Uneven Processes and Environmental Degradation in the World-Economy

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Abstract

Consumption and concomitant environmental degradation are among the most pressing global issues confronting us today. Drawing from recent empirical studies in environmental sociology and international political-economy, I test the extent to which the impacts of urbanization, domestic income inequality, and literacy rates on per capita ecological footprints vary across zones in the contemporary world-system. This involves the construction of "slope-dummies" and their incorporation into contextual effects analyses that test for heterogeneity of slopes among zones in the world-economy while controlling for additional relevant predictors. Using partial data for 208 countries, I find that the effects of predictor variables do vary among world-system tiers. Domestic income inequality in the core has a positive effect on per capita footprints while the impact of the former in all other zones is negative. The effect of urbanization on per capita footprints is most pronounced in the core, followed by the semiperiphery, high periphery, and low periphery, and the overall effect of literacy rates on ecological footprints is positive while between zone differences are inconclusive.

Keywords: *ecological footprints, environmental degradation, world-economy, slope-dummies*

Introduction

Previous studies identify several macro-level causes of cross-national variation in consumption of natural resources. The most salient ones include relative position in the core-periphery hierarchy, urbanization and other population dynamics, levels of domestic income inequality, and levels of human capital, such as literacy rates. These analyses generally treat causal explanations in linear terms, paying little attention to the possibility that structural causes of material consumption and other forms of environmental degradation may operate quite differently in varying regions or zones of the international stratification system. Drawing from recent theoretical and empirical developments in world-systems analyses, environmental sociology, and other international political-economic perspectives, I argue that factors impacting overall environmental degradation do vary in form and intensity among zones in the core-periphery hierarchy of the world-economy. These differences are largely a function of the general asymmetrical relational structure of the core-periphery hierarchy and its influence on varying domestic conditions and processes within and among zones of the global system (e.g., Arrighi 1994; Arrighi and Drangel 1986; Burns, Kick and Davis 2003; Chase-Dunn 1998, 2002; Chase-Dunn and Hall 1997; Chase-Dunn and Jorgenson 2003a, 2004, forthcoming; Evans 1979, 1995; Jorgenson and Kick 2003; Kentor 2000; Smith 1994; Wallerstein 1974).

I test this general proposition concerning non-linear environmental outcomes and interaction effects through a series of quantitative cross-national analyses of the structural causes of variation in per capita consumption of natural resources, measured as ecological footprints. This involves the construction of a series of interaction terms known as slope-dummies and their incorporation into contextual effects analyses that test for the heterogeneity of slopes among world-system zones while controlling for additional relevant predictors. I include the relevant predictors of per capita consumption identified by Jorgenson's (2003a) recent study: world-system position, urbanization, domestic income inequality, and literacy rates. Jorgenson (2003a) models direct, indirect, and total effects, but treats all relationships as linear. While this approach is theoretically relevant in addressing intervening mechanisms and identifying course-grained macrosociological relationships, it fails to address key components of world-systems and other political-economic perspectives which suggest that many social factors closely associated with environmental degradation tend to vary by or interact with a nation's relative position in the international stratification system (e.g., Burns, Kick and Davis 2003; Chase-Dunn 1998, 2002).

Results of this study provide empirical evidence suggesting that the effects of certain predictor variables on environmental impacts do vary among world-system zones. Domestic income inequality in the core has a positive effect on per capita footprints while the impact of the former in all other zones is negative. I find this positive effect in the core is largely attributable to domestic conditions in the United States. The effect of urbanization is most pronounced in the core, followed by the semiperiphery, high periphery, and low periphery. I determine that the overall effect of literacy rates on ecological footprints is positive while between zone differences are inconclusive.

Most countries consume natural resources at levels higher than the global ecological system can support (Jorgenson 2003a; Jorgenson and Burns 2004; Wackernagel et al. 2000; York, Rosa and Dietz 2003). Taking a macro-analytical and improved empirical approach provides insights necessary for understanding and dealing with the most important environmental problems the world will face in the coming century (Burns, Kick and Davis 2003; Smith 2001). By identifying how central factors impacting per capita consumption of natural resources vary among world-system zones, I advance our understanding of the complexities of global social dynamics and domestic conditions, and how these factors impact environmental degradation differently.

Recent Approaches to Studying Cross-National Variation in Consumption

A growing body of empirical work in the social sciences specifically addresses structural and relational factors that explain varying cross-national levels of total and per capita consumption of all natural resources in the contemporary world-economy. This comprehensive approach to material consumption and its environmental impacts focuses both analytically and empirically on the ecological footprints of given populations (e.g., Andersson and Lindroth 2001; Jorgenson 2003a; Jorgenson and Burns 2004; Proops et al. 1999; Rothman 1998; York, Rosa and Dietz 2003; Wackernagel and Rees 1996; Wackernagel et al. 2000). Recently, Mathis Wackernagel and associates (2000) calculated national-level ecological footprints (both total and per capita) for the majority of nations in the world. These footprints consist of the area of cropland required to produce the crops consumed, the area of grazing land required to produce the animal products, the area of forest required to produce the wood and paper, the area of sea required to produce the marine fish and seafood, the area of land required to accommodate housing and infrastructure, and the area of forest that would be required to absorb the carbon dioxide emissions resulting from the unit's energy consumption (Wackernagel et al. 2000). Footprints are measured in area units where one footprint equals one hectare.[2] The footprint method captures indirect effects of consumption that are difficult to measure because this approach does not require knowing specifically what each consumed resource is used for (Wackernagel et al. 2000).

Recently, social scientists modeled and tested the effects of population, affluence, and other factors on *total national-level ecological footprints* (York, Rosa and Dietz 2001, 2003). Their results indicate that population and affluence by themselves account for 95% of the variance in total national footprints. The argument set forth is a blending of neo-Malthusian and political-economic perspectives, whereby total consumption is primarily a function of population size and growth, but the impact of population is higher in more developed countries (York, Rosa and Dietz 2003). York et al.'s analysis provides robust evidence of the impacts of total population and economic development (i.e., affluence) on total consumption of natural resources.[3] They include a logarithmic form that controls for the potentially non-linear effect of population size and find that the effect is relatively close to proportional.[4] Moreover, countries with relatively larger percentages of domestic populations between the ages of 15 and 65, and higher percentages of urban populations possess larger total footprints. An additional strength of their analysis is the incorporation of polynomial models (e.g., x_1 and x_1^2) to test for nonmonotonic effects[5] of per capita GDP and urbanization on total footprints of nations. York et al. suggest that anthropogenic impacts on the environment are not directly the result of world-systemic dynamics, but rather generated by more basic material conditions that may be mediated by international political-economic processes (York, Rosa and Dietz 2003, 294). However, the structure of their research design does not address potential intervening mechanisms or interactions between domestic processes and world-economic factors (see Burns, Kick and Davis 2003; Burns, Kentor and Jorgenson 2003; Jorgenson and Burns 2004; Jorgenson and Kick 2003; Kentor 2001; Kick et al. 1996).

Using an ecostructural world-systems approach, Jorgenson (2003a) analyzes the structural causes of per capita ecological footprints. Ecostructuralism represents a recent attempt to give the environment a more prominent positioning in sociological studies, particularly those that address environmental outcomes as being a function of social structural factors[6] (Grant, Jones and Bergesen 2002). In the study, Jorgenson (2003a) models world-system position as an exogenous variable while domestic income inequality, urbanization, and literacy rates are endogenous variables that partly mediate the effects of world-system position on per capita footprints. Strengths of the analyses include the testing of direct, indirect, and total effects of predictor variables. However, potential non-linear processes or interaction effects are not addressed empirically with the exception of a descriptive analysis of the distribution of per capita footprints within zones of the world-economy.

Jorgenson's (2003a) findings indicate that a country's level of per capita consumption is largely a function of its relative position in the international stratification system. Overall, core countries consume at the highest levels, followed by semiperipheral and peripheral countries. Furthermore, countries with relatively higher levels of urbanization and literacy rates consume resources at much higher per capita levels, and countries with relatively lower levels of domestic income inequality experience elevated levels of per capita consumption (Jorgenson 2003a). The three latter factors are partly a function of relative position in the world-economy.

On average, core regions contain more productive economies and articulated markets while peripheral and semiperipheral regions generally contain more extractive oriented economies and disarticulated markets[7] (Boswell and Chase-Dunn 2000; Bunker 1985). Unprocessed, natural resources are generally exported from more extractive peripheral economies to productive core economies where they are either consumed in their natural form or transformed through industrial material production into commodities. These commodities generally remain in the same regions that contain articulated markets, or are transported to other core regions where — due to domestic levels of development and relative position in the world-economy — consumption levels are relatively high as well. On average, non-core countries with extractive economies are rather highly dependent on a small number of primary exports, most notably agricultural products and other natural resources (e.g., Burns, Kentor and Jorgenson 2003; Jorgenson 2003a, 2003b, 2004; Tucker 2002). The complicated processes of underdevelopment, emerging dependent industrialization,[8] and economic stagnation limit the domestic levels of natural resource consumption in foreign capital dependent[9] nations. This is further exacerbated by the classically dependent, extractive characteristics of many non-core countries (Bunker 1985; Hornborg 2001, 2003; Jorgenson 2003a).

Populations in core nations have relative economic advantages when compared to non-core countries, which enable them to acquire and consume natural resources and produced commodities at higher levels (Burns et al. 2001; Hornborg 2001, 2003; Jorgenson 2003a). Moreover, core nations possess relatively greater military size, strength, and international political dominance, which increase their abilities to maintain and reproduce unequal trade relations with less-powerful countries, and overall military size as well as continual research and development elevate both total and per capita consumption levels (Broswimmer 2002; Bunker 1985; Chase-Dunn 1998; Chase-Dunn and Hall 1997; Dycus 1996; Jorgenson 2003a; Kentor 2000).

Within countries possessing higher levels of income inequality a relatively higher proportion of a nation's annual income is accounted for by the top 10 or 20% of the domestic population (e.g., Beer 1999; Beer and Boswell 2002). Non-core countries with higher levels of intra-inequality also tend to possess characteristics of disarticulated extractive economies (Bunker 1985). Thus, these regions possess relatively lower per capita consumption levels since on average: 1) the majority of the population has substantially lower income levels and 2) the domestic market focuses on the exportation of raw materials and commodities produced by means of dependent industrialization (Beer and Boswell 2002; Evans 1979; Jorgenson 2003a).

Generally, higher levels of literacy correspond with higher incomes, which increase the opportunities for greater material consumption (Jorgenson 2003a). More literate populations are also subjected to increased consumerist ideologies and contextual images of "the good life" (Princen 2002) through mass media, primarily advertising, which corresponds with what many social scientists label the "cultural ideology of consumerism/consumption" (Clapp 2002, 161; Sklair 2001).

Many core nations with higher levels of urbanization contain productive economies of scale that favor large and integrated economic enterprises and a spatial concentration of economic and industrial activities (Bornschier and Chase-Dunn 1985; Bunker 1985; Jorgenson 2003a). Biospheric resources are consumed at higher levels in core urban regions through: 1) modern industrial processes of commodity production and 2) corresponding domestic articulated consumer markets (Jorgenson 2003a). These areas, some of which fit the criteria of global cities, are key markets for material goods that require bio-productive elements in their production (e.g., Alderson and Beckfield 2004; Chase-Dunn and Jorgenson 2003b; Jorgenson 2003a; Sassen 1991). Furthermore, most urban areas possess relatively higher literacy rates than agrarian regions. On average, educational institutions are more developed and accessible in urban areas, and higher literacy rates are a characteristic of the managerial sectors and specialized labor populations nested within urban regions of core countries in the world-economy (Bornschier and Chase-Dunn 1985).

Urbanization processes in less developed countries vary substantially from urban regions in more developed core nations. Foreign capital dependence accelerates rates of urbanization in many peripheral nations, but only certain sectors of the domestic urban economy experience relative growth: the informal and tertiary sectors (e.g., Evans and Timberlake 1980; Kentor 1981; Timberlake and Kentor 1983; Smith 1996, 2000, 2003). Moreover, this effect of investment dependency is accompanied by its inhibition of growth in the industrial labor sector and often results in overurbanization[10] (Kentor 1981, 202; Timberlake and Kentor 1983).

Many urbanized regions in less-developed peripheral countries are largely characterized by their relative increases in outdated manufacturing sectors that are exported from more developed cities of core nations (Grimes and Kentor 2003; Smith 1996). This is coupled with their increased roles as nodes in the exportation of natural resources from regional extractive economies (Bunker 1985; Smith 1996). These urbanized areas generally do not experience significant increases in the size of labor pools for manufacturing relative to the tertiary and informal sectors. Manufacturing employment may increase, but it remains inadequate to absorb the burgeoning urban populations (Burns et al. 1994; Firebaugh 1976; Kick et al. 1996; Smith 1996, 2000).

Various major cities in less developed peripheral countries experienced domestic changes resulting from regional economic crises and the restructuring of the world-economy in the 1980s (Portes, Dore-Cabral and Landolt 1997; Smith 2000). Furthermore, this led to a major shift in the roles many of these cities play in the global economy. More specifically, this shift is largely a function of the movement from import substitution industrialization (ISI) to export oriented development (EOD) and reduced government intervention (Portes, Dore-Cabral and Landolt 1997; Smith 2000). These structural changes dramatically impacted levels of urban inequality, poverty, the structure of informal sectors, and spatial/residential polarization (Portes, Dore-Cabral and Landolt 1997; Smith 1996).

Overall, slowed rates of economic development and increased levels of domestic inequality in overurbanized regions of less developed countries limits relative levels of domestic per capita consumption of natural resources. This is further exacerbated by the common shift to export oriented development coupled with the continual role as nodes for the exportation of natural resources from regional extractive economies to core nations in the world-economy. These complexities of uneven urbanization and environmental degradation are unaccounted for in other cross-national studies of natural resource consumption (e.g., Jorgenson 2003a; York, Rosa and Dietz 2003).

While it is difficult to track, consumption in core nations is a significant cause of environmental degradation in other zones of the contemporary world-economy. This becomes increasingly pronounced over time as less developed countries increase domestic production of manufactured goods and agricultural products, and extract natural resources for consumption in other parts of the world, particularly the core (e.g., Bunker 1985, 1996, 2003; Burns, Kentor and Jorgenson 2003; Burns et al. 2001, 12; Frey 2003; Grimes 1999; Hornborg 1998, 2001, 2003; Jorgenson 2003a, 2004; Jorgenson and Burns 2004; York and Rosa 2003). Countries with the lowest levels of per capita consumption experience the highest rates of deforestation, organic water pollution, and increasing levels of carbon dioxide emissions per capita (e.g., Jorgenson 2003a, 2003b; see also Burns, Kick and Davis 2003; Grimes and Kentor 2003; Jorgenson and Burns 2004; Roberts, Grimes and Manale 2003). These various environmental outcomes have disastrous consequences for local human populations as well as the biosphere, including relatively high infant mortality levels and violence (for examples see Burns, Kentor and Jorgenson 2003; Frey 2003; Homer-Dixon 1999; Jorgenson 2004; Jorgenson and Burns 2004).

Many macrosociologists argue that political-economic and other social domestic conditions exist and operate differently in core, semiperipheral, and peripheral regions of the modern world-system (e.g., Arrighi 1994; Boswell and Chase-Dunn 2000; Chase-Dunn 1998, 2002; Chase-Dunn and Hall 1997; Chase-Dunn and Jorgenson 2003a, 2004; Evans 1995; Kentor 2000; Smith 2003; Wallerstein 1974). These differences suggest that standard linear analyses are inadequate for studying international outcomes, including uneven environmental conditions. In this article, I provide results of a series of exploratory analyses that address potential interaction effects in the contemporary world-economy to gain a clearer picture of what factors in which zones of the world-system contribute the most to varying levels of per capita consumption of natural resources. These analyses move beyond the general relationships identified by Jorgenson's (2003a) work, providing a deeper understanding of how certain factors and processes impact consumption differently among tiers of the contemporary world-economy.

Methodological Approaches to Studying Uneven Outcomes and Interaction Effects

A growing community of social scientists working in a "greener" world-systems perspective identifies numerous examples of non-linear relationships and processes. Many studies find that particular environmental outcomes resemble a curvilinear-type of distribution in terms of world-system position. For example, Burns et al. (1994) and Kick et al. (1996) discover that deforestation was most severe in semiperipheral countries during previous decades, while in a more recent analysis Burns, Kick, and Davis (2003) find that deforestation rates increased substantially in the periphery relative to other areas during the last decade of the 20th century. At least two separate studies (Roberts and Grimes 1997; Roberts, Grimes and Manale 2003) discovered a similar relationship between world-system position and carbon dioxide emissions intensity (CO_2 emitted per unit of GDP) in which these emissions are most pronounced in middle-tier countries. Furthermore, Burns, Davis, and Kick (1997) find that total levels of methane emissions are highest in "semi-core" countries, roughly corresponding to a curvilinear distribution across the international stratification system. Given fundamental assumptions of world-systems perspectives concerning the heterogeneity among core, semiperipheral, and peripheral regions coupled with their asymmetrical relational ties, these non-linearities are not all that surprising (e.g., Arrighi 1994; Arrighi and Drangel 1986; Chase-Dunn 1998; Chase-Dunn and Hall 1997; Chase-Dunn and Jorgenson 2003a, 2004; Kentor 2000; Wallerstein 1974; see also Evans 1979, 1995).

A common methodological approach to testing for non-linearities or non-monotonic relationships involves polynomial models composed of the quadratic for a given variable (e.g., x_1^2) in addition to its original form (e.g., x_1) while controlling for other relevant predictors[11] (see Allison 1999, 153-158; Vogt 1998, 179; Weisberg 1985). In curvilinear or inverted "U" shaped distributions, a characteristic feature is that as x_1 increases, y first increases, until it reaches a maximum, and then decreases in which the effect of x_1^2 on y is negative. This is also commonly referred to as a Kuznet's curve, and often analyzed cross-nationally by social scientists studying environmental outcomes from world-systems and similar political-economic perspectives (e.g., Ehrhardt-Martinez, Crenshaw and Jenkins 2002; Roberts and Grimes 1997; Roberts, Grimes and Manale 2003; Shi 2003; York, Rosa and Dietz 2003).

A second method involves the construction and application of relevant dummy variables to analogous studies (e.g., Ehrhardt-Martinez, Crenshaw and Jenkins 2002). If applied correctly, this method could be more useful for some analyses than the application of a quadratic polynomial. For example, unlike the latter, dummy variables may not impose any particular pattern on the relationship between the independent and dependent variables, and the numerical results might be somewhat simpler to interpret (see Allison 1999). However, dummy variables only distinguish varying intercepts between categories, which limits their overall explanatory power.

Another option for researchers working in world-systems or similar traditions is to test models for cases falling in different zones or regions separately. Yet, issues of data availability and sample size are some of the most central limitations of quantitative cross-national studies, and the parceling out into within-zone or regional series of cases only exacerbates these problems (see Jorgenson and Burns 2004; Tilly 1984).

These methods indicate whether there is a curvilinear relationship, non-monotonic relationship, or the outcome variable differs among zones. However, by themselves they do not empirically specify how relevant causal processes and factors *operate* differently within or among zones or regions and how this ultimately impacts variation in whatever outcome is being studied. Recently, Burns, Kick, and Davis (2003), and Kick et al. (1996) applied a more sophisticated and appropriate method for the identification and testing of interacting causal processes to cross-national analyses of deforestation. This method of interaction effects, sometimes referred to as slope-dummies, allows for the examination of potential heterogeneity of slopes among tiers or zones of the world-economy. Use of this method allows for the testing of main effects and possible interactive effects between discrete and continuous variables. Rather than simply addressing curvilinear distributions of dependent variables in terms of level of economic development or world-system position, this method allows for the analysis of how structural factors and/or processes interact differently with world-economy position, and how these differences may impact environmental outcomes.

A slope-dummy variable is a type of interaction term created by multiplying a continuous measurement variable (e.g., x_1 = literacy rate) by a dichotomous dummy variable (e.g., x_2 = semiperiphery), which creates a new variable (e.g., literacy rate * semiperiphery = x_1x_2). The newly constructed variable x_1x_2 has the values of x_1 for all cases for which the dummy variable (i.e., x_2) is coded as "1" and "0" for all the remaining cases (see Burns, Kick and Davis 2003; Hamilton 1992, 88-92). This approach is somewhat different than those most common in social scientific studies that generally construct interaction terms between two categorical and/or discrete variables (e.g., gender and ethnicity).

One test for heterogeneity of slopes using this approach consists of entering into a regression model the original main effect of interest (e.g., literacy rate), and the (k-l) slope-dummy variables created from this main effect and relevant dichotomous variables (see Hamilton 1992, 88-92). A significant coefficient for any slope-dummy variable in this type of analysis indicates that the slope for that particular category/group differs significantly from the excluded category/group (Burns, Kick and Davis 2003; Hamilton 1992).

Anqing Shi (2003) applies this approach to an analysis of the effects of population pressure on carbon dioxide emissions. Noteworthy strengths of this study include the analysis of pooled cross-national data that covers two decades and the modeling of fixed-effects to represent country-specific and year-specific intercepts. Shi constructs slope-dummy interaction terms for low, lower-middle, and upper-middle income countries that test for the heterogeneity of slopes among these groupings for the effects of population on total emissions. High-income countries are treated as the omitted category. Results specify that the impact of population pressure on emissions is most pronounced in lower-middle income countries, followed by low-income countries, upper-middle income countries, and high-income countries (Shi

2003, 38-39). While Shi controls for manufacturing and services as a percentage of total GDP and country-specific fixed effects, other relevant predictors identified in recent studies are missing from the analysis. These include accumulated stocks of foreign direct investment and military spending as percentage of total GDP (Grimes and Kentor 2003; Roberts, Grimes and Manale 2003).

In order to empirically identify the couplings of a country's relative position in the world-economy to the substantive regressors in a more fully specified model that includes relevant controls, one must extend their analysis to include slope-dummies for *all categories* or dichotomous variables (rather than k-1) as well as other independent variables of interest (Burns, Kick and Davis 2003). This involves the creation of a series of independent variables in which the original measurement variable (e.g., literacy rate) is split into separate regressors (e.g., core literacy, semiperiphery literacy, periphery literacy). Thus, the original predictor (e.g., literacy rates) is not controlled for in this type of model because all categories are included. A finding of statistical significance for a slope-dummy in a model with this design simply indicates the likelihood of obtaining a coefficient of that magnitude by chance (Burns, Kick and Davis 2003, 368). It does not indicate that the slopes for two different categories (e.g., core and periphery) for the given measurement variable (e.g., literacy rate) are statistically different as is the case in the technique described above (i.e., k-1). Moreover, the coefficients associated with these slope-dummy variables quantify the relative contribution of the independent variable within that tier or category to explaining variation in the dependent variable, while controlling for other independent variables in the tested model (Burns, Kick and Davis 2003, 368; see also Hamilton 1992).

I apply this method to a series of analyses of the structural causes of per capita ecological footprints. I draw from prior cross-national studies, particularly Jorgenson's (2003a) analysis of per capita ecological footprints and Burns, Kick, and Davis' (2003) application of slope-dummies to an analysis of deforestation. I test for the heterogeneity of slopes among the interactions of world-system zones and continuous predictor variables identified by Jorgenson (2003a). This approach incorporates a more accurate and relevant coupling of measurement and theory for world-systems and other similarly oriented analyses, especially for studying uneven impacts of the world-economy on environmental outcomes, in this case consumption measured as ecological footprints (Burns, Kick and Davis 2003; Kick et al. 1996). Specifically, this allows for the testing of the couplings of core, semiperipheral, high peripheral, and low peripheral countries compared to one another, which enables researchers to test the extent to which varying patterns and structural features within each zone impact levels of per capita consumption differently. Through this type of analysis a more thorough picture is provided of the possible interactions between various structural conditions and world-system zones, and their possible effects on environmental outcomes.

Methodology

Country Sample

The sample used includes countries for which data were available on all or some of the independent and dependent variables at the time the study was conducted. For the variables of interest I found at least partial data for 208 countries. The numbers of valid cases for each variable are given in Appendix B. Actual sample sizes for each variable range from 95 to 201 cases. This is a rather common limitation in quantitative cross-national research.

Variables Included in the Analyses

I include the same variables used by Jorgenson (2003a) with the addition of slope-dummies which I calculate using the particular method described below. This allows for direct comparisons to Jorgenson's (2003a) linear analyses of direct, indirect, and total effects. The dependent variable of consumption is measured as the ecological footprint per capita for 1996. These data are taken from Wackernagel et al. (2000).

Jeffrey Kentor's measure of world-system position (2000) is used due to its theoretical significance and level of sophistication (see also Chase-Dunn 1998, 2002). Kentor's index combines relevant attributes and relational characteristics of world-system position as one standardized, continuous measure.[12] His initial multidimensional measure of world-system position includes level of capital intensiveness, production size, trade size, global capital control, military expenditures, military exports, global military control, export commodity concentration, foreign capital dependence, and military dependence. Using these data, he creates national-level index scores that measure relative position in the modern world-system. Because of problems with availability for some of these measures for non-core nations, Kentor constructs a surrogate measure of position in the world-economy to increase the sample size for cross-national comparisons. Total GDP, GDP per capita, and military expenditures are included in the new measure, which correlates with the original index at .99 while substantially increasing the sample size for this indicator. Hence, the surrogate measure is applied to the current analyses. Use of this indicator allows for the theoretically and empirically multidimensional characteristics of relative position in the core/periphery hierarchy to be accounted for in one variable (Chase-Dunn 1998, 2002).

The gini index, which measures domestic income inequality, is included as the second predictor variable[13] (World Bank 1999). The third predictor variable is level of urbanization for 1992, which represents the midyear percent of a nation's total population residing in urban regions (World Bank 2000). The fourth predictor variable is literacy rates, referring to the percent of a nation's population over the age of 15 that can read and write a short, simple statement about their everyday life (World Bank 2000). These data are for the year 1994, and are transformed from illiteracy into literacy rates by subtracting the initial values from one hundred.

To empirically explore the possibility of heterogeneity of slopes among four constructed tiers in the world-system (i.e., core, semiperiphery, high periphery, low periphery), I construct slope-dummy variables for the interaction between each zone and 1) domestic income inequality (gini coefficients), 2) urbanization, and 3) literacy rates. I begin with Kentor's continuous measure (2000) of world-system position and create "boundaries" between each zone that are relatively consistent with previous studies (e.g., Kick 1987; Nemeth and Smith 1985; Snyder and Kick 1979). Through this process I transform Kentor's continuous variable into a categorical scale consisting of four rank-ordered categories of world-system position (i.e., core, semiperiphery, high periphery, low periphery).[14] This categorical variable is changed into a series of dummy-variables for each category of world-system position. I create slope-dummy interaction terms by multiplying each dummy-variable by the continuous variables discussed above. Descriptive statistics and correlations for all variables included in the analyses are provided in Appendix B.

Model Estimation Procedures

Consistent with Burns, Kick, and Davis (2003), I focus on more fully specified "contextual analyses" in which a series of models are tested with each consisting of one set of slope-dummy variables while controlling for the other original predictors.[15] While Jorgenson (2003a) addressed direct, indirect, and total effects, the current study focuses on main and interaction effects using the application of maximum likelihood estimation (MLE) and AMOS software (Arbuckle and Wothke 1999; Byrne 2001). MLE is gaining momentum as a more useful approach to dealing with missing data, an endemic problem in cross-national, quantitative research. Many argue that a maximum likelihood estimation of missing data is preferable to the other, more common methods of addressing the missing value problem — most notably listwise and pairwise deletion in OLS regression[16] — because it provides more consistent and less biased results than either of those methods (Arbuckle 1996; Byrne 2001; Eliason 1993; Kaplan 2000; Weisberg 1985; see also Burns, Kentor and Jorgenson 2003; Jorgenson 2003a; Jorgenson and Burns 2004; Kentor 2001). Standard maximum likelihood estimates (Std. M.L.E.), maximum likelihood estimates (M.L.E.), standard errors (S.E.), and critical ratios (C.R.) are provided for each analysis.

Results and Discussion[17]

In the analysis reported in Table 1, I model and test the direct effects of Jorgenson's (2003a) original four predictors on per capita footprints. Results replicate those of Jorgenson's (2003a) in that world-system position, urbanization, and literacy rates all have positive and statistically significant effects on per capita consumption while domestic income inequality has a negative, statistically significant effect.[18] More importantly, this model provides a benchmark for the analyses that follow. Comparing findings of the contextual effects analyses of slope-dummies to Jorgenson's (2003a) linear direct effects analysis allows for evaluation of the former method in terms of its methodological utility and overall contribution to better understanding complex dynamics of the contemporary world-economy.

Table 1. Main Effects Model.[a]

	Std. M.L.E.	M.L.E.	S.E.	C.R.
World-System Position	.32***	.33	.061	5.384
Domestic Inequality	-.27***	-.06	.012	-5.373
Urbanization	.47***	.05	.006	7.612
Literacy Rate	.13*	.01	.007	1.870
R-square	.77			

[a]Dependent Variable = Ecological Footprint per capita 1996
*p < .10 **p < .05 ***p < .01

Table 2 reports findings for the first of three contextual effects models. In this analysis I include slope-dummies that quantify the interaction between the four world-system categories and domestic income inequality while controlling for urbanization, literacy rates, and world-system position.

In the fully controlled model I find that the effects of world-system position, urbanization, and literacy rates are consistent with those reported in the main effects model (see Table 1). Turning to the slope-dummies for domestic inequality, I discover that the effect of income inequality on per capita consumption is not linear as suggested by our main effects model or initially theorized and empirically specified by Jorgenson (2003a). Rather, the effect of inequality on consumption in the core is positive and barely significant, while the effect is negative in the three other zones, non-significant for the semiperiphery and low periphery and significant for the high periphery. Even though tolerance levels and variance inflation factors (for the unreported listwise analysis) indicate no problems of instability due to multicollinear-

Table 2. Contextual Effects Model 1: Slope-Dummies for Domestic Inequality.[a]

	Std. M.L.E.	M.L.E.	S.E.	C.R.	Std. M.L.E.	M.L.E.	S.E.	C.R.
World-System Position	.18**	.20	.098	2.063				
Urbanization	.55***	.05	.006	8.875	.54***	.05	.006	8.438
Literacy Rate	.17**	.02	.007	2.237	.23***	.02	.007	3.237
Core Domestic Inequality	.13*	.03	.018	1.914	.23***	.05	.013	4.329
Semi-P Domestic Inequality	-.08	-.02	.014	-1.544	-.07	-.02	.014	-1.304
High-P Domestic Inequality	-.10**	-.02	.009	-2.048	-.11**	-.02	.009	-2.157
Low-P Domestic Inequality	-.06	-.01	.009	-1.116	-.06	-.01	.009	-1.242
R-square	.70				.68			

[a]Dependent Variable = Ecological Footprint per capita 1996
*p < .10 **p < .05 ***p < .01

ity, I run an analysis while excluding world-system position due to its high correlation with the core slope-dummy. Upon doing so I find the same general outcomes as the more fully specified model with the only notable exception being the increased positive (and more significant) effect of inequality in the core on per capita footprints. Thus, the more specified model is valid.

To determine the extent to which this new finding is influenced by the United States, I reran the analysis excluding this case in the sample. This is done largely due to the United States' hegemonic position in the world-economy, high level of per capita footprints, and relatively high level of intra-inequality relative to other more developed, core countries (see Chase-Dunn and Jorgenson forthcoming; Chase-Dunn et al. 2002). Results are provided in Appendix C. The effect of core domestic inequality on consumption remains positive but non-significant in the more fully specified model and positive and statistically significant when excluding world-system position as a control variable. Tolerance levels and variance inflation factors (for the unreported listwise analysis) indicate that the more specified model is stable and not impacted by multicollinearity. Hence, the negative effect of income inequality in the core is largely influenced by domestic conditions in the United States.

The positive effect of domestic income inequality in the core and the negative effects in the other three tiers are partly attributed to: 1) relatively higher levels of economic well-being and consumption of the domestic lower-class in the U.S. compared to domestic lower classes in other nations, 2) structural properties of global production, and 3) the relationship between foreign capital dependence, production, and domestic inequality in non-core regions of the world-economy. Previous research shows that both total and per capita consumption are generally higher in more economically developed core regions, most notably the United States (see Clapp 2002; Conca 2002; Jorgenson 2003a; Tucker 2002; Wackernagel et al. 2000; York, Rosa and Dietz 2003). Even with the relatively high level of domestic income inequality in many core nations — especially the United States — segments of the domestic population with lower levels of income still consume at relatively higher levels than the lower classes in other countries. More simply, the material well-being and quality of life of the lower classes in the core is substantially higher than lower classes in the semiperiphery and periphery (e.g., Bradshaw and Wallace 1996; Burns, Kentor and Jorgenson 2003; Chase-Dunn 1998; Jorgenson and Burns 2004).

Global production is largely characterized by processes of raw materials, agricultural products, and mass-produced commodities being transferred from non-core regions to core nations for further production, intra-core redistribution, and domestic consumption (e.g., Bunker 1985, 2003; Burns, Kentor and Jorgenson 2003; Frey 2003; Jorgenson 2003a; Jorgenson and Burns 2004). Non-core nations are also largely dependent on foreign capital penetration, which increases domestic levels of income inequality (Beer 1999; Beer and Boswell 2002; Bornschier 2002; Bornschier and Chase-Dunn 1985; Kentor 2001). The environmentally unfriendly production facilities associated with this foreign investment generally produce goods for core consumption and possibly the small elite segment of the host economy (Beer and Boswell 2002; Grimes and Kentor 2003). Yet, most of these goods are exported for articulated markets in core regions and marketed towards broader segments of the population.

Both upper and lower classes in core countries consume at relatively higher levels than lower classes in non-core nations. This is partly attributed to their wider access to commodified goods and forms of credit, which further increases their levels of conspicuous consumption (see Clapp 2002; Manning 2000; Sklair 2001).

Table 3 provides results for the contextual effects analysis of slope-dummies for the interaction between world-system tier and urbanization while controlling for domestic income inequality, literacy rates, and world-system position. Like the main effects model in Table 1, world-system posi-

Table 3. Contextual Effects Model 2: Slope-Dummies for Urbanization.[a]

	Std. M.L.E.	M.L.E.	S.E.	C.R.	Std. M.L.E.	M.L.E.	S.E.	C.R.
World-System Position	.20**	.21	.094	2.261				
Domestic Inequality	-.26***	-.06	.015	-4.005	-.21***	-.05	.016	-2.893
Literacy Rate	.32***	.03	.007	4.244	.42***	.04	.006	6.347
Core Urbanization	.33***	.03	.007	4.970	.36***	.04	.007	5.580
Semi-P Urbanization	.19***	.02	.007	3.394	.17***	.02	.007	2.912
High-P Urbanization	.14**	.02	.006	2.480	.10*	.01	.006	1.751
Low-P Urbanization	-.007	-.01	.011	-0.123	-.05	-.01	.012	-0.798
R-square	.66				.61			

[a]Dependent Variable = Ecological Footprint per capita 1996
*p < .10 **p < .05 ***p < .01

tion and literacy rates both have significant positive effects on per capita footprints while domestic inequality's effect is negative and significant. Upon examination of the interaction between world-system zone and urbanization, I discover that the impact of urbanization on per capita consumption is greatest in the core, followed by the semiperiphery, high periphery, and low periphery. The effect of the interaction between low periphery and urbanization is non-significant. Like the previous model, I run this analysis with and without world-system position to determine if the relatively high correlation between the slope-dummy for the core and world-system position creates problems due to multicollinearity. Given the minimal differences between the two models, I conclude that the more fully specified model is valid.

The striking differences among slopes of the four zones strongly support uneven urbanization hypotheses (e.g., Chase-Dunn and Jorgenson 2003b; Evans 2002; Evans and Timberlake 1980; Kentor 1981; Portes, Dore-Cabral and Landolt 1997; Smith 1996, 2000, 2003). Core nations with higher levels of urbanization contain productive economies of scale that favor large and integrated economic enterprises and a spatial concentration of economic and industrial activities (Jorgenson 2003a; see also Bornschier and Chase-Dunn 1985; Bunker 1985). Bioproductive resources are consumed at higher levels in core urban regions through: 1) modern industrial processes of commodity production, 2) corresponding domestic articulated consumer markets, and 3) the overall built urban infrastructure. These areas, some of which fit the criteria of global cities, are key markets for material goods that require bio-productive elements in their production (Chase-Dunn and Jorgenson 2003b; Sassen 1991). In general, the most powerful, highest consuming cities are nested within core countries of the world-economy (Alderson and Beckfield 2004; Smith 1996, 2000, 2003; Smith and Timberlake 2001).

Urbanized areas in semiperipheral and high peripheral nations experience slowed rates of economic development, increased levels of domestic inequality, and increased focus on export oriented production (e.g., Kentor 1981; Portes, Dore-Cabral and Landolt 1997; Smith 2003). These conditions limit domestic levels of per capita consumption of natural resources. To further exacerbate concomitant ecological impacts, non-core urban regions are largely dependent on foreign investment, which generally takes the form of unregulated, highly polluting, and non-energy efficient production industries (e.g., Grimes and Kentor 2003; Roberts, Grimes and Manale 2003). Thus, these regions will most likely experience heightened levels of environmental degradation through a combination of an expanded built environment and the dirty manufacturing of export goods for core consumption. Urbanized areas in more peripheral nations are centers for exports of natural resources from regional extractive economies (e.g., Bunker 1985).

Like the previous contextual effects analysis, heterogeneity of slopes for the interactions between urbanization and world-system position are unaccounted for in simpler linear models. Current findings suggest that environmental impacts of urbanization do interact with world-system zones. These critically important interaction effects are only identified through the analysis of slope-dummies. Furthermore, the application of more traditional methods (i.e., quadratic polynomials) is often less effective in identifying these complex relationships.

In the third and final contextual effects analysis, I include slope-dummies for the interaction between world-system position and literacy rates while controlling for domestic income inequality, urbanization, and world-system position. Effects of the three controls are all significant and consistent with the previous models. Table 4 provides results with and without world-system position as a control variable for analogous reasons as the preceding series of analyses.

Findings indicate that all world-system position specific slopes for literacy rates are non-significant. These results are consistent in both models. It warrants noting that in all pre-

Table 4. Contextual Effects Model 3: Slope-Dummies for Literacy Rates.[a]

	Std. M.L.E.	M.L.E.	S.E.	C.R.	Std. M.L.E.	M.L.E.	S.E.	C.R.
World-System Position	.40***	.46	.077	5.998				
Domestic Inequality	-.26***	-.06	.013	-04.621	-.23***	-.05	.016	-03.468
Urbanization	.55***	.06	.006	10.091	.70***	.07	.006	12.522
Core Literacy Rate	-.06	-.01	.010	-00.995	.06	.01	.010	1.119
Semi-P Literacy Rate	-.008	-.01	.006	-00.175	-.04	-.01	.006	-00.725
High-P Literacy Rate	.000	.000	.004	-00.003	-.08	-.01	.005	-01.420
Low-P Literacy Rate	.005	.01	.006	.094	-.06	-.01	.007	-01.143
R-square	.76	.66						

[a]Dependent Variable = Ecological Footprint per capita 1996
*p < .10 **p < .05 ***p < .01

vious models and Jorgenson's (2003a) analyses the overall effect (treated as a linear effect) is positive and statistically significant. Unlike the prior series of contextual effects analyses, I determine that the impact of literacy rates on per capita footprints is not unique in any particular zone of the world-economy. Rather, the overall effect of literacy rates is somewhat linear in a more general sense. In sum, the impact of literacy on per capita footprints is not unique in any particular zone of the world-economy, especially when controlling for other relevant factors.

Conclusion

Political-economic processes and domestic conditions exist and operate differently in core, semiperipheral, and peripheral regions of the world-economy. These differences certainly suggest that their environmental impacts are likely to vary in form and intensity among zones of the global system. This study builds primarily on Jorgenson's (2003a) cross-national analysis of per capita ecological footprints, and Burns, Kick, and Davis' (2003) application of slope-dummies to a study of deforestation. Slope-dummy interaction terms provide an exceptional wedding of methods and world-systems approaches to human-environment interactions (Burns, Kick and Davis 2003; Kick et al. 1996). Construction and analyses of slope-dummy interaction terms improves social scientists' abilities to empirically identify the complexities of uneven impacts of political-economic and other factors on environmental outcomes.

Findings of this study improve our understanding of how certain structural factors and processes impacting per capita consumption of natural resources operate differently among zones in the contemporary world-economy. Through the construction and testing of contextual effects of slope-dummies for interactions between world-system zones and urbanization, domestic income inequality, and literacy rates, I discover that the impact of these predictors on per capita ecological footprints do vary among world-system zones with the exception of literacy rates. Domestic income inequality in the core positively affects per capita ecological footprints, while the effects of interactions between the remaining zones and intra-inequality are negative. The positive effect in the core is largely attributed to conspicuous consumption of all domestic groups in the United States; the effect becomes non-significant when the United States is excluded from the analysis. This finding certainly warrants further inquiry beyond the scope of the present study.

The impact of urbanization on per capita consumption is more pronounced in the core, followed by the semiperiphery, high periphery, and low periphery. Uneven urbanization processes and export oriented development in semiperipheral and peripheral nations limit relative levels of domestic consumption of natural resources. Like Jorgenson (2003a), I find that the overall effect of literacy rates on per capita footprints is positive and does not vary in intensity among tiers of the world-system. The heterogeneity of slopes identified in these analyses clearly illustrates the empirical and theoretical utility of slope-dummy interaction terms in cross-national studies of environmental degradation.

Missing data for certain variables could limit the present study. However, the analyses reported here employ maximum likelihood estimation. This approach is a more effective method for dealing with missing values (e.g., Arbuckle 1996; Burns, Kentor and Jorgenson 2003a; Jorgenson 2003, 2004; Jorgenson and Burns 2004; Kentor 2001). Moreover, unreported findings from analyses employing listwise deletion are very consistent with those presented here, adding further validity to the results.

Uneven levels of natural resource consumption are certainly a global problem impacting all living species. Most human societies consume natural resources at per capita levels higher than the biosphere can support. The next step in this critical research agenda involves the construction and analysis of trade-connected indicators between countries with relatively low per capita footprints and their trading partners to test the extent to which various forms of environmental degradation (e.g., deforestation, organic water pollution, carbon dioxide emissions) are a function of exports being sent to countries with relatively higher per capita footprints. This would allow researchers to test the extent to which more powerful, higher consuming countries externalize their concomitant ecological costs to less-powerful countries that generally consume at or below the global bio-capacity per capita (see Jorgenson 2003a; Jorgenson and Burns 2004; Wackernagel et al. 2000).

Endnotes

1. E-mail: jorgensonandrew@hotmail.com
2. One hectare is the equivalent of approximately 2.47 acres.
3. York, Rosa, and Dietz's empirical indicator for world-system position consists of an index that quantifies "official development assistance and official assistance" (2003, 209). This does not include other economic, political, and military dimensions associated with relative position in the world-economy, and per capita GDP is not considered to be an explicit attribute of a country's world-system position (see Kentor 2000; Chase-Dunn 1998; Jorgenson 2003a). However, their findings provide robust evidence of the impacts of population dynamics and economic development on the total consumption of natural resources by nations in the contemporary world-economy.
4. The author gratefully thanks a reviewer for pointing out a discrepancy in the interpretation of York, Rosa and Dietz's (2003) analysis in an earlier draft of this article.
5. Nonmonotonic effects refer to a relation in which increases or decreases in one variable are always accompanied by increases or decreases in another, but the changes are not uniform. The direction of change is always the same, but the rate of change increases or decreases (Vogt 1998).
6. Schnaiberg (1980), Schnaiberg and Gould (1994), O'Connor (1998), Foster (1999a, 1999b, 2002), and others have also been pivotal in stimulating discourse and research on the environmental impacts of political-economic processes.
7. Disarticulated economies depend on external markets while articulated economies are able to focus on internal, domestic markets (Bunker 1985).
8. Dependent industrialization refers to industrial development resulting from foreign capital dependence in less developed countries that focuses on the production of goods via cheap labor and less efficient, dirty production practices for the exportation to more developed core countries.
9. Foreign capital dependence refers to the accumulation of stocks of foreign direct investment within a less developed host country that comprises a significant amount of the host country's total gross domestic product.
10. Overurbanization usually refers to an excessive growth of a region's urban population relative to its economic growth, usually represented by the size of the industrial labor force (Kentor 1981; Smith 1996).
11. Quadratics are generally centered by subtracting the mean of the variable and then squared to reduce multicollinearity (e.g., York, Rosa and Dietz 2003).
12. The correlation between per capita GDP and Kentor's measure of world-system position (both for 1990) is approximately .58. For a more in-depth discussion of the methodology involved in the construction of this indicator, see chapter four in Kentor (2000).
13. A gini index score of zero equals perfect equality while an index score of 100 suggests perfect inequality (World Bank 1999).
14. With Kentor's (2000) world-system position classification, China and Russia are identified as core countries. This is largely a function of the size of their economies, populations, and militaries. Both countries have relatively lower per capita levels of economic development than other core nations, and many would argue that both are semiperipheral countries. However, as discussed in note 17, reported analyses are not influenced by influential cases. See Appendix A for a list of countries in each "zone" of the world-economy.
15. Due to severe multicollinearity, a valid analysis is not possible that includes all 12 slope-dummy variables (see Burns, Kick and Davis 2003; Hamilton 1992).
16. Pairwise and listwise deletion are more conservative approaches that generally reduce the sample size. Often, this involves the exclusion of partial data for non-core nations, which could bias empirical analyses. MLE includes all available data, which potentially leads to other possible concerns (e.g., largely reliant on probability), but it generally aids in creating a relatively more representative analysis that better reflects cross-national and world-systemic processes. MLE is also argued to be more appropriate for these types of analyses because missing values are "missing at random" rather than "missing completely at random" (Arbuckle 1996, 245).
17. Like others (e.g., Jorgenson 2003a; Jorgenson and Burns 2004), I run all models in additional analyses using listwise deletion and OLS regression. Results are almost identical to those presented in this article, which further validates the reported findings.
18. I test for influential cases using Cook's Distance which yields the same results as Jorgenson's (2003a) study — findings of the main effects model are not influenced by outliers. However, I run each contextual effects analysis with and without the United States and discuss findings if they deviate from those for corresponding analyses that include the United States in the sample.

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Appendix A

CORE
United States
Russia
Japan
China
Germany
France
United Kingdom
Italy
Canada
Switzerland
Netherlands
Sweden
Australia
Denmark
Belgium
Austria
Norway
Finland
Spain

SEMIPERIPHERY
Saudi Arabia
New Zealand
Korea, Rep.
Brazil
India
Portugal
Greece
Israel
Czech Republic
Venezuela
Trinidad and Tobago
Poland
Argentina
Mexico

HIGH PERIPHERY
Kuwait
Oman
Hungary
Chile
Yugoslavia
Turkey
Indonesia
Malaysia
Thailand
Colombia
Syrian Arab Rep.
Uruguay
Romania
South Africa
Botswana
Iraq
Philippines
Peru
Panama
Algeria
Tunisia
Ecuador
Jordan
Sri Lanka
Egypt
Pakistan
Morocco
Gabon
Paraguay
Dem. Rep. of Congo

LOW PERIPHERY
Guatemala
Dominican Rep.
El Salvador
Nigeria
Bolivia
Zimbabwe
Cameroon
Honduras
Nicaragua
Sudan
Bangladesh
Cote d'Ivoire
Senegal
Kenya
Myanmar
Uganda
Haiti
Lesotho
Mozambique
Liberia
Zambia
Angola
Togo
Tanzania
Burkina Faso
Rep. of Congo
Ethiopia
Mali
Chad

Appendix B

Correlation Matrix and Descriptive Statistics

	1.	2.	3.	4.
Ecological Footprint per capita 1996				
World-System Position 1990	.67			
Domestic Inequality	-.46	-.24		
Urbanization 1992	.75	.42	-.26	
Literacy Rate 1994	.58	.40	-.06	.58

	N	Mean	S.D.	Skewness	Kurtosis
Ecological Footprint per capita 1996	147	2.96	2.45	1.33	1.34
World-System Position 1990	95	-00.005	2.50	4.19	23.77
Domestic Inequality	96	39.76	10.47	0.35	-00.87
Urbanization 1992	201	51.73	23.92	0.14	-00.94
Literacy Rate 1994	131	72.69	22.82	-0.65	-00.78

Appendix C

Contextual Effects Model 1: Slope-Dummies for Domestic Inequality (Excluding United States)[a]

	Std. M.L.E.	S.E.	Std. M.L.E.	S.E.
World-System Position	.06	.178		
Urbanization	.57***	.006	.59***	.006
Literacy Rate	.19***	.007	.21***	.007
Core Domestic Inequality	.15	.024	.19***	.013
Semi-P Domestic Inequality	-.07	.014	-.07	.014
High-P Domestic Inequality	-.11**	.008	-.11**	.008
Low-P Domestic Inequality	-.07	.009	-.07	.009
R-square	.68		.68	

[a]Dependent Variable = Ecological Footprint per capita 1996
*p < .10 **p < .05 ***p < .01