic dynamics connecting far-flung localized areas with global markets but it is the overarching nomothetic tendencies that are of interest within this study.

Distribution of exports to the core industrialized countries (% of total exports)--annual average 1989-1990 is a measure of the degree to which a country is integrated into the global economy through exports to the most developed capitalist countries. This variable is included to

evaluate the effects of trade partner concentration upon uneven deforestation. Data source: IMF *Direction of Trade Statistics* CD-Rom (2003). This variable is averaged over a two-year period to avoid anomalous fluctuations present in any particular year.

Slope dummy interaction terms are employed to model the effects of this variable across country income positions. Few studies of deforestation examine export partner concentration, and no studies in the research literature have analyzed the potential effects of proportion of exports to the core upon rates of forest loss or gain. [23]

Control Variables

Total population change (%) 1980-1990. Data source: World Bank *WDI 2005* CD-Rom. Although the specific mechanisms vary, population growth is nonetheless linked to deforestation across world-system positions in general (Burns et al. 1994) and among a sample of LDCs in particular (Ehrhardt-Martinez 1998). In LDCs population growth is associated with increased demand for agricultural land and for fuel, thus contributing to deforestation (Burns et al. 1994). Population growth also influences deforestation indirectly through the promotion of rural encroachment or migration into forested areas (Burns et al. 1994). Population growth in industrialized countries is linked to increased demand for forest products in terms of finished products and fuel for energy (Burns et al. 1994).

Urban population (% of total population) 1990. Data source: World Bank *WDI 2005* CD-Rom. Previous research highlights level of urbanization is positively associated with deforestation among a sample of LDCs (Ehrhardt-Martinez 1998), and that this relationship is

[23] Jorgenson's research (2006) is an exception. He finds no statistically significant association between export partner concentration operationalized as the percentage of total exports destined for the single largest import partner and rates of deforestation 1990-2000 among a sample of LDCs. Further, he does not uncover a significant association between export commodity concentration, defined as the percentage of total exports accounted for by the single largest export, and deforestation 1990-2000.

particularly relevant among non-core countries (Burns et al. 2003). Urban agglomerations are resource intensive and often strain domestic natural capital assets within LDCs.

Rural population change (%) 1980-1990. Data source: World Bank *WDI 2005* CD-Rom. This variable is calculated from point estimates of rural population total in 1990 relative to 1980 or ((1990-1980)/1980)*100. Previous research suggests rural population growth contributes to deforestation across world-system positions, even net the effects of total population change (Kick et al. 1996).

Urban population change (%) 1980-1990. Data source: World Bank *WDI 2005* CD-Rom. This variable is calculated from point estimates of urban population total in 1990 relative to 1980 or ((1990-1980)/1980)*100. Previous research suggests urban population change is positively associated with deforestation (Ehrhardt-Martinez 1998) but research by Jorgenson (2006) reveals a statistically significant correlation with reforestation among a sample of LDCs.

GDP per capita change (%) 1980-1990. Data source: World Bank *WDI 2005* CD-Rom. Previous research supports the contention that economic growth promotes deforestation within LDCs (Capistrano and Kiker 1995; Ehrhardt-Martinez 1998) although Jorgenson (2006) uncovers a significant association with reforestation over the 1990-2000 period.

Exports (% of GDP)--annual average1988-1990. Data source: World Bank *WDI 2005* CD-Rom. This variable is included to control for export intensity or degree of export integration into the global economy. The data are averaged over a three-year period to avoid anomalous fluctuations in the data present in any particular year.

Total debt service (% of GNI)--annual average1988-1990. Data source: World Bank *WDI 2005* CD-Rom. This variable is included as a measure of the potential effects of debt dependency. Previous research suggests debt promotes deforestation within LDCs (Inman 1992;

Kahn and McDonald 1995). The data are averaged over a three-year period to avoid anomalous fluctuations in the data present in any particular year.

Forest stock 1990 (% of land area forested). Data source: World Bank *WDI 2002* CD-Rom. It is common practice in previous research to control for initial level of forestation in order to adjust for the different starting points across countries (Burns et al. 2003; Inman 1992; Jorgenson 2006; Kick et al. 1996).

Desert Countries (dummy variable measuring countries with < 4% of total land area forested) is included to adjust for the potential anomalous dynamics related to deforestation in desert relative to non-desert countries. Data source: World Bank *WDI 2002* CD-Rom. Controlling for desert countries is common practice in many previous research efforts (Burns et al. 2003). [24]

Regression Diagnostics

Natural log transformations were applied to the natural resource exports and total debt service variables because of evidence of non-normal distributions. Consistent with standard practice, VIF values of 6-7 or higher are viewed as evidence of problematic multicollinearity. None of the independent variables in the reported regression models violate this standard or acceptable tolerance levels. Examination of standardized DFBETAS revealed Burundi constituted an overly influential case because of its extreme value on the dependent variable, and it was excluded from the analyses. Burundi illustrates the highest rate of forest cover change 1990-2000 within the sample, with average annual deforestation over the period of 9 percent. Botswana constitutes an influential outlier on the urban population change variable and is therefore excluded from all analyses incorporating this measure. The data indicate Botswana is

[24] The desert countries in the sample include (N=19): Afghanistan, Algeria, Burundi, Egypt, Haiti, Iraq, Jordan, Kuwait, Lebanon, Lesotho, Libya, Mauritania, Niger, Pakistan, Saudi Arabia, Syria, Tunisia, United Arab Emirates, and Yemen.

characterized by a 222 percent increase in urbanization from 1980-1990, the greatest change in the sample. Utilization of Cook's distance did not reveal any cases in the sample are overly influential outliers.

Hypotheses

This chapter has argued that a key dimension of ecological unequal exchange is environmental cost-shifting whereby industrialized countries off-shore or displace many of the negative ecological consequences of their production and consumption activities to more marginalized countries in the global economy. Figure 9 provides descriptive evidence of environmental cost-shifting in terms of the cross-national dynamics related to forest product consumption and uneven patterns of deforestation. The regression analyses below are an attempt to examine two possible mechanisms of cost-shifting underlying the patterns illustrated in figure 9. In particular, the potential effects of proportion of exports to the core and the export of non-fuel natural resources, both delineated by country income position.

As Chase-Dunn notes (1975), Marxist-oriented, dependency/world-system scholars tend to view the global economy as influenced by control structures shaping power-dependence relations between nonequivalent partners. Proportion of exports to the core and natural resource exports represent potential structural elements within the global economy whereby non-equivalent countries enact processes of environmental cost-shifting.

This expectation is fundamentally at odds with the theory of comparative advantage. This perspective does not propose that trade with the most industrialized countries is generally harmful for LDCs. If pursuing their respective comparative advantages, all countries benefit through trade regardless of level of development or the divergent development levels of particular trading partners, although the relative benefits of trade accruing to each partner may

not be equal. Typically, the theory of comparative advantage suggests attracting exchange relations with more developed countries is, in fact, a positive step towards development as it facilitates the diffusion of advanced technology, more efficient and rational management practices, and LDC access to bigger markets for their exports.

Moreover, if all countries adhere to the principal of comparative advantage the international division of labor should, in large part, be characterized by the specialization of poor countries in natural resource exports (Ragin and Delacroix 1979). This is not based upon power-dependence relations but the most efficient utilization of differential cross-national factors of endowment. This is particularly true of the poorest LDCs, which are often argued to possess few other trade-related options.

Based upon the tenets of ecological unequal exchange and the theory of comparative advantage, the following hypotheses are tested in this chapter:[25]

Ecological unequal exchange:
1. Less developed countries with a greater proportion of natural resource exports have *higher* rates of deforestation.
2. Less developed countries with a greater proportion of exports to the core countries have *higher* rates of deforestation.

Comparative Advantage Theory:
3. Less developed countries with a greater proportion of exports to the core countries have *lower* rates of deforestation.

Results and Discussion[26]

Table 11 includes forest cover change 1990-2000 regressed on the baseline, natural resource export slope dummies, and alternative dependency control variables.[27] Model 1

[25] We do not define hypotheses for upper middle-income countries because we anticipate less well-defined results or, in other words, outcomes that are a blending of both lower middle and high-income countries.
[26] All F-tests for the models reported in tables 11 and 12 are significant at the .001 level or below and are therefore not reported in the text.
[27] Tables A8 and A9 in the Appendix include descriptive statistics and bivariate correlations for all of the variables in the analyses in this chapter.

contains the baseline variables, consisting of economic, population, and forest controls derived from previous research. Of note, GDP per capita change is positively associated with reforestation across the sample. This is consistent with Jorgenson's research (2006) examining forest cover change over the same period among a sample of LDCs but contrasts with the results of other research (Burns et al. 2003; Capistrano and Kiker 1995; Ehrhardt-Martinez 1998). Level of urban population is also positively correlated with reforestation over the period. In turn, this result is congruent with previous research over the same time period (Jorgenson 2006) but contrasts with other research (Burns et al. 2003; Ehrhardt-Martinez 1998). The divergence between the results illustrated in model 1 and previous research (Burns et al. 2003; Capistrano and Kiker 1995; Ehrhardt-Martinez 1998) raises the possibility of the period-specific effects of economic growth and urbanization upon deforestation and whether these effects are changing over time. Such a scenario might be an interesting focus for future research efforts.

Model 2 includes the k-1 test for the non-homogeneity of slopes for the non-fuel natural resource exports variable. The low-income category is strongly non-parallel with the excluded category, high-income countries, and statistically significant at the .01 level. The lower middle and upper middle-income categories also appear non-parallel to the excluded category but are not statistically significant at the .05 level or below. The low-income category was the only slope dummy significantly non-parallel to the excluded category at an acceptable level in model 2. Therefore, in models 3-6 the focus in particular is upon the impact of natural resource exports among low income countries as it influences forest cover change.

Table 11. Forest Cover Change 1990-2000 by Natural Resource Exports--Non Fuel

Independent Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	[-2.102] (.569)	[-1.243] (.768)	[-1.243] (.768)	[-1.953] (.901)	[.374] (.976)	[.288] (1.067)
Forest Stock 1990 (% of land area forested)	-.166+ [-.0123] (.007) *1.343*	-.124 [-.0092] (.007) *1.433*	-.124 [-.0092] (.007) *1.433*	-.167+ [-.0126] (.007) *1.452*	-.124 [-.0093] (.007) *1.497*	-.050 [-.0035] (.009) *1.656*
Desert Countries (4% or less Forest Cover) Dummy Variable—Reference Category: Non-Desert Countries	-.051 [-.258] (.519) *1.559*	-.070 [-.353] (.543) *1.695*	-.070 [-.353] (.543) *1.695*	-.094 [-.471] (.527) *1.658*	-.138 [-.716] (.570) *1.867*	-.133 [-.641] (.625) *1.741*
GDP per capita Change (%) 1980-1990	.320*** [.01765] (.005) *1.251*	.248** [.01366] (.006) 1.499	.248** [.01366] (.006) *1.499*	.277** [.01616] (.006) 1.506	.238* [.01452] (.006) *1.612*	.259* [.01445] (.007) *1.434*
Total Population Change (%) 1980-1990	.086 [.00953] (.012) *1.745*	.197+ [.02230] (.013) *1.948*	.197+ [.02230] (.013) *1.948*		.230+ [.02621] (.014) *2.447*	.145 [.02194] (.019) *1.710*
Urban Population (% of total population) 1990	.475*** [.03384] (.007) *1.265*	.262* [.01879] (.009) *2.509*	.262* [.01879] (.009) *2.509*	.372* [.02682] (.011) *3.631*	.192 [.01397] (.009) *2.603*	.199 [.01567] (.011) *2.168*
Natural Resource Exports-Non-Fuel (% of GDP) (ln)--Low Income Countries		-.533** [-.776] (.320) *6.976*	-.354* [-.516] (.218) *3.247*	-.363** [-.537] (.217) *3.249*	-.487** [-.736] (.229) *3.549*	-.549** [-.744] (.260) *3.797*
Natural Resource Exports-Non-Fuel (% of GDP) (ln)--Lower Middle Income Countries		-.314+ [-.471] (.275) *4.881*	-.140 [-.210] (.189) *2.295*	-.093 [-.140] (.187) *2.322*	-.308* [-.492] (.225) *3.049*	-.361+ [-.506] (.261) *3.567*
Natural Resource Exports-Non-Fuel (% of GDP) (ln)--Upper Middle Income Countries		-.247+ [-.489] (.257) *2.445*	-.115 [-.228] (.230) *1.958*	-.058 [-.119] (.232) *1.907*	-.170 [-.348] (.269) *2.656*	-.201 [-.352] (.315) *3.306*
Natural Resource Exports-Non-Fuel (% of GDP) (ln)--High Income Countries			.115 [.261] (.299) *2.542*	.137 [.311] (.295) *2.565*	.076 [.171] (.339) *3.499*	
Natural Resource Exports-Non-Fuel (% of GDP) (ln)—Main Effect (all countries)		.134 [.261] (.299) *3.420*				
Urban Population Change (%) 1980-1990				.315** [.01797] (.007) *2.102*		
Rural Population Change (%) 1980-1990				.047 [.00533] (.014) *2.247*		

Table 11. Continued

Proportion of Exports to the Core (% of total exports)					-.248** [-.0234] (.008) *1.176*	-.303** [-.0252] (.009) *1.159*
Exports (% of GDP)					.126 [.01447] (.013) *1.843*	-.066 [-.0072] (.016) *2.096*
Total Debt Service (% of GNI) (ln)						.219+ [.394] (.222) *1.575*
Sample Size	107	101	101	99	96	77
Adjusted R^2	.273	.304	.304	.345	.377	.291

Note: Negative values of the dependent variable indicate deforestation whereas positive values indicate reforestation; first number reported is the standardized coefficient, unstandardized coefficients in brackets, standard errors in parentheses, VIFs in italics; +p<.10 *p<.05 **p<.01 ***p<.001 (two-tailed tests); ln = natural log transformation.

Model 3 incorporates a contextual test evaluating the income specific variance of natural resource exports upon forest cover change controlling for the baseline variables. The results illustrate low-income countries with a greater proportion of non-fuel natural resource exports exhibit higher deforestation rates or declining forest cover over period 1990-2000, controlling for the influence of the baseline variables. This effect is moderately strong and statistically significant at the .05 level. Of note, inclusion of the slope dummies lowers the effect size of GDP per capita change and level of urbanization, although both remain significantly associated with the dependent variable.

The results in model 3 can be interpreted as suggestive of environmental cost-shifting dynamics. Low-income countries more integrated into the global economy as suppliers of non-fuel natural resources, which may or may not include forest products, are characterized by greater deforestation. In other words, the level of natural resource exports among the poorest countries in the sample shapes the rate of deforestation. Arguably, the results highlighted in model 3 support the ecological unequal exchange contention that the structure of international

trade shapes deforestation dynamics, although this only appears to be relevant to the poorest LDCs. This effect contrasts somewhat with results obtained by Ehrhardt-Martinez (1998) that failed to reveal a significant relationship between change in natural resource exports among a sample of LDCs and deforestation from 1980-1990.

In an effort to examine population change dynamics in a more comprehensive manner, model 4 excludes the total population change variable but alternatively includes separate measures of urban and rural population change. The results illustrate urban population change is positively correlated with reforestation across the sample. This relationship is congruent with previous research conducted by Jorgenson (2006) examining forest cover change over the same period but diverges from results reported by Ehrhardt-Martinez (1998) examining forest loss 1980-1990. Of note, the inclusion of urban and rural population change does not substantially temper the effect observed between the natural resource exports of low-income countries and deforestation observed previously.

Model 5 includes a control for proportion of exports to the core countries and export intensity. Congruent with the theory of ecological unequal exchange in general and the assertion of environmental cost-shifting dynamics in particular, countries with greater exports to the core exhibit higher deforestation. Further, the inclusion of this measure strengthens the effect of natural resource exports upon deforestation within low-income countries and the slope dummy for the lower middle-income category now becomes significant at the .05 level. The interpretation of the effect of natural resource exports among lower middle-income countries upon deforestation is complicated, however, by the fact that this slope dummy failed to reach statistical significance at the .05 level in model 1. The relationship observed in model 5, therefore, should be viewed with caution. Of note, the moderate effect of level of urbanization

weakens and drops from statistical significance in model 5, and export intensity is not significantly correlated with the dependent variable.

Model 6 includes a control for debt dependency. No high-income countries in the sample have outstanding external debt. Therefore, inclusion of this variable excludes all high-income countries from the analysis. Debt dependency is not associated with forest cover change among the LDCs in the sample at the .05 level or below. Further, inclusion of this measure strengthens the effect observed between proportion of exports to the core across the sample and low-income natural resource exports upon deforestation.

Table 12 includes slope dummies delineated by country income level and proportion of exports to the core. The results illustrated in table 11 suggest this variable is a relevant predictor of deforestation across the sample but the models presented in table 12 are intended to evaluate whether this effect is contingent upon country income position, net the effects of the baseline, natural resource exports, and alternative dependency measures.

Model 7 in table 12 includes a k-1 test for the non-homogeneity of slopes for the proportion of exports to the core measure. The results highlight that the low-income and upper middle-income slopes are significantly non-parallel to the excluded category, high-income countries. The effect observed for lower middle-income countries fails to reach statistical significance at the .05 level. Subsequently, in models 8-11 the focus is upon the slope dummy effects observed among the low and upper middle-income categories and forest cover change. Of note, GDP per capita change and level of urbanization are significantly correlated with reforestation across the sample, congruent with the results obtained in table 11. In contrast to the results observed in table 11, total population change now reaches statistical significance and is positively correlated with reforestation.

Table 12. Forest Cover Change 1990-2000 by Exports to the Core

Independent Variables	Model 7	Model 8	Model 9	Model 10	Model 11
Constant	[-.409] (.963)	[-.409] (.963)	[-.666] (1.072)	[-.0339] (.993)	[.108] (1.101)
Forest Stock 1990 (% of land area forested)	-.132 [-.0099] (.007) *1.411*	-.132 [-.00999] (.007) *1.411*	-.158 [-.0120] (.007) *1.414*	-.155 [-.0117] (.007) *1.433*	-.057 [-.00401] (.009) *1.629*
Desert Countries (4% or less Forest Cover) Dummy Variable—Reference Category: Non-Desert Countries	-.122 [-.633] (.558) *1.740*	-.122 [-.633] (.558) *1.740*	-.109 [-.566] (.538) *1.649*	-.165 [-.855] (.573) *1.849*	-.159 [-.763] (.627) *1.717*
GDP per capita Change (%) 1980-1990	.278** [.01621] (.006) *1.564*	.278** [.01621] (.006) *1.564*	.253** [.01482] (.006) *1.515*	.251** [.01526] (.006) *1.628*	.276* [.01541] (.007) *1.468*
Total Population Change (%) 1980-1990	.267* [.03061] (.014) *2.321*	.267* [.03061] (.014) *2.321*		.228+ [.02602] (.015) *2.523*	.106 [.01603] (.019) *1.606*
Urban Population (% of total population) 1990	.275* [.02019] (.010) *2.918*	.275* [.02010] (.010) *2.918*	.343* [.02514] (.012) *3.821*	.245+ [.01778] (.010) *2.986*	.272+ [.02146] (.012) *2.490*
Natural Resource Exports-Non-Fuel (% of GDP) (ln)--All countries	-.154+ [-.307] (.177) *1.186*	-.154+ [-.307] (.177) *1.186*	-.148+ [-.296] (.177) *1.202*	-.243* [-.495] (.210) *1.607*	-.311** [-.612] (.243) *1.538*
Proportion of Exports to the Core (% of total exports) --Low Income Countries	-.458** [-.0233] (.010) *5.347*	-.472** [-.0241] (.009) *4.490*	-.506** [-.0264] (.009) *4.477*	-.516** [-.0264] (.009) *4.573*	-.580** [-.0267] (.010) *4.369*
Proportion of Exports to the Core (% of total exports) --Lower Middle Income Countries	-.237+ [-.0145] (.008) *2.509*	-.249+ [-.0152] (.009) *3.375*	-.225 [-.0137] (.009) *3.491*	-.303+ [-.0184] (.009) *3.607*	-.388* [-.0207] (.010) *3.510*
Proportion of Exports to the Core (% of total exports) --Upper Middle Income Countries	-.232* [-.0157] (.007) *1.770*	-.243+ [-.0164] (.009) *2.980*	-.234+ [-.0158] (.009) *3.011*	-.315* [-.0212] (.010) *3.356*	-.405* [-.0238] (.011) *3.393*
Proportion of Exports to the Core (% of total exports) --High Income Countries		-.013 [-.00072] (.010) *4.267*	-.018 [-.0010] (.010) *4.361*	-.109 [-.00625] (.010) *4.909*	
Proportion of Exports to the Core (% of total exports)--Main Effect (all countries)	-.008 [-.0007] (.010) *1.586*				
Urban Population Change (%) 1980-1990			.284* [.01642] (.007) *2.230*		

Table 12. Continued

Rural Population Change (%) 1980-1990			.039 [.00439] (.014) *2.249*		
Exports (% of GDP)				.165 [.01891] (.012) *1.756*	-.011 [-.00123] (.015) *1.974*
Total Debt Service (% of GNI) (ln)					.202 [.364] (.225) *1.580*
Sample Size	97	97	96	96	73
Adjusted R^2	.358	.358	.377	.365	.276

Note: Negative values of the dependent variable indicate deforestation whereas positive values indicate reforestation; first number reported is the standardized coefficient, unstandardized coefficients in brackets, standard errors in parentheses, VIFs in italics; +p<.10 *p<.05 **p<.01 ***p<.001 (two-tailed tests); ln = natural log transformation.

Table 12 includes non-fuel natural resource exports as a main effect or generic control variable. Inclusion of this variable in model 7 suggests it does not reach statistical significance at the .05 level when measured across the sample. The results illustrated in table 11 suggest why this is the case as its effect is the most pronounced and salient among low-income countries. Modeling this effect across the entire sample conceals its covariation with country income level. It ensures, however, the slope dummies modeling proportion of exports to the core are evaluated net the influence of non-fuel natural resource exports.

Model 8 incorporates a contextual test containing all of the slope dummies measuring proportion of exports to the core but excluding the main effect measure. The results illustrate low-income countries with a greater proportion of exports to the core exhibit greater deforestation over the period. This effect is moderately strong and significant at the .01 level. This result supports an ecological unequal exchange interpretation as it suggests that not only are low-income countries with a greater proportion of natural resource exports characterized by higher rates of deforestation, as observed in table 11, but low-income countries with a greater

proportion of exports to the core industrialized countries also exhibit greater forest loss. In combination, this provides inferential evidence that the environmental cost-shifting ostensibly observed in figure 9 is arguably underwritten by both the flow of natural resources from low-income countries and their structural interaction with the industrialized countries most advantageously positioned within the global economy.

The results illustrated in model 8 are suggestive of dependency-oriented arguments concerning the uneven effects of LDC exchange with the most developed countries. Moreover, they support the assertion substantiated empirically by Jorgenson (2006) that more-developed countries externalize their consumption-based environmental costs upon LDCs. The methodological difference between Jorgenson's research and the present study is that Jorgenson calculates a weighted index measuring the degree to which a country exports to more economically developed partners, whomever they may be, whereas the present study measures exports to the 11 countries occupying the pinnacle of the hierarchical structure of global trade, as identified by Smith and White (1992). Nevertheless, the results indicate trade between non-equivalent partners can produce uneven effects, an argument both Hirschman (1945) and Galtung (1971) advanced in their pioneering efforts conceptualizing trade dependency dynamics.

Model 9 excludes total population change and includes both urban and rural population change measures. Congruent with that observed in table 11, urban population change is positively correlated with reforestation across the sample. Further, the effect of proportion of exports to the core among low-income countries upon deforestation remains moderately strong and statistically significant.

Model 10 includes a control for export intensity. As a consequence of inclusion of this measure proportion of exports to the core among upper middle-income countries now reaches

statistical significance. Further, natural resource exports across the sample also reach statistical significance at the .05 level.

The greater the proportion of exports destined for the core the higher the rate of deforestation among upper middle-income countries, net export intensity and the baseline control variables. This result is moderately strong and theoretically unexpected. One ad hoc explanation may be that the greatest levels of cross-national deforestation appear to be shifting over time from the semi-periphery to the periphery of the world-system (see Burns et al. 1994, 2003, 2006). It is possible the trade partner dependency dynamics underlying cross-national deforestation are evolving in turn and the present analysis captures remnants of both the rise and demise of these underlying patterns.

Model 11 incorporates a control for debt dependency. This measure is not significantly associated with forest cover change but its inclusion strengthens the effect of proportion of exports to the core within the low and upper middle-income categories. Further, the effect for the lower middle-income category now reaches statistical significance at the .05 level. The failure of the lower middle-income slope dummy to reach statistical significance in model 7, however, suggests this result should be observed with caution.

Conclusion

Environmental cost-shifting refers to the displacement of the negative ecological consequences of the natural resource consumption rates of industrialized countries onto extraction-oriented LDCs. The theory of ecological unequal exchange maintains international trade South to North in energy and natural resources within an historical context of declining terms of trade is central to the processes of externalization underlying cost-shifting dynamics.

The consumption/environmental degradation paradox, wherein those countries with the lowest consumption of a natural resource exhibit the highest resource loss, appears to characterize forest cover change at a global level. Descriptive evidence presented in figure 9 supports this contention and suggests environmental cost-shifting is a central factor accounting for this conundrum. In 2000 high-income countries are characterized by an average per capita forest product demand that is 24 times that of low-income countries. Nonetheless, deforestation 1990-2000 is clearly the most pronounced among low-income countries, on average, while high income countries exhibit reforestation over the period.

Further, regression analyses conducted in this chapter provides inferential evidence that low-income countries with a greater proportion of natural resource exports are characterized by higher rates of deforestation 1990-2000, net appropriate control variables. In addition, low and upper middle-income countries with a greater proportion of exports to the core exhibit higher deforestation over the period. The core countries are those identified through network analysis research as occupying the dominant positions within the global economy as defined by the analysis of cross-national commodity trade patterns (Smith and White 1992). This effect obtains net the influence of economic growth, population dynamics, proportion of natural resource exports, and alternative dependency variables.

Admittedly, the uneven forest cover change patterns illustrated in this chapter are shaped by domestic attributes in terms of variable economic development and the capacity/incapacity to engage in reforestation efforts. The empirical results highlighted in tables 11 and 12, however, further suggest the structure of international trade is also a salient consideration in accounting for uneven deforestation rates at a cross-national scale. In this respect the results in this chapter are congruent with Bunker's general assertion that the mechanisms of environmental degradation

vary systematically by position in the world-system (1984, 1985) and previous research in particular substantiating the impact of international trade upon deforestation within LDCs (Kick et al. 1996; Jorgenson 2006).

In terms of theoretical considerations, the results in this chapter are relevant to the assertion of an ecological dimension of unequal exchange in juxtaposition to the theory of comparative advantage. Many LDCs occupy a position in the international division of labor as exporters of raw and semi-processed natural resources. This role is generally congruent with their respective comparative advantages as conceptualized by mainstream neoclassical economics. From this perspective, their position as exporters of primary product commodities is based upon rational and efficient utilization of their most abundant factors of endowment relative to other, differentially situated countries in the global economy. Accordingly, the theory of comparative advantage suggests natural resource exporting LDCs will benefit through international trade based upon the efficiency gains accrued through international exchange of differential factor endowments.

From a neoclassical economics perspective deforestation within LDCs can conceivably be conceptualized as an acceptable short-term price to be paid in return for progressive socio-economic development congruent with greater economic integration into the global economy. Further, the EKC posits development at time "B" can provide the resources and capacity to address the short-term environmental contradictions encountered previously at time "A," such that short-term environmental degradation is a rational strategy in return for the accumulation of alternative capital assets promoting long-term sustainable welfare. This line of argument, however, is based upon the premise that the utilization of and depletion of natural capital assets will be offset by the accrual of physical, human, and financial capital assets.

The examination of the shifting "portfolio of capital assets" of LDCs is beyond the scope of this study, but the empirical results reported in chapter five illustrating natural resource exporting low-income countries are characterized by lower social development lends credence to the ecological unequal exchange assertion that deforestation within the poorest countries may not be offset by subsequent socio-economic gains. In addition, the empirical results reported in this chapter do not reveal deforestation conforms to a clearly defined EKC pattern wherein forest loss increases with country income up to a tipping point wherein deforestation declines relative to economic development. Such a pattern would support the theory of comparative advantage as it would suggest deforestation among natural resource exporting LDCs may be an acceptable tradeoff in return for progressive socio-economic development, a consequence of reliance upon and evolving comparative advantage opportunities.

In contrast, the empirical evidence in tables 11 and 12 illustrates deforestation 1990-2000 exhibits a regressive linear pattern, such that the poorest countries in the sample are characterized by the highest forest loss. Moreover, non-fuel natural resource exports, that which is ostensibly the relative comparative advantage of many of the poorest LDCs, and proportion of exports to the core are important factors shaping this regressive linear pattern.

CHAPTER SEVEN

CONCLUSION

Theoretical Argument Guiding the Present Study

The foundation of human societies is the continual appropriation of energy and raw materials from and externalization of waste products or pollution with ecological systems. Human societies are connected not only to nature but interwoven into systemic patterns of cross-national exchange of energy and natural resources. Global environmental change, in turn, is influenced not only by domestic economic and population dynamics but also the interdependencies among countries. Such processes not only shape uneven cross-national domestic environmental burdens and advantages but also the cumulative path dependencies underlying global alteration of ecological systems.

The theory of ecological unequal exchange examines the distributional processes underlying the socio-economic metabolism requirements of industrialized countries. Ecological unequal exchange refers to the inequalities enacted through international trade wherein economically dominant export partners appropriate value or productive potential embodied in natural resource assets originating within LDCs. It advances the argument that industrialized countries are increasingly appropriating both global natural resources and the sink-capacity or waste assimilation properties of ecological systems. Industrialized countries import biological capacity from and export sink-capacity services to the periphery of the world-system in order to meet the consumptive demands underwriting their standards of living, easing pressures on domestic natural capital. As a consequence, LDCs shoulder many of the socio-economic and ecological costs of natural resource extraction and utilization that is the foundation of industrial economies.

International trade shapes the ability of dominant industrialized countries to obtain the carrying capacity of countries disadvantageously integrated into the global economy. The structure of international trade shapes the cross-national over and under-consumption of natural resources, has a direct negative impact upon social development in LDCs, and shifts environmental degradation to the periphery of the global economy.

Further, the theory of ecological unequal exchange has been incorporated within a broader world-systems orientation. A world-systems perspective is useful for highlighting the contingencies and contradictions underlying cross-national capital accumulation and the hierarchical interaction structures within the global economy reproduced through trade relations. In particular, dependency/world-system conceptualizations of trade dependency dynamics are utilized in an effort to ground abstract ecological unequal exchange tenets within an established macro-structural research literature within sociology and a body of specific operational measures.

The present study establishes a sustained dialogue between the divergent expectations of the ecological unequal exchange perspective and the theory of comparative advantage, an underlying narrative pursued throughout the study. Comparative advantage maintains that if a country focuses production and trade upon the one or several commodities over which it is most efficient relative to other activities, thereby minimizing opportunity costs or losses from activities foregone, and trades with other countries pursuing their comparative advantage the consequence is greater and more efficient economic output.

Restatement of the Research Problem

Processes of ecological unequal exchange are characterized by three interrelated empirical dimensions: 1) *Environmental cost-shifting* or externalization of the social and

ecological costs of extraction and distribution of natural resource exports from LDCs, enhancing environmental degradation and depletion at the local level; 2) The disproportionate utilization of global *environmental space* or available sink-capacity and biologically productive area, limiting utilization opportunities of LDCs; and, 3) *Underdevelopment* as a consequence of the out-flow of value associated with the export of cheap natural resources, eroding socio-economic development potential within LDCs.

The research problem guiding this study, in turn, encompasses the following: The assertion of processes ecological unequal exchange, varying according to position in the global economy, requires explicit, quantitative empirical evidence oriented towards illustrating the cross-national interconnections inequitably shaping environmental cost-shifting, appropriation of environmental space, and underdevelopment. The challenge lies not in documenting the relatively greater environmental and socio-economic problems in LDCs but in connecting such outcomes to the structure of trade relations between LDCs and industrialized countries. Accordingly, the empirical chapters in the present study focus upon examination of the three dimensions of ecological unequal exchange.

Disproportionate Utilization of Environmental Space: Empirical Results

Environmental space encompasses the stocks of natural resources and sink capacity or waste assimilation properties of ecological systems supporting human social organization. It focuses upon the flows of materials, energy, and industrial waste between human societies and ecological systems through the chain of extraction, production, consumption, and disposal (Sachs 1999). The cross-national appropriation of environmental space becomes increasingly problematic when it enhances the socio-economic and environmental opportunities of some countries at the expense of others.

Trade between economically imbalanced partners is one mechanism shaping cross-national disparities over access to environmental space (Andersson and Lindroth 2001). Further, access is becoming increasingly zero-sum as global ecological systems are straining to accommodate the demands of human social organization.

The prodigious human impact upon global ecological systems gives the concept of environmental space meaning and relevance. A recent United Nations report concludes that over the past 50 years humans have altered global ecological systems more rapidly and extensively than in any comparable period of time in human history (MEA 2005). Such changes are primarily the consequence of increasing demand for food, fresh water, timber, fiber, and fuel (MEA 2005). In the wake of such changes, assessing the boundaries between productive utilization and overexploitation of ecological systems lies at the heart of efforts to measure environmental space constraints.

In particular, the proposition that exports to the core industrialized countries shapes uneven access to global environmental space as measured by the ecological footprint is examined. The ecological footprint measures the biologically productive area required to support the consumption of renewable natural resources and assimilation of carbon dioxide waste products of a given population (Wackernagel and Rees 1996; Chambers et al. 2002). Of particular relevance to the consideration of cross-national ecological-distributional conflicts, in turn, is ecological footprint evidence that global demand for renewable natural resources exceeds regenerative capacity by approximately 20 percent (Wackernagel et al. 2002).

Descriptive analyses examining the ecological footprint illustrates high-income countries, on average, consume more natural resources than are available domestically, exhibiting an overall ecological deficit. Non-high income countries generally use fewer natural resources than

are available domestically. This pattern is particularly relevant given that global consumption of renewable natural resources currently overshoots available biocapacity (Loh and Wackernagel 2004). This suggests industrialized countries may be promoting the unsustainable utilization of global environmental resources rather than at the forefront of sustainability dynamics, an argument contrary to ecological modernization thought. Further, from 1991-2001 per capita ecological footprint demand in low income countries, on average, declined substantially concurrent with a significant increase among high income countries and a modest increase among upper middle income countries (Loh and Wackernagel 2004).

Regression analysis examining the per capita ecological footprint demand of 148 countries delineated by income level illustrates low and lower middle income countries with a greater proportion of exports to the core industrialized countries are characterized by lower consumption of environmental resources. This contradicts the theory of comparative advantage expectation that greater proportion of exports to core countries is positively correlated with ecological footprint demand within LDCs.

This result, arguably, is a consequence of the disproportionate utilization of global environmental space by core countries at the expense of countries less advantageously integrated into the global economy. This suggests the structure of international trade supports the disproportionate per capita material consumption rates typically characteristic of industrialized countries but, equally problematic, it also shapes the under-consumption confronting the poorest countries in the world.

Results of this study build upon previous research utilizing the ecological footprint but move beyond by evaluating the consequences of export structure upon divergent cross-national footprint demand. In turn, our analysis is relevant to considerations of sustainable development

as the results suggest trade with core countries is associated with greater polarization rather than convergence of environmental consumption. Many LDCs arguably require greater consumption of natural resources congruent with progressive social and economic development, not less (Sachs et al. 1998). As Andersson and Lindroth (2001) note, not all countries exhibiting high footprint demand are characterized by high rates of social development but countries with low footprint demand are universally mired in poverty (Andersson and Lindroth 2001).

The Export of Natural Resources and Social Development: Empirical Results

Bunker's characterization of the interrelationship of productive industrial economies and natural resource extracting LDCs as constituted by fundamental internal socio-organizational processes of acceleration-deceleration respectively has crucial implications for the consideration of cross-national social development (1984, 1985). The proposition that the greater the proportion of natural resource exports from LDCs the lower the social development level exhibited is deduced from Bunker's argument. This proposition directly contradicts the theory of comparative advantage. From this perspective a greater proportion of natural resource exports should be positively correlated with level of social wellbeing in LDCs. In particular, this relationship should apply to the poorest countries in the world, those that typically have few other economic options than to engage in natural resource extraction for export.

The "classical" dependency perspective has long suggested that the international division of labor wherein LDCs exchange primary product commodities for manufactured products from industrial countries is based upon unequal exchange. Despite this recognition, few studies in the research literature directly incorporate natural resource exports as an explicit explanatory variable shaping social development outcomes. Instead, dependency/world-systems researchers tend to examine the traditional dimensions of trade dependency. These factors include: export

intensity or magnitude of trade integration, trade partner concentration or the ratio of exports destined for the one largest trading partner, and export commodity concentration or the ratio of the largest single export type relative to total exports. Such trade dependency measures have often been associated with negative social development outcomes within LDCs in previous research (Ragin and Bradshaw 1992), in addition to evidence that investment dependence or FDI also has negative impacts (London and Williams 1988, 1990).

This study seeks to overcome the limitations of previous research by evaluating the effect of natural resource exports, with and without fuels included in the calculation, upon level of social development directly, net the impact of traditional trade dependency factors, external debt, and investment dependence. The Human Development Index (HDI) and the Human Wellbeing Index (HWI) are employed as measures of social development. The HDI is composed of four indicators: life expectancy at birth, adult literacy rate, school enrollment, and GDP per capita. The HWI calculation is composed of the unweighted average of five dimensions, these include: health and population, wealth, knowledge, community, and equity. It incorporates 36 separate indicators.

The empirical results consistently illustrate low-income countries with a greater proportion of natural resource exports are characterized by lower levels of social development as measured by the HDI. This effect holds regardless of whether fuels are included or excluded in the calculation and is moderately strong net the effects of urbanization, age structure (proportion of the population under 14 years of age), level of economic freedom, and inclusion of appropriate alternative dependency variables, including sectoral disarticulation.

The HWI is more sensitive to differentiation between natural resource exports with and without fuels included in the calculation. For example, empirical results highlight low-income

countries with a greater proportion of non-fuel natural resource exports exhibit lower levels of social development. Conversely, upper middle and high-income countries exhibit higher levels. This beneficial effect is particularly strong among high-income countries. This dichotomy is net the statistically significant and positive effects upon social development of urbanization, state strength, economic freedom, and the negative effects of FDI and sectoral disarticulation.

The results support an ecological unequal exchange interpretation as they illustrate the poorest countries, those the theory of comparative advantage suggests should disproportionately benefit from natural resource extraction, are instead characterized by lower levels of social development. High-income countries, those the theory of comparative advantage suggest should benefit the least from the export of natural resources as their comparative advantages typically lie elsewhere, are those characterized by higher levels of social development.

Including fuels in the calculation substantially alters the effects observed when employing the HWI as a measure of social development. Low, lower middle and upper middle-income countries with a greater proportion of primary product exports exhibit lower levels of social development when fuels are included. This negative impact is particularly strong among low-income countries. The positive impact of natural resource exports among high-income countries drops from statistical significance when including fuels in the calculation. Overall, these effects are net the positive relationship of urbanization, state strength, economic freedom, and export intensity and the negative relationship of FDI and sectoral disarticulation upon social wellbeing.

Environmental Cost-Shifting and Cross-National Forest Cover Change: Empirical Results

Environmental cost-shifting refers to the displacement of the negative ecological consequences of the natural resource consumption rates of industrialized countries onto

extraction-oriented LDCs. The theory of ecological unequal exchange maintains international trade South to North in energy and natural resources within an historical context of declining terms of trade is central to the processes of externalization underlying cost-shifting dynamics.

The consumption/environmental degradation paradox, wherein those countries with the lowest consumption of a natural resource exhibit the highest resource loss, characterizes forest cover change at a global level. Descriptive evidence presented in chapter six supports this contention and suggests environmental cost-shifting is a central factor accounting for this conundrum. High-income countries are characterized by an average per capita forest product demand that is 24 times that of low-income countries. Nonetheless, deforestation 1990-2000 is clearly the most pronounced among low-income countries, on average, while high income countries exhibit reforestation over the period.

Further, regression analyses provides inferential evidence that low-income countries with a greater proportion of natural resource exports are characterized by higher rates of deforestation 1990-2000, net a series of appropriate control variables. In addition, low-income and upper middle-income countries with a greater proportion of exports to the core exhibit higher deforestation over the period. This effect obtains net the influence of economic growth, population dynamics, proportion of natural resource exports, and alternative dependency variables.

The empirical results illustrate the structure of international trade is a salient consideration, in addition to population and economic development factors, in accounting for uneven deforestation rates at a cross-national scale. Theoretically, the results are relevant to the assertion of an ecological dimension of unequal exchange in juxtaposition to the theory of comparative advantage. Many LDCs occupy a position in the international division of labor as

exporters of raw and semi-processed natural resources. This role is generally congruent with their respective comparative advantages as conceptualized by mainstream neoclassical economics. From this perspective, their position as exporters of primary product commodities is based upon rational and efficient utilization of their most abundant factors of endowment relative to other, differentially situated countries in the global economy. Accordingly, the theory of comparative advantage suggests natural resource exporting LDCs will benefit through international trade based upon the efficiency gains accrued through international exchange of differential factor endowments.

From a neoclassical economics perspective deforestation within LDCs can conceivably be regarded as an acceptable short-term price to be paid in return for progressive socio-economic development congruent with greater integration into the global economy. However, the empirical results reported in this study illustrating natural resource exporting low-income countries are also characterized by lower social development lends credence to the ecological unequal exchange assertion that deforestation within the poorest countries may not be offset by subsequent socio-economic gains. In addition, the empirical results reported in chapter six do not reveal cross-national deforestation rates conform to a clearly defined EKC pattern wherein forest loss increases with country income up to a tipping point wherein deforestation declines relative to economic development. Such a pattern would support the theory of comparative advantage as it would suggest deforestation among natural resource exporting LDCs is potentially an acceptable tradeoff in return for progressive socio-economic development, a consequence of reliance upon and evolving comparative advantage opportunities.

In contrast, deforestation 1990-2000 exhibits a regressive linear pattern, such that the poorest countries in the sample are characterized by the highest forest loss. Moreover, non-fuel

natural resource exports, that which is ostensibly the relative comparative advantage of many of the poorest LDCs, and proportion of exports to the core are important factors shaping this regressive linear pattern.

Theoretical and Empirical Implications of the Present Study

There are several general theoretical and empirical implications to be derived from the analyses in this study. First, the slope dummy results across all three empirical chapters fail to uncover evidence of environmental Kuznets curve (EKC) dynamics. Such processes would be evident if upper middle-income countries tended to exhibit the greatest negative trade dependency effects but low and high-income countries exhibited the least. This would point to an inverted-U dynamic or EKC curve wherein there are non-linear processes that are the most substantially expressed within the middle ranges of the global economy. Evidence of EKC dynamics would be theoretically significant because it could be interpreted as evidence of a developmental transformation wherein countries first encounter negative ecological unequal exchange dynamics in an additive manner until reaching a turning point wherein such processes begin to decline. This would argue for the conclusion that socio-economic development is a solution to negative cross-national ecological-distributional conflicts. Ecological unequal exchange processes, moreover, would not necessarily be characterized as mechanisms of underdevelopment but, rather, a developmental stage that can be transcended as a consequence of progressive socio-economic development.

Rather than highlighting EKC processes, the empirical results in this study predominantly illustrate regressive linear dynamics in which the richest countries exhibit the lowest negative ecological unequal exchange effects and the poorest countries exhibit the highest. Ecological-distributional conflicts interact with or covary by country position in the global economy, in

other words, but appear to do so in a substantially regressive manner wherein the poorest countries are the most substantially impacted, as the effects appear increasingly strong moving down the international hierarchy. This result is congruent with Bunker's original argument (1984, 1985) and Bunker and Ciccantell's (2005) later work in which cross-national ecological-distributional conflicts shape the underdevelopment of resource extraction oriented LDCs. This is theoretically significant as it implies that ecological unequal exchange dynamics more closely approximate parasitic or fundamental zero-sum relations rather than linear stages in the developmental process. This conclusion reflects the proposition that the ability to procure natural resources in an unequal manner is contingent upon country position in the hierarchical structure of the global economy.

The absence of EKC dynamics, moreover, is relevant to the critical evaluation of the ecological modernization theory contention that the most developed industrialized countries are increasingly approximating "environmental states" or are actively pursuing the most sustainable development trajectories. Results of the present study suggest cautious observance of overly optimistic conceptions of industrialized countries as environmental states as the evidence presented in this study illustrates substantial ecological-distributional processes enacted at a cross-national scale. Moreover, ecological modernization research uncovering EKC patterns among developed countries must consider the potential for cost-shifting through international trade or run the risk of mistakenly identifying trends among industrialized countries as evidence of ecological modernization when in fact they are simply artifacts of ecological-distributional processes.

Second, processes of ecological unequal exchange imply consumption and cross-national socio-economic and environmental equity should be recognized as central concerns of the

sustainable development challenge. Sustainable development, as defined by the Brundtland report, highlights the importance of considering both *inter-generational* and *intra-generati*onal equity (WCED 1987). This is illustrated in the report's well-known definition suggesting sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987:8).

To address inter-generational equity it is necessary to first examine cross-national material consumption and the failure to meet the "needs" of a significant proportion of the human population in the contemporary world. The 20th century was characterized by an unprecedented expansion in private and public consumption (Human Development Report [HDR] 1998). But the poorest 20 percent, over one billion people, have been excluded from this expansion, deprived of even the most basic consumption needs (HDR 1998). In 70 countries levels of consumption at the end of the 20th century were lower than they were 25 years earlier, and yet consumption per capita has increased steadily within industrialized countries over this period (HDR 1998). Residents of high-income countries account for 86 percent of total global private consumption expenditures, although industrialized countries can also exhibit considerable domestic consumption inequalities as well (HDR 1998). It is the poorest people in the poorest countries, however, that are the most affected by the environmental and socio-economic consequences of uneven world consumption (HDR 1998).

Evidence of fundamental ecological-distributional conflicts at a cross-national scale and failure to substantiate central tenets of the theory of comparative advantage in the present study challenge the validity of "free market" sustainability. Free market sustainability promotes increasing global economic integration as the most optimal strategy for achieving sustainable development ends. Based upon the neoclassical economic paradigm, it further encourages

development of global markets as a means of generating and distributing resources (Petrucci 2002). This approach suggests economic activity can be made sustainable through the internalization of environmental and social costs, often through taxes, pollution permits, and other economic measures (Petrucci 2002). Further, reliance upon the proposed comparative advantages thought to underlie international trade facilitates the economic and social development of LDCs, in turn promoting the acquisition of greater resources to devote to social and environmental issues.

The question remains, however, as to whether free market sustainability primarily serves as a rhetorical device justifying further Northern-led global economic growth beneath a veneer of ecological concern, with little regard for issues of distributive justice (Petrucci 2002). The cost-shifting and inequitable appropriation of environmental space underlying ecological unequal exchange suggests O'Connor's (1994) second or cost-side contradiction of capitalism is recognizable at a cross-national level. In an effort to reduce costs of production to boost or maintain profits, the logic of capitalism coerces producers into strategies that degrade or fail to sustain environmental resources. The pressure to forego internalizing the true costs of production, which would include environmental impacts, forces firms to undercut the material conditions of their own future production by degrading natural resources (O'Connor 1994).

The first contradiction of capitalism is a demand crisis rooted in the need to cut costs, including wage labor. This produces an imbalance in production and consumption. One way around this problem is through the expansion of markets. However, expansion is limited because the number of markets is bounded and natural resources are ultimately finite (O'Connor 1994). This leads to the second contradiction: escalating production depletes the natural resources

required to sustain production, which escalates costs and erodes profits. The continued depletion of resources can lead to an environmental crisis, as nature's capital and services are lost.

Ecological unequal exchange highlights the assertion that environmental disruptions need not be contiguous with the sites of production and consumption driving second contradiction dynamics. Policies advocating global economic integration as the surest means to address sustainable development issues are misguided if they simply displace the negative ecological consequences of the socioeconomic metabolism of industrialized countries to the periphery of the global economy.

It is worth noting that the strongest ecological unequal exchange processes uncovered in the present study were exhibited primarily within low income countries. The one exception is the disproportionate utilization of environmental space highlighted in chapter 4 wherein exports to the core illustrated a roughly equivalent suppressing influence upon material consumption among both low and lower middle income countries. However, in chapters 5-6 the deleterious social development and environmental cost-shifting dynamics were clearly the most pronounced among low income countries.

There are unique, upwardly mobile countries in the world-system that are engaged in substantial domestic environmental degradation that is the consequence of concerted efforts to developed economically. China is the most obvious example in the contemporary era. The Chinese economy has taken an enormous toll upon the domestic environment even as China is increasingly obtaining natural resources from abroad to meet its growing material consumption demands.

However, the results of the present study suggest that overall the poorest countries in the global economy are the most profoundly impacted by uneven ecological unequal exchange

processes. This diverges from the hypotheses delineated in chapters 4-6 as it was anticipated that the strongest effects would be observable among the low and lower middle income countries, categories roughly approximate to the low and upper peripheral countries from a Wallersteinian perspective. The empirical results highlighted in chapters 4-6 therefore suggest a reconceptualization of the scope conditions underlying the theory of ecological unequal exchange. This reconceptualization should be based upon the empirical evidence suggesting that it is the low income countries, or the lower periphery from a Wallersteinian perspective, that appear to be the most fundamentally impacted by the political-economic dynamics shaping ecological unequal exchange.

The results of the present study illustrate one aspect of the enormous obstacles confronting low income countries in moving towards greater socio-economic development. Indeed, the challenge centers upon the need for greater per capita material consumption within low income countries enacted within a global context in which material consumption levels are already in tension with the integrity and resilience of global ecological systems (MEA 2005), in large part driven by the demands of industrialized countries (Wackernagel et al. 2002). Efforts to approximate genuinely broad-based sustainable development must necessarily confront evidence that global consumption of natural resources has potentially reached an unsustainable level and yet a majority of the world's population remains impoverished and requires greater consumption of natural resources congruent with progressive socio-economic development.

Future Research Efforts

Future research efforts are needed to further document and articulate the mechanisms promoting and inhibiting ecological unequal exchange dynamics. First, this area of inquiry might benefit from a focus upon the potential contingent effects of foreign direct investment by

position in the global economy. Because it embodies investment in such diverse operations as chemical and petroleum plants, pharmaceuticals, electronics, mining, automobile manufacturing, logging, and agriculture, as well as service sector activities, foreign direct investment is rooted in the transnational movement of environmentally significant production activities. Frey (2003) has contributed valuable case study data in this regard and Jorgenson (forthcoming) has examined this issue from a cross-national quantitative perspective that disaggregates foreign direct investment by economic sector.

Second, the results of the present study primarily illustrate that ecological unequal exchange dynamics are the most substantial within low income countries. Lower middle and upper middle income countries appear less subject to such processes. A potentially valuable area of future inquiry concerns the social processes facilitating and constraining ecological unequal exchange dynamics, particularly as they are differentially expressed between low and lower middle income countries. One area of possible inquiry could be the examination of the size and integrity of state institutional structures. Strong state structures that approximate Weberian bureaucracies have been shown to enhance economic growth within LDCS (Evans and Rauch 1999) and may constrain ecological unequal exchange processes as well. Weberian bureaucratic state agencies are those that employ meritocratic recruitment and offer predictable and rewarding long-term careers (Evans and Rauch 1999). Further, more Weberian bureaucratic agencies are more efficient and effective at serving broad interests in society rather than the purely narrow interests of the individuals holding advantageous positions within such organizations (Evans and Rauch 1999). Third, additional dependent variable measures examining international political-economic issues in ecological terms need to be incorporated to further conceptualize the challenges related to environmental consumption, equity, and unsustainable structural

relationships within the global economy.

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APPENDIX

SUMMARY STATISTICS AND CORRELATION MATRICES

Table A1. Countries Included in the Study by Income Level (N=148)

High (N=25)	Lebanon	Macedonia, FYR	Guinea-Bissau
Australia	Libya	Morocco	Haiti
Austria	Malaysia	Namibia	India
Belgium/Luxembourg	Mauritius	Papua New Guinea	Indonesia
Canada	Mexico	Paraguay	Kenya
Denmark	Panama	Peru	Korea, DPR (North)
Finland	Poland	Philippines	Kyrgyzstan
France	Saudi Arabia	Romania	Lao PDR
Germany	Slovakia	Russian Federation	Lesotho
Greece	South Africa, Rep.	Serbia and Monten.	Liberia
Ireland	Trinidad and Tobago	Sri Lanka	Madagascar
Israel	Turkey	Swaziland	Malawi
Italy	Uruguay	Syria	Mali
Japan	Venezuela	Thailand	Mauritania
Kuwait	**Lower Middle (N=39)**	Tunisia	Moldova, Rep.
Netherlands	Albania	Turkmenistan	Mongolia
New Zealand	Algeria	**Low (N=59)**	Mozambique
Norway	Belarus	Afghanistan	Myanmar
Portugal	Belize	Angola	Nepal
Slovenia	Bolivia	Armenia	Nicaragua
Spain	Bosnia and Herz.	Azerbaijan	Niger
Sweden	Bulgaria	Bangladesh	Nigeria
Switzerland	China	Benin	Pakistan
United Arab Em.	Colombia	Burkina Faso	Rwanda
United Kingdom	Cuba	Burundi	Senegal
United States	Dominican Rep.	Cambodia	Sierra Leone
Upper Middle (N=25)	Ecuador	Cameroon	Somalia
Argentina	Egypt	Central African Rep.	Sudan
Botswana	El Salvador	Chad	Tajikistan
Brazil	Guatemala	Congo	Tanzania
Chile	Honduras	Congo, Dem. Rep.	Togo
Costa Rica	Iran	Côte d'Ivoire	Uganda
Croatia	Iraq	Eritrea	Ukraine
Czech Rep.	Jamaica	Ethiopia	Uzbekistan
Estonia	Jordan	Gambia, The	Vietnam
Gabon	Kazakhstan	Georgia	Yemen
Hungary	Latvia	Ghana	Zambia
Korea, Rep. (South)	Lithuania	Guinea	Zimbabwe

Income categories are based upon World Bank estimates of 1999 Gross National Income per capita (2002). Low income = $755 or less; Lower middle income = $756-2995; Upper middle income = $2996-9265; High income = $9266 or more. Countries in bold italics are the "core" industrialized countries (Smith and White 1992) (N=11).

Table A2. Descriptive Summary of Variables in the Ecological Footprint Analysis

Variable	Min.	Max.	Mean	Std. Dev.	Skew
Ecological Footprint 2001 (ln)	-1.20	2.29	.59	.76	.298
GDP per capita (ln)	6.1	10.4	8.3	1.1	.125
Urbanization (residualized)	-38.9	34.5	-5.0E-14	14.6	.044
Proportion of Exports to Core (%)—All Countries	7.9	97.7	50.8	18.6	-.067
Exports (% of GDP) (ln)	.57	110.2	33.7	17.9	1.027
FDI (% of GDP) (ln)	-1.6	6.5	2.8	1.1	-.737
Export Commodity Concentration (ln)	.10	4.6	2.8	.88	-.114

Ln = natural log transformation

Table A3. Ecological Footprint Analysis Correlation Matrix

		1.	2.	3.	4.	5.
Ecological Footprint 2001 (ln)	**1.**	---				
GDP per capita (ln)	**2.**	.88***	---			
Urbanization (residualized)	**3.**	.12	.00	---		
Proportion of Exports to Core (%)—All Countries	**4.**	.12	.26**	-.16*	---	
Proportion of Exports to Core (%)—Low Income	**5.**	-.66***	-.70***	-.11	.09	---
Proportion of Exports to Core (%)—Lower Middle Income	**6.**	-.02	.01	.02	.26**	-.38***
Proportion of Exports to Core (%)—Upper Middle Income	**7.**	.24**	.29***	.16	.15	-.29***
Proportion of Exports to Core (%)—High Income	**8.**	.67***	.69***	-.09	.28***	-.31***
Exports (% of GDP) (ln)	**9.**	.31***	.31***	-.09	.09	-.23**
FDI (% of GDP) (ln)	**10.**	.12	.17*	-.06	.08	-.13
Gross Domestic Investment	**11.**	.09	.17*	-.11	.08	-.21**
Export Commodity Concentration (ln)	**12.**	-.41***	-.43***	.01	.01	.34***

*p<.05 **p<.01 ***p<.001 (two-tailed test); ln = natural log transformation

Table A3 Continued. Ecological Footprint Analysis Correlation Matrix

		6.	7.	8.	9.	10.	11.
Ecological Footprint 2001 (ln)	**1.**						
GDP per capita (ln)	**2.**						
Urbanization (residualized)	**3.**						
Proportion of Exports to Core (%)—All Countries	**4.**						
Proportion of Exports to Core (%)—Low Income	**5.**						
Proportion of Exports to Core (%)—Lower Middle Income	**6.**	---					
Proportion of Exports to Core (%)—Upper Middle Income	**7.**	-.23**	---				
Proportion of Exports to Core (%)—High Income	**8.**	-.24**	-.18*	---			
Exports (% of GDP) (ln)	**9.**	-.01	.19*	.14	---		
FDI (% of GDP) (ln)	**10.**	-.01	.13	.05	.42***	---	
Gross Domestic Investment	**11.**	.01	.16	.04	.27***	.37***	---
Export Commodity Concentration (ln)	**12.**	-.02	-.07	-.26**	-.04	-.01	.01

*p<.05 **p<.01 ***p<.001 (two-tailed test); ln = natural log transformation

Table A4. Descriptive Summary of Variables in the Human Development Index Analysis

Variable	Min.	Max.	Mean	Std. Dev.	Skew
Human Development Index 2003	.28	.96	.69	.19	-.424
Urbanization (% of total population)	6.1	97.5	53.1	22.6	-.041
Age Structure (% of pop. 14 years or less)	14.4	49.8	32.9	10.7	-.228
State Strength—Central Government Expenditures (% of GDP)	9.0	56.2	27.5	10.5	.367
Democracy	-10	10	3.4	6.5	-.619
International Non-Governmental Ties (ln)	.69	7.6	4.5	1.3	-.173
Economic Freedom	1.00	4.24	2.7	.79	-.176
Natural Resource Exports, Non-Fuel (% of GDP) (ln)	-2.04	3.70	1.6	1.1	-.808
Natural Resource Exports, Including Fuels (% of GDP) (ln)	-1.61	4.09	2.1	1.0	-.534
Proportion of Exports to Core (%)	7.9	97.7	50.1	18.6	-.067
Exports (% of GDP)	.57	110.2	33.7	17.9	1.027
FDI (% of GDP) (ln)	-1.61	6.49	2.8	1.1	-.737
Gross Domestic Investment (% of GDP)	8.6	48.7	21.3	6.8	1.274
Sectoral Disarticulation (ln)	1.31	4.84	3.4	.87	-.487
Total Debt Service (% of GNI) (ln)	-.86	3.59	1.5	.81	-.544

ln = natural log transformation

Table A5. Human Development Index Analysis Correlation Matrix

		1.	2.	3.	4.	5.	6.	7.
HDI 2003	**1.**	---						
Urban.	**2.**	.77***	---					
Age Structure	**3.**	-.87***	-.65***	---				
Central Govt. Expenditures	**4.**	.34***	.32***	-.39***	---			
Democracy	**5.**	.45***	-.49***	-.49***	.20*	---		
INGO Ties (ln)	**6.**	.38***	.41***	-.37***	.41***	.44***	---	
Econ. Freedom	**7.**	.62***	.51***	-.52***	.21**	.66***	.50***	---
Natural Resource Exports, W/Fuels (ln)	**8.**	-.16	.03	.26**	.02	-.22**	.15	-.18*
Natural Resource Exports, Non-Fuel (ln)	**9.**	-.21**	-.24**	.14	-.11	.17*	.26**	.05
Proportion of Exports—Core	**10.**	.15	.09	-.09	-.01	.25**	.22**	.26**
Exports	**11.**	.29***	.18*	-.23**	.36***	.11	.41***	.21**
FDI (ln)	**12.**	.12	.09	-.03	.22**	.18*	.29***	.27***
GDI	**13.**	.17*	.06	-.11	.28***	-.01	.09	.08
Disarticulation (ln)	**14.**	-.69***	-.58***	.62***	-.39***	-.37***	-.36***	-.47***
Total Debt Service (ln)	**15.**	.35***	.39***	-.26**	.29**	.24**	.16	.31***

*p<.05 **p<.01 ***p<.001 (two-tailed test); ln = natural log transformation

Table A5 Continued. Human Development Index Analysis Correlation Matrix

		8.	9.	10.	11.	12.	13.	14.
HDI 2003	**1.**							
Urban.	**2.**							
Age Structure	**3.**							
Central Govt. Expenditures	**4.**							
Democracy	**5.**							
INGO Ties (ln)	**6.**							
Econ. Freedom	**7.**							
Natural Resource Exports, W/Fuels (ln)	**8.**	---						
Natural Resource Exports, Non-Fuel (ln)	**9.**	.49***	---					
Proportion of Exports—Core	**10.**	-.12	-.14	---				
Exports	**11.**	.49***	.33***	.09	---			
FDI (ln)	**12.**	.31***	.32***	.08	.42***	---		
GDI	**13.**	-.04	-.18*	.09	.27***	.38***	---	
Disarticulation (ln)	**14.**	.19*	.06	-.04	-.16	-.07	.01	---
Total Debt Service (ln)	**15.**	.41***	.25**	.09	.36***	.27**	.13	-.17

*p<.05 **p<.01 ***p<.001 (two-tailed test); ln = natural log transformation

Table A6. Descriptive Summary of Variables in the Human Wellbeing Index Analysis

Variable	Min.	Max.	Mean	Std. Dev.	Skew
Human Wellbeing Index 1999	3.00	82.00	39.7	21.7	.357
Urbanization (% of total population)	5.7	96.9	51.5	22.9	-.014
State Strength—Central Government Expenditures (% of GDP)	8.5	57.4	29.2	11.1	.278
International Non-Governmental Ties (ln)	2.6	8.0	6.1	1.1	-.394
Economic Freedom	1.00	4.24	2.7	.77	-.176
Natural Resource Exports, Non-Fuel (% of GDP) (ln)	.00	3.78	1.9	.82	-.045
Natural Resource Exports, Including Fuels (% of GDP) (ln)	.18	4.19	2.3	.87	-.002
Proportion of Exports to Core (%)	.41	95.3	51.3	20.7	-.304
Exports (% of GDP)	1.4	87.4	32.5	17.2	.731
FDI (% of GDP) (ln)	.00	5.9	2.3	.98	.02
Gross Domestic Investment (% of GDP)	4.0	60.5	21.8	7.3	1.36
Sectoral Disarticulation (ln)	1.3	4.8	3.4	.88	-.487

ln = natural log transformation

Table A7. Human Wellbeing Index Analysis Correlation Matrix

		1.	2.	3.	4.	5.	6.
HWI 1999	**1.**	---					
Urbanization	**2.**	.74***	---				
Central Govt. Expenditures	**3.**	.38***	.29***	---			
INGO Ties (ln)	**4.**	.65***	.55***	.14	---		
Economic Freedom	**5.**	.72***	.49***	.13	.65***	---	
Natural Resource Exports, W/Fuels (ln)	**6.**	-.19**	-.01	.04	-.23**	-.14	---
Natural Resource Exports, Non-Fuel (ln)	**7.**	-.14	-.25**	-.08	-.22**	.01	.57***
Proportion of Exports--Core	**8.**	.17*	.06	.03	.46***	.24**	-.01
Exports (% of GDP)	**9.**	.25**	.22**	.33***	-.10	.16	.50***
Foreign Direct Investment (% of GDP) (ln)	**10.**	.08	-.01	.15	.15	.30***	.31***
Gross Domestic Investment (% of GDP)	**11.**	.17*	.07	.09	.04	.17*	-.04
Sectoral Disarticulation (ln)	**12.**	-.72***	-.61***	-.39***	-.43***	-.43***	.22**

*p<.05 **p<.01 ***p<.001 (two-tailed test); ln = natural log transformation

Table A7 Continued. Human Wellbeing Index Analysis Correlation Matrix

		7.	8.	9.	10.	11.
HWI 1999	**1.**					
Urbanization	**2.**					
Central Govt. Expenditures	**3.**					
INGO Ties (ln)	**4.**					
Economic Freedom	**5.**					
Natural Resource Exports, W/Fuels (ln)	**6.**					
Natural Resource Exports, Non-Fuel (ln)	**7.**	---				
Proportion of Exports--Core	**8.**	-.08	---			
Exports (% of GDP)	**9.**	.29***	-.03	---		
Foreign Direct Investment (% of GDP) (ln)	**10.**	.31***	.26**	.31***	---	
Gross Domestic Investment (% of GDP)	**11.**	-.09	-.08	.25**	.10	---
Sectoral Disarticulation (ln)	**12.**	.09	.01	-.11	.01	-.05

*p<.05 **p<.01 ***p<.001 (two-tailed test); ln = natural log transformation

Table A8. Descriptive Summary of Variables in the Forest Cover Change Analysis

Variable	Min.	Max.	Mean	Std. Dev.	Skew
Forest Cover Change 1990-2000, Annual Average %	-9.00	5.00	-.37	1.7	-.774
Forest Stock 1990 (% of land area forested)	.00	85.00	29.2	21.3	.497
Desert Countries (4% or less Forest Cover) Dummy Variable--Reference Category: Non-Desert Countries	.00	1.00	.13	.34	2.245
GDP per capita Change (%) 1980-1990	-76.0	110.1	8.1	28.6	.884
Total Population Change (%) 1980-1990	-3.2	69.9	22.4	14.4	.321
Urban Population (% of total population) 1990	5.3	96.5	49.4	23.0	.048
Natural Resource Exports-Non-Fuel (% of GDP) (ln)	.00	3.80	1.9	.86	-.120
Urban Population Change (%) 1980-1990	.63	222.7	41.7	31.6	1.505
Rural Population Change (%) 1980-1990	-31.8	44.4	10.2	15.7	-.200
Proportion of Exports to the Core (% of total exports)	6.38	98.5	59.5	19.0	-.571
Exports (% of GDP)	2.8	77.9	28.5	15.7	.835
Total Debt Service (% of GNI) (ln)	-1.9	3.0	1.5	.86	-1.006

ln = natural log transformation

Table A9. Forest Cover Change Analysis Correlation Matrix

		1.	2.	3.	4.	5.
Forest Cover Change 1990-00 (%)	**1.**	---				
Forest Stock 1990 (%)	**2.**	-.130	---			
Desert Countries	**3.**	-.073	-.491***	---		
GDP p.c. Change (%) 1980-90	**4.**	.248**	.033	-.147	---	
Total Population Change (%) 1980-90	**5.**	-.232**	-.095	.372***	-.413***	---
Urban Population (%) 1990	**6.**	.459***	-.021	.013	.018	-.384***
Natural Resource Exports—Non-Fuel (% of GDP) (ln)	**7.**	-.243**	.124	-.277**	-.133	.047
Urban Population Change (%) 1980-90	**8.**	-.285***	-.026	.257**	-.071	.747***
Rural Population Change (%) 1980-90	**9.**	-.386***	-.051	.047	-.301***	.621***
Proportion of Exports to the Core (% of total exports)	**10.**	-.107	.004	-.053	.006	-.064
Exports (% of GDP)	**11.**	.239**	.027	.010	.125	-.015
Total Debt Service (% of GNI) (ln)	**12.**	.098	.082	.119	-.021	.047

*p<.05 **p<.01 ***p<.001 (two-tailed test); ln = natural log transformation

Table A9 Continued. Forest Cover Change Analysis Correlation Matrix

		6.	7.	8.	9.	10.	11.
Forest Cover Change 1990-00 (%)	**1.**						
Forest Stock 1990 (%)	**2.**						
Desert Countries	**3.**						
GDP p.c. Change (%) 1980-90	**4.**						
Total Population Change (%) 1980-90	**5.**						
Urban Population (%) 1990	**6.**	---					
Natural Resource Exports—Non-Fuel (% of GDP) (ln)	**7.**	-.209**	---				
Urban Population Change (%) 1980-90	**8.**	-.480***	.110	---			
Rural Population Change (%) 1980-90	**9.**	-.705***	.177*	.342***	---		
Proportion of Exports to the Core (% of total exports)	**10.**	.098	-.045	-.053	-.052	---	
Exports (% of GDP)	**11.**	.321***	.361***	-.003	-.237**	.285**	---
Total Debt Service (% of GNI) (ln)	**12.**	.259**	.303**	-.003	-.145	.198	.499***

*p<.05 **p<.01 ***p<.001 (two-tailed test); ln = natural log transformation