Disaggregating the Ecological Footprint: The Effects of Intensive and Extensive Processes in the Capitalist World-System

Abstract:

Previous research has indicated that certain components of the Ecological Footprint are largely a function of the position in the international stratification system. This paper posits that the causal factors of the components of the Ecological Footprint will vary based on whether they are related to intensive or extensive processes. World-System position is argued to be related closely to the concentration of "core processes" which tend to rely more on intensifying the rate of production through technological advances. In this way, energy intensive production processes will be associated with position in the capitalist World-System. With respect to carbon dioxide emissions, we would expect a close relationship between the carbon dioxide Ecological Footprint and World-System position. With respect to other components of the Ecological Footprint such as Built-up Land and Fuelwood, we would expect more extensive factors such as Gross Domestic Product and population to be more closely associated with these components of the Ecological Footprint. Components such as Built-up Land and Fuelwood are not as reliant on core, intensive processes, but extensive factors such as the amount of wealth necessary for expansion or the number of people utilizing environmental resources. The results of the analysis in this paper tend to support these hypotheses.

Theoretical Backdrop

To understand the anthropogenic effects of people's interaction with nature, it is first necessary to conceptualize how people's interaction with the environment is organized. Karl Marx (1971; Marx 1973; Marx 1977; Marx 1981a; Marx 1981b; Marx 1998) discussed at length this exact problematic in both his early and later works. For Marx, society was organized through the necessary metabolic interaction with the environment. In order to meet their needs, people must obtain the necessary elements from nature through the use of their labor. The process of obtaining these necessary elements from nature through labor is metabolic interaction. The very creation of society in its primitive origins resulted from the necessary interchange with the environment to obtain and create the means essential for survival. The social nature of people is a result of the organization of relationships between people to meet their daily needs, based on the given environmental circumstances. The interaction with nature is part of the dialectical relationship between social organization and the material-environmental circumstances. Environmental conditions shape the social organization, and the act of obtaining and creating the means to life through a specific, historic social organization alters the given environmental conditions. Neither aspect remains static as both social organization and material- environmental circumstances transform as a result of the dialectical interchange.

Capitalism is the contemporary social organization dictating the form of our relationship with nature. Capitalism is a form of social arrangement based on capital accumulation, primarily through wage labor, that orders the extraction, production and distribution of the means of life through a metabolic interaction with nature. Like any other social organization, capitalism must take natural elements and transform them into the means necessary for life, in other words engage in a metabolic interaction with nature. Marx argued that the inherently expansionary capitalist production process necessitates an ever increasing use of nature's elements. "The more capitalist production is developed, bringing with it greater means for a sudden and uninterrupted increase in the portion of the constant capital that consists of machinery, etc., and the more rapid the accumulation (particularly in times of prosperity), the greater is the relative overproduction of machinery and other fixed capital, the more frequent the relative overproduction of plant and animal raw materials" (Marx 1981b:214). To deal with the natural limits of nature's productions, capitalists are left with three possible solutions: extract raw materials from greater distances, expand production of the raw material on a greater scale, and replace the natural elements with surrogates or more economical use of waste products (Marx 1981b:213-4). In this way, “The natural materials which are exploited productively (and which do not form an element of capital's value) i.e. soil, sea, mineral ores, forests, etc. may be more or less severely exploited, in extent and intensity, by greater exertion of the same amount of labor-power, without an increase in the money capital advanced” (Marx 1981a:431).

Thus, the metabolic interaction Marx described can be understood to have extensive and intensive components. The way people organize the extraction of elements from nature for people's needs assumes historically specific geographic (extensive) and temporal (intensive) dimensions. Geographic, extensive, means that capitalism expands the amount of nature's elements extracted to meet the ever increasing drive for accumulation. To meet the needs of accumulation, ever greater regions and materials are brought under capitalist production. New fields are incorporated into agricultural production, more mine shafts are dug, more forests are cleared, etc. Simply put, production is expanded.

Similarly, capitalist production attempts to increase the intensity of the metabolism with the environment (the speed at which nature's elements can be extracted and transformed) by altering the social relations and technology of production. Marx discussed natural processes such as wine fermentation and the ripening of food plants. Little labor is necessary for the natural processes to occur, but the capital must lie idle while the processes take place. Capitalists seek to shorten these natural processes to limit the idle time of their capital (Marx 1981a:316-8). "The turnover period can often be shortened to a greater or lesser extent by the artificial shortening of the production time. Examples of this are the introduction of the chemical in place of open-air bleaching, and more effective drying apparatus in the drying processes" (Marx 1981a:317). In short, production is intensified.

The extensive and intensive needs of capital for ever increasing expansion lead to "an irreparable rift in the interdependent process of social metabolism, a metabolism prescribed by the natural laws of life itself" (Marx 1981b:949). See also Foster (Foster 1997; Foster 1999; Foster 2000; Foster 2002) for a deeper discussion of Marx's concept of metabolic rift. The metabolic rift, both extensive and intensive (defined below) results from the accumulation logic of capital that necessitates ever greater expansion of profit, and subsequently the use of nature. The extensive rift results from the geographic expansion of the metabolic interaction due to the increasing demands of capital to bring ever more of nature under production and the further division of town and country. As more of nature is involved in capitalist production, the distance between extraction and consumption grows, nature is depleted in one region while waste is concentrated in another. Metabolic cycles are disrupted as nutrients and resources extracted from one area are not returned, but are deposited in another distant geographic region, often as waste.

Marx specifically outlined the extensive rift as the division of town and country and the problem of capitalist agriculture (Marx 1977:637-8; Marx 1981b:195, 949-50). The concentration of people in cities and the agricultural production in rural areas "disturbs the metabolic interaction between [people] and the earth, i.e. it prevents the return to the soil of its constituent elements consumed by [people] in the form of food and clothing; hence it hinders the operation of eternal natural condition for the lasting fertility of the soil (Marx 1977:637). The expansion of capitalist production reaches out further and further geographically for the elements necessary for production, while the end products are concentrated in the regions of accumulation where the natural elements are not returned to their origin. Not only are the elements not returned, they may become waste in the area where their consumption occurs. Marx states, "In London, for example, they can do nothing better with the excrement produced by 4 million people than pollute the Thames with it, at monstrous expense" (Marx 1981b: 195). By creating this extensive rift, the natural metabolic cycles are broken as the elements are not reentered into the cycle.

The intensive rift results from the increasing speed of the use of nature's elements in the capitalist production process. Capitalists attempt to increase their profits by reducing the amount of time necessary for the production of their products through the intensification of the use of nature in the production process. The intensification of the use of nature disrupts natural metabolic processes by destabilizing the relationships within natural processes. The resulting rift is the disproportionate depletion of nature's elements and concentration of waste, at the point of extraction, from the intensification of the metabolic interaction with nature.

The intensive rift is slightly different in that it results from increasing the rate of the productions of nature. Natural processes are quickened and intensified, creating disturbances in natural cycles. The disturbance in natural cycles is the intensive metabolic rift. The most notable example of the intensive rift is the disruption of global climate as a result of the anthropogenic production of CO_2 from burning fossil fuels. CO_2 is naturally produced by volcanic venting, decomposition of organic matter, forest fires, etc. but is also removed from the atmosphere and oceans through a number of interrelated processes (Lovelock 2000; Smil 1997). The use of fossil fuels has enabled capitalism to greatly increase the rate of production and accumulation, but at a potentially high cost. The CO_2 that could be released by the burning of all accessible fossil fuels is ten times greater than exists currently in the atmosphere (Weart 2004). Instead of using the available solar radiation and biomass, fossil fuels are used as a form of stored sunshine, intensifying the energy available for use in capitalist society. By producing anthropogenic CO_2 levels out of step with natural climatic processes, fossil fuel use produces an intensive metabolic rift exhibited by the disrupted climate. Because of the complexity of the natural climatic processes, the long term effects of industrial CO_2 production are difficult to perceive, but it appears as though climatic change as a result of anthropogenic CO_2 emissions is a well established fact in the scientific community (Hunter 2002; Vitousek 1994; Weart 2003).

The intensive and extensive metabolic rifts are linked, and can be found in the same production process as a result of their common origin in the expansionary accumulation logic of capital. Capital intensive agriculture provides an example of both an intensive and extensive metabolic rift. The division of town and country and the removal of nutrients from the soil to a distant location where it is concentrated as waste represent the extensive rift. With the intensive rift, the application of intensive agricultural production techniques to increase yield and profit result in an imbalance of soil chemistry, beyond the overall depletion of the soil. While providing certain nutrients such as nitrogen, capitalist agriculture depletes others, reducing the long-lasting fertility of the soil due the imbalance created in the soil chemistry.

While it may appear that technology is responsible for the metabolic rift, it is the accumulation logic of capitalism that is specifically responsible. The accumulation logic of capital demands that technology is put toward uses that increase profit and are inherently expansionary, necessitating ever greater and more intense use of nature. "Capitalism maximizes the throughput of raw materials and energy because the greater this flow–from extraction through the delivery of the final product to the consumer–the greater the chance of generating profits" (Foster 1994). Potentially, societies organized under a logic that is not inherently expansionary could employ technology in a fashion that does not lead to a metabolic rift.

The metabolic interaction with nature is arranged globally through a capitalist world-economy of socio-economic-political relationships. Since Marx's (1970; Marx 1977; 1981a; 1981b) discussion of the world-economy, Immanuel Wallerstein (1974; 1983; 2004) has developed a theoretical perspective to analyze the operation of the capitalist world-economy. Through the world-systems perspective, the truly global interaction of the environment and society can be theorized and tested. Although there are competing explanations for the operation of the capitalist world-economy (Lenin 1975; Magdoff 1969; Magdoff 1978), this research will focus on Wallerstein's perspective.

The Ecological Footprint and World-Economy Position

While a number of self-explanatory measures of ecological impact such as deforestation and CO_2 emissions are used by researchers, another measure of ecological impact, Ecological Footprint, requires some description before discussing research where it is used. The Ecological Footprint is a measure of ecological impact based on the natural resources or "bioproductive capacity" of the planet consumed by people as a result of their activities. The measure accounts for the resource consumption and waste assimilation necessary for a given population in terms of the land area (hectares) necessary to support the population. The components of the Ecological Footprint measure the area of land needed for: growing crops for food, animal feed, fiber, oil and rubber; grazing animals for meat, hides, wool, and milk; harvesting timber for wood, fiber, and fuel; marine and freshwater fishing; accommodating infrastructure for housing, transportation, industrial production, and hydro-electric power; and burning fossil fuel (Wackernagel and Rees 1996:9-10; Wackernagel et al. 2002b:9266). What is so unique about the Ecological Footprint measure is that it is able to attribute the ecological impact of the components it addresses to the nation (or other population unit) that consumes the resources. The Ecological Footprint "accounts for the flows of energy and matter to and from any defined economy and converts these into the corresponding land/water area required from nature to support these flows" (Wackernagel and Rees 1996:3). In this way, the Ecological Footprint accounts for the imports to a nation while it subtracts the exports from the nation's Ecological Footprint. This technique gives a more accurate accounting of the actual ecological impact of the nation in question because it attributes the ecological impact to the consuming nation regardless of the origin of the product or activity.

While the Ecological Footprint measure is relatively new, its use is growing quickly to analyze the impact of the world-economy position on the Ecological Footprint.

Richard York, Eugene Rosa and Thomas Dietz (2003) set out to test the ability of various theories of the environment to predict Ecological Footprint. In addition to the theories of modernization, political economy, world-systems analysis and human ecology, the authors provide a parsimonious "STIRPAT" model. The STIRPAT (*ST*ochastic *I*mpacts by *R*egression on *P*opulation, *A*ffluence, and *T*echnology) model is a modification of the IPAT model in stochastic terms by the inclusion of an error term. In the model the authors use, technology is included in the error term and the variables are logged in order to create an elasticity model. The STIRPAT model includes the log of population and the log of GDP per capita. A quadratic STIRPAT also includes the quadratic of GDP per capita. The world-economy position is defined in this research based on the level of dependency indicated by official development assistance. Core nations are considered those that do not receive assistance. Semiperiphery nations are those nations that receive assistance less than .5 percent of their GDP. The periphery includes all nations not included in the other two categories. The authors found firm support for the STIRPAT model while the world-economy variables were non-significant in the analysis.

Andrew Jorgenson (2003) focuses specifically on the world-economy position and the Ecological Footprint. Using structural equation modeling, Jorgenson assesses the connection between Ecological Footprint per capita and world-economy position as defined by Kentor (2000) and three mediating variables: income inequality (GINI), percent of total urban population, and literacy rate. Jorgenson (2003) argues that his hypotheses are supported. World-economy position is found to have a positive effect on per capita footprints due to the more productive economies and articulated markets. The GINI measure is negatively related to Ecological Footprint, argued to be a result of the lower consumption of low wage workers in the periphery. The results also supported the argument that urbanization is positively related to Ecological Footprint because cities are viewed as key markets and concentrated areas of economic and industrial activities. The author's assertion that literacy is related to responsiveness to consumerist ideologies is also supported. Jorgenson (2003) estimates a second model that includes GDP per capita. GDP per capita, world-economy position and all of the mediating variables remain significant except literacy rate. Jorgenson (2003) concludes that “per capita footprints are largely a function of a country's position in the core/periphery hierarchy of the world-system”, but his model adds GDP per capita and does not test for the effects of GDP per capita absent of his world-economy position variable.

DATA AND METHODS

Operationalization of World-Economy Position

Beginning with the basic theoretical concepts outlined by Wallerstein, it is possible to develop an operationalization in firm theoretical grounding. Wallerstein begins with an axial division of labor that is comprised of an occupational hierarchy of core and periphery processes. The distribution of core and periphery processes is organized geographically through the processes of unequal exchange, which drains surplus value from the periphery to the core, perpetuating the relationships. Strong states are integral to the geographic distribution of core processes in specific regions of the world-economy and the ability to limit certain regions of the world-economy to peripheral processes. The historical development of the capitalist world-economy did not occur instantaneously, but proceeded over time through the process of incorporation. Incorporation has both an extensive component with respect to the actual geographic inclusion of regions in the capitalist relational processes and an intensive component regarding the intensification of the inequality in the capitalist relational processes.

Developing empirical indicators of the axial division of labor is very difficult. A number of authors attempt to address Wallerstein's conceptual contribution of core and peripheral processes, but they tend to focus on products. Wallerstein has provided such definitions of core and periphery processes that include high wage, high technology, quasi monopolies, etc., but very little global data deals with these specific issues. While some data exist on wages from the World Bank WDI database (World Bank 2001), a number of cases are missing including Australia, Canada, Germany, Netherlands, United States and United Kingdom.

Tracking the indicators of unequal exchange is equally as difficult. Defining unequal exchange itself has proved difficult empirically, while the actual data is elusive. For Wallerstein, the focus on unequal exchange is the flow of surplus value from the periphery to the core. It could be argued that nations are exhibiting the negative effects of unequal exchange when the value of their imports exceeds the value of their exports, but there are two problems with this view. First, core and semiperiphery nations are able to maintain trade imbalances over the short-run while maintaining their relative position in the world-economy. Second, the importance is specifically focused on the inequality of exchanges and not the actual monetary amount of the nation's total trade. A peripheral region may maintain a relative trade balance in monetary units while the peripheral region consistently loses surplus value in the transactions due unequal exchange. Part of the definition of core processes is quasi-monopoly status, but defining commodity classifications with respect to quasi-monopoly status would be time consuming and possibly fraught with classification errors.

Some authors have attempted to include political power in their operationalizations of world-economy position. Unfortunately, many of these attempts have focused on the military aspect of state strength. Government expenditures on military, military imports or exports, military or political conflict and indicators of repressiveness of the government are examples of indicators used by previous researchers. Wallerstein's focus, however, is on the preservation and promotion of quasi-monopolies. While military tactics are admittedly part of the process of protecting quasi-monopoly status of core processes, it is not the only or most important method. Economic dominance and control of international political decision-making bodies are also others, with broader application to more nations at the same time.

Incorporation is another possible means to define position in the capitalist world-economy. While Wallerstein argues geographic (extensive) incorporation was effectively completed by the beginning of the twentieth century (Wallerstein 1976:351), intensive incorporation continues. The relations between the regions of the world-economy deepen. While incorporation could be measured by the expansion of capitalist accumulation in the core and the official colonial incorporation into the world-economy of colonial territories, intensive incorporation could also be viewed as a relative integration in the capitalist relations of the world-economy.

While nations and regions were incorporated into the capitalist world-economy at different times, their specific environmental and historical trajectories determined the degree to which they became ensnared in the unequal relations between core and periphery processes in the axial division of labor. While timing in the incorporation of the world-economy is important, the development of core and peripheral processes within a nation, articulated with strong and weak state relations, helps to determine the degree to which nations are incorporated in the world-economy. While a historical analysis of each nation's incorporation into the world-economy would be helpful to understand how a nation was incorporated, as well as its present position in the unequal relations in the axial division of labor, it is not easily undertaken. Another possibility which has been undertaken in various ways by other authors is an attempt to locate nations' positions in the world-economy through the network of world trade.

Terence Hopkins cautions against singling out trade as the form of the relationship between the core and the periphery (Hopkins 1982:152).

“Accordingly, to let the relation which 'core-and-periphery' designates slip into the background is to let the labor process as it operates on a world scale slip into the background as well. One place in particular where this sort of slippage seems to occur frequently is in discussion of 'trade' between 'core' and 'periphery'. With the latter pair as classificatory terms, we say, 'Here's a core-country and here's a periphery-country; now, how are they related? Why, through 'trade'.' And with that, a set of activities and interactions we call 'trade' ceases to be just one of many ways in which the interrelations linking the partial-production-operations formative of 'cores' and those formative of 'peripheries' are actualized, in given times and places. And instead 'trade' (almost invariably as 'market trade') becomes the form of the relationship between the core and the periphery.”

Hopkins offers strong caution against the reduction of the world-economy to trade relations, but it may be possible to situate trade in unequal exchange of core and peripheral processes. Perhaps just as core states and peripheral states can be used as a shorthand for core and peripheral processes at the nation state level, trade can be used as a shorthand for world-economy relations as long as the inequitable nature of the relations is retained and the researcher refrains from positing trade as the world-economy relation and the defining feature of the world-economy. While using trade relations as an indicator, it must be acknowledged that they do not represent the sole relationship of the world-economy, but act as a proxy for the relations of unequal exchange between core and peripheral processes. World trade as represented by total imports and/or exports can possibly describe the relations of unequal exchange and the relative position of nations in those relationships if the relative strength of each nation in the world-economy is accounted for in a network of world-economic relations. No single measure can capture completely the historical operation of the capitalist world-economy, but it may be possible to develop a parsimonious indicator that may act as a proxy for world-economy relations in broad cross-national research.

While world trade as expressed as imports or exports has been used by World-Systems analysts, few tend to use more than mere ties between nations with respect to trade. Breaking from authors who use simple ties, Tieting Su (2002) conducts a network analysis of world trade data to determine the structure of the world-economy over time. To construct a trade network, Su adds imports to exports. Su then calculates, for each nation, the proportion of its total trade that is exchanged between each other nation. In this way, Su argues that a high percentage of trade with one nation may indicate a nation's dependence on its trading partner. Su then constructs a matrix for network analysis including only ties where trade levels are 10% or greater for all of the years of the study. The author uses network analysis specifically to determine the composition of trade blocks in four separate years: 1928, 1938, 1960 and 1999. While Su's analysis appears to confirm the author's hypothesis that the world-economy consists of waves of trade interdependence and trade fragmentation, Su's technique points to a promising indicator of world-economy position.

Although Su's analysis is "designed to fathom trade structures" (Su 2002:360), it is possible to use a similar technique to construct an indicator of world-economy position. One measure, centrality, is especially useful for this type of analysis. The centrality measure in network analysis counts the number of ties between "actors" in the network and can be viewed as a measure of inequality between trading partners in the world-economy. "It is based on this theoretical and empirical ground that centrality is used to identify major trading partners" (Su 2002:360). Trade centrality can be understood as a measure of the centrality of a nation in the relations of unequal exchange between core and periphery processes described by Wallerstein. The more central a nation is in the network of relations in the world-economy, the more likely the nation is dominated by core processes and using this advantage through unequal exchange to better its position in the capitalist world-economy. More central nations are deepening their intensive incorporation into the relations of the world-economy to further benefit from unequal exchange. While mere centrality of ties may indicate the connectedness of a nation within the network, the relative trading strength of each nation adds another crucial dimension. The command of trade flows, both import and export, represent the historical development of the world-economy into gaining zones and losing zones (Wallerstein 1983:32). Large trade flows could be understood to represent both the ability to gain through unequal exchange through the amount of trade, but also the rewards accumulated to a nation through the unequal exchange of core and peripheral processes. The processes of the operation of unequal exchange in the world-economy are inextricably linked to the outcomes. Unlike GDP, however, a measure of trade centrality including trading strength is more than a simple measure of economic outcome. While the extensive nature of incorporation was effectively completed in the early 20th century, trade centrality captures two elements of the intensive nature of the world-system. Increasing trade ties and the expanding disparity of the volume of world trade both demonstrate the intensification of relations of unequal exchange within the world-economy. While there will be some expected correlation with other measures of economic strength such as GDP, the combined nature of trade strength and trade ties provides a measure that captures, with simple data and methods, both the sheer size of an economy and the centrality of the nation within the capitalist world-economy.

Because of the applicability and the parsimony of its design, trade centrality will be used as a measure of position in the world-economy in this dissertation. Network analysis has been used by a number of world-systems analysts, especially in the case of block modeling (Kick 1987; Smith and White 1992; Steiber 1979). Block modeling techniques as constructed by previous authors tended to include a variety of variables rather than a single indicator. The trade network for this dissertation will be comprised solely of import data from 1999 in the International Monetary Fund's (IMF) Direction of Trade Statistics (DOTS) (International Monetary Fund 2000). Imports and exports representing the trade between nations in millions of US dollars are listed for each included nations. Total volume of trade, imports and exports, is necessary to represent the combined trade role played in the relations of unequal exchange in the world-economy. Unfortunately, import and export data are compiled differently and are not necessarily equivalent because of inconsistencies in data collection. Export data is calculated as "free on board" (f.o.b.) while import data is "cost including insurance and freight" (c.i.f.). The data collection contains a number of inconsistencies including: differences in the classification concepts and detail, when the data is recorded, the valuation of the goods, processing errors and issues of coverage such as free trade zones. Nemeth and Smith (1985) also suggest the use of import data due to the greater accuracy of import figures. For these reasons, the construction of the trade centrality focuses solely on import data. IMF DOTS import data is entered in matrix form listing imports on the vertical axis while the horizontal axis would, technically, indicate exports to the importing nation. The import matrix is used to calculate a sum of both imports and a measure of exports by transposing the import matrix and adding the transposed matrix (exports) to the import matrix. I have used this combined import-export matrix in favor of a simple import or export matrix because it gives a more complex picture of a nation's trading relationships. It may be possible to use an asymmetrical matrix that could provide a measure of indegree and outdegree (imports and exports), but focusing only on imports or exports would provide significantly different results. Some nations are strong exporters like China, but it is not nearly as strong as an importer as other similar nations. Others like Poland and the US import more than they export. Depending on the conceptualization, the different patterns will develop in the measures. Focusing on imports as a measure of consumer power gives one measure, while a focus on exports, productive capacity or dependence, would give another measure. Conceptually, I combined the imports and exports to create a single, combined measure of power in the world economy.

Nations are included in the matrix for use in the network analysis if the IMF DOTS provided trade data for a specific nation. If the IMF did not provide a complete trade account for a specific nation, it is deleted from the analysis even if several nations reported trade with the nation. As a result, nine nations (Afghanistan, Botswana, Eritrea, Laos, Lesotho, Mongolia, Namibia, Nepal, North Korea) are missing compared to the dependent variables' data sets, Ecological Footprint (defined below).

The IMF DOTS trade matrix is imported into the UCINET 6 network program (Borgatti, Everett and Freeeman 2002) to create the network centrality variable. Since the data is transposed and added to itself (described above), the resulting matrix is symmetrical. The value of combined imports and exports is retained in the matrix. UCINET 6 is used to calculate Freeman's Degree Centrality with the IMF DOTS trade matrix. The resulting variable will be referred to as World-Economy Centrality (W-E Centrality). Freeman's Degree Centrality measures the number of ties for each actor with others in the network (Hanneman 2001:61). Since the data contains a monetary value for trade between nations, Freeman's Degree Centrality sums the values of all the ties for each actor in the network (Borgatti, Everett and Freeeman 1992:82). Therefore, not only are the number of connections important, but the relative importance (import/export trade volume) of trading partners increases the value of the actor's centrality measure. In general, nations whose trade is low in volume with other nations will have lower centrality scores than nations that have high trade volumes with their trading partners.

Returning to world-systems analysis, nations with numerous trade ties have greater opportunity for profiting from unequal exchange, and the total volume of trade as a result of the ties indicates the success of a nation as a “gaining zone.” Although a significant amount of intercore trade accounts for sizeable portions of trade volume, the fundamental relationship of inequality holds with nations relying primarily on peripheral processes, and their low volume of trade value and few ties can be understood as an indication of the subordinate role in the world-economy.

Other Variables Included in the Analysis

Prior to describing the remaining variables in the dissertation, a word must be said about the relationships between variables. Given the nature of the world-economy as a hierarchal network, the relationship between variables is assumed to be loglinear in nature. Moving from the periphery to the core, it is expected that economic indicators associated with the world-economy will increase exponentially. Consistent with the World-Economy Centrality measure and other economic indicators, it is argued that environmental impact, including Ecological

Footprint, will also follow this pattern. Logging the W-E Centrality and Ecological Footprint variables will also normalize distributions to meet the assumptions of regression analysis.

In addition to the world-economy position variables, a number of other variables are relevant to the analysis. Since environmental impact is being measured, some control variables need to be added that may have effects on the dependent variable. First, the assumption of the IPAT model suggests that population contributes to environmental degradation. York et al. (2003) support the idea of population as a significant contributor to environmental impact. The more people a nation has, the greater the ecological impact. Land area operates as a control variable to account for the possibility that the more land area that exists to be degraded within a nation, the greater the potential environmental impact. Greater population densities from limited land area will also tend to have greater environmental impact. Therefore, population and land area, as provided by the Living Planet Report (Wackernagel et al. 2002a), shall both be included.

Another variable that must be included in the analysis is GDP. While many world-systems researchers have used GDP in the operationalization of world-economy position (Arrighi and Drangel 1986; Kentor 2000; Roberts, Grimes and Manale 2003), others have looked at the impacts of GDP on environmental impact (Burns et al. 1994; Jorgenson 2003; Jorgenson, Rice and Crowe 2005). While some authors contend GDP does have an effect, York et al. (2003) argue GDP is one of the most salient. Below, the role of the size of an economy, GDP, and world-economy position are explained. It will be argued that GDP and World- Economy Centrality have different effects on environmental degradation.

The Integration of Theory and Method

Prior to outlining the dependent environmental variables used in this analysis, the theoretical roots of the contribution of world-economy position will be discussed. The world-systems literature is virtually silent when it comes to applying the theoretical contributions of Immanuel Wallerstein to the study of cross-national environmental impacts. Many researchers claim a world-systems perspective, but few root their analysis in Wallerstein's conceptualization when developing their hypotheses. This paper will attempt to develop an analysis of environmental impact based on a combination of Marx's metabolic interaction and Wallerstein's theoretical perspective.

While Marx discusses both people's metabolic interaction with nature and the metabolic rift, the nature of the dependent variables, the components of Ecological Footprint, do not allow for the direct testing of the metabolic rift. Only processes indicating an intensive or extensive metabolic interaction are present within the Ecological Footprint components. The ten components of the Ecological Footprint from the 2002 Living Planet Report (Wackernagel et al. 2002a) include: CO2 emissions, Nuclear Power, Hydro Power, Fuelwood and Charcoal, Forest excluding Fuelwood, Built-up Land, Water Withdrawls, Grazing Land, Fishing Grounds and Cropland. While the effects of the components of the Ecological Footprint can be linked to intensive and extensive metabolic rifts such as climate change or soil degradation, the variables themselves represent the intension and extension of people's metabolic interaction with nature, driven by the capitalist accumulation logic. In other words, CO2 emissions and Grazing Land do not represent the rift itself, but are the result of the capitalist accumulation logic and identify processes associated with the intensive and extensive metabolic interaction with nature. Since the Ecological Footprint components do not represent the rift, the terms "intensive process" and “extensive process” will be used to describe the processes associated with the intensive and extensive metabolic interaction.

As discussed above, the metabolic interaction has intensive and extensive components. The extensive metabolic interaction is geographic in nature and refers to the need to incorporate increasingly greater shares of nature in the capitalist production process. As a result of production under capitalism constantly increasing, the point of extraction of natural resources becomes divided from the point of consumption of those resources - the division of town and country.

The intensive metabolic interaction is specifically speeding up the natural processes to increase efficiency and decrease the amount of time necessary for production. Karl Marx acknowledged the pressures of capital to increase efficiency, specifically in terms of the use of waste in the production. “Marx (1981b:196-7) described the use of rags in the making of woolen garments and also the use of the byproducts of the chemical industry” (Prew 2003). But Marx also argued that it did not improve capital’s relation with nature. Capitalist production, “for all its stinginess, . . . make[s] it very wasteful of material resources, so that it loses for society what it gains for the individual capitalist” (Marx 1981b:180).

Marx (1981a:316-8) also argued capitalists seek to shorten the unfolding of natural processes such as chemical bleaching and other technological advances. Through the use of technological means, the intensive metabolic interaction means that natural processes are accelerated causing disruptions in natural metabolic cycles. By reducing the time necessary for natural processes, profit is increased because capital is idle for shorter periods of time and throughput is increased.

The extensive and intensive processes can be readily tied to Wallerstein's analysis of the capitalist world-economy. Wallerstein's begins his analysis with the axial division of labor rooted in the unequal exchange between core and periphery processes. The axial division of labor and unequal exchange is expanded and deepened through the process of incorporation. While extensive incorporation was effectively completed by the early 20th century, intensive incorporation continues to deepen the relations of unequal exchange. While at one pole, a gaining zone develops; at the other, grows a losing zone.

In the losing zone, poverty and inequality grow. Peasants and indigenous peoples are forced from productive land as it is incorporated into the capitalist production process through the ownership of wealthy landholders. Those forced from the land have two options: either move to less productive land and attempt to maintain a subsistence lifestyle or move to urban areas in an effort to gain employment. Neither option reduces poverty; rather, they tend to worsen it. The direct result of the increasing poverty and dislocation originating from unequal exchange is the expansion of an extensive metabolic interaction through the expanding use of natural resources, and subsequently increasing the distance between where the resources are extracted and where they are consumed. Extensive processes can be linked to the increasing poverty of the peripheral regions. People must travel farther for Fuelwood and graze animals on lands (Grazing Land) not suitable for food production. Increasing urbanization in the form of Built-up Land expands the division of town and country through the increasing reliance on rural agricultural production (Cropland) and other natural resource needs like lumber (Forest).

The extensive processes are furthered by another result of the operation of unequal exchange. In the capitalist world-economy, the operation of unequal exchange can be argued to lead to growing poverty and stunted economic growth in peripheral regions. As a result, the demographic transition to low birth rates has been delayed in peripheral regions. Most peripheral regions, while able to lower infant mortality in appreciable numbers, were unable to secure the economic standing necessary to lead to reduced birth rates. As a result, populations have grown rapidly in peripheral regions (Foster 1994:15-16). These two factors, poverty and high population growth rate, combine to intensify the extensive processes in the peripheries, such as the consumption of food in the form of fish, grazing land and cropland. The impact of extensive processes is worsened by the rate of population growth.

The environmental impact in the core is qualitatively different from in the periphery. While the operation of unequal exchange accumulates wealth in the gaining zone, environmental issues develop from both extensive and intensive processes. The metabolic interaction increases extensively from the increased economic resources as a result of unequal exchange. The accumulation logic, central to capitalism, spurs increasing consumer demand for the products of the capitalist production process. To meet the needs of capital accumulation and the relatively wealthy consumers of the core demands that more of nature is brought into production. Larger economies allow for greater consumption of natural resources in the form of commodities. As more people to move to cities, urban areas grow (Built-up Land), aided by industrialized agriculture (Cropland). Like in the periphery, the extensive processes such as Built-up Land, Cropland and Forestry are linked to the increase in wealth in the core.

While the operation of the capitalist world-economy produces similar results in the core and periphery with respect to extensive processes, intensive processes can be directly linked to the core processes described by Wallerstein. Core processes are in their nature intensive processes. Core processes, as high technology, quasi-monopolies, use production processes that intensify the use of nature, i.e. intensive processes. Core processes are dependent on increased energetic throughput created through fossil fuel burning, nuclear power or other forms of energy such as hydro-electric dams. By burning "stored sunshine," production processes in the core are able to access energy unavailable through the current bio-productivity of the earth, by some estimates, hundreds of times more than current bio-productivity (Dukes 2003). Fossil fuel use is one of the most significant means to intensify the throughput of production. As a result, CO_2 represents a means through which capital intensifies the metabolic interaction with nature. Nuclear and hydrological power are similar strategies to increase production intensively. Hydrological power, however, because of its dependence on available waterways, may be more closely related to sufficient land area to provide suitable locations for hydro-electric dams.

Compared to regions of the world with few core processes, especially in regions of great poverty, energetic needs are met with less technology and more natural resource consumption. Instead of intensifying the metabolic interaction, extensive processes are used to meet energetic needs in the periphery, burning forest as fuelwood for example. Consumption of high tech, core processes occurs primarily in the core due to the relatively wealthier consumers. Core processes are directly linked to intensive processes with respect to the metabolic interaction with nature. Therefore, the production of CO_2, an intensive process produced in regions with high technology quasi-monopolies, should be found to be a direct function of the role in the world-economy, more so than a measure of the sheer size of the economy such as GDP. The existence of quasi-monopolies and high technology not only allows for production from nature on a grander scale, it also allows the more intensive use of nature's products. The high technology, quasi-monopolies of core processes attempt to increase efficiency in terms of usable byproducts of production and shortening natural metabolic processes. In this way, greater efficiency actually intensifies the use of nature in the production of goods. Greater ability for throughput results in a greater overall use of nature due to the ever expanding accumulation logic of capital.

Water use is an environmental impact that should be closely associated with population, but water is not just used for drinking. Industrial processes use water in great quantities. The question of whether water use is an example of an extensive or intensive process depends on whether the water is drawn in one region to be consumed in another, such as distant reservoirs that feed large urban areas, or systematically depleted in order to increase the productive output, as in irrigation agriculture in semi-arid regions. Whether water use is more associated with extensive or intensive processes is unclear with respect to the Ecological Footprint measure of water withdrawls, which does not provide a clear distinction of water use.

While the operation of the capitalist world-economy can be theoretically linked to both population and national economic size, the environmental impacts resulting from the extensive processes may be more closely associated with population and economic size (GDP) than world-economy position itself. The operation of the capitalist world-economy may be antecedent to the development of large populations and economic power, but population and GDP would be expected to have more proximate effects on natural resource use associated with the extensive processes. Cropland use, fuelwood burning, forest consumption and built-up land can be more closely tied to the economic resources needed to consume the goods and the populations that put pressure on natural resources. Intensive processes differ from extensive processes since intensive processes are more directly connected to the operation of the capitalist world-economy, specifically the presence of core processes within a nation.

As a result of the operation of the capitalist world-economy, both extensive and intensive metabolic processes exist. Like population, greater economic production and consumption, indicated by GDP, are associated with extensive processes. What is unique about core processes are the specific intensive processes associated with the intensification of the use of nature's resources. The more core a nation, the greater the intensive processes such as CO2 production are found within that nation. Despite the fact that this paper uses nation states instead of specifically core/periphery processes, the use of nation state as "shorthand" for core should still demonstrate the relationship between core status and intensive processes.

The defining feature of the operationalization of world-economy position used in this paper is based on the degree of a nation's incorporation into the capitalist world-economy. The operationalization of world-economy position as trade centrality as an indicator of incorporation in the capitalist world-economy should be consistent with the presence of core processes within a nation. The concentration of core processes within a nation, protected and supported by a strong state, places a nation in an advantageous position in the axial division of labor within the capitalist world-economy. Nations that are not central actors in the capitalist world-economy will be less likely to be dominated by core processes. While Wallerstein argues semiperiphery nations are defined by a relatively even distribution of core and periphery processes, certain anomalous cases can be pointed out. Large geographic nations like the US contain within them peripheral processes, but a nation like Belgium may appear to be more core because it contains relatively less peripheral processes than the US. While certain anomalies exist, especially geographically smaller nations within Europe, the general principle of relatively even distribution of core and periphery processes still holds for most semiperipheries. Core nations will have greater total core processes, while the semiperiphery will have less and, in general, a relatively even distribution of core/periphery processes. The environmental impact of the semiperiphery should be less than the core but greater than the periphery which contains almost exclusively peripheral processes. Speaking more specifically, the world-economy position should be closely tied to intensive processes because of the more direct link between core processes and intensive processes. Extensive processes, while influenced by world-economy position, will be more closely linked to population and GDP.

The focus on total core processes compared to the relative distribution between core and periphery processes is an important theoretical point. Environmental impact, especially intensive, should be tied to the number of core processes within a nation state's boundary. The unique position in the world-economy given by the amount of core processes within a nation determines the specific form and degree of environmental impact of a nation. For the purposes of this dissertation, the totality of the characteristics of the nation state is important, not relative measures such as ratio of core to periphery processes or per capita influences. Like argued above, this is not to say that the ratio of core to periphery processes is not important, but the total amount of core processes takes precedence in this analysis because it focuses on nation state effects. Since the nation state is the focus of this analysis, the total environmental impact of the core processes contained within the nation is important, not relative measures such as per capita environmental impact.

Likewise, total economic power such as GDP is also important and used in this analysis. Nations vary in the inequality that exists within them, the populations that they must support and the land area available for demographic expansion. While some nations may be able to support larger populations due to land area (Brazil compared to Belgium for example), the relative wealth, as indicated by per capita GDP, is not as important as the total economic power of the nation in the world-economy[1]. China, while its per capita economic indicators may be lower

[1] GDP and GDP PC present a larger issue for me. While many researchers use GDP PC, I have significant reservations about its use. Specifically, what does it represent theoretically and empirically? It is could be

than less populous nations in Europe for example, has a greater impact in the world-economy by the sheer size of its economy and its more central location in the axial division of labor in the capitalist world-economy. Like centrality in the world-economy, the total economic wealth of a nation gives it sway in capitalist world-economy, not the relative wealth of its citizens as in per capita economic figures. While population has effects, they will be parsed out by including population as a control variable. The total impact of a nation's world-economy centrality and GDP on total environmental impact is the focus of this analysis.

This paper argues that the operation of the capitalist world-economy has direct effects, not only on generalized environmental impact, but also on the specific types of processes related to environmental impact. The operationalization of the world-economy, defined as World-Economy Centrality, will have direct effects on measures of environmental impact. Since the theory suggests environmental impact will vary regarding extensive and intensive processes, it is necessary to identify measures of environmental impact capable of making these distinctions. Fortunately, the Ecological Footprint measure can be disaggregated into various measures of ecological impact representing extensive and intensive processes. While GDP and population should be related to extensive processes such as build-up land, World-Economy Centrality should be more closely associated with intensive processes such as CO2 emissions.

Environmental Impact Variables

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understood to be economic strength or consuming buying power, but the list of nations tend to include widely different nations in close proximity, e.g. Slovenia and Portugal, United States and Norway, China and Jamaica. Does Jamaica truly play the same role in the world-economy as China?

Due to the nature of the variable, there is not a singular statement we can make to explain a nation's position within GDP PC. Some nations like the social democratic nations at the top are good at reducing inequality and providing for the needs of their population, while others simply have extremely large GDP's and a maldistribution of wealth like the US. Others have modest GDP's with a small population (Ireland). Others have large GDP's and large populations (China, India) that drop their GDP PC ranking. What does GDP PC represent specifically?

In order to test such theoretical assertions, it is necessary to identify an indicator of environmental impact. While a number of potential measures exist, few are as versatile as the Ecological Footprint. One environmental impact measure is based on assessing the share of net primary production (NPP) appropriated by societies. "NPP is the amount of energy left after subtracting the respiration of primary producers (mostly plants) from the total amount of energy (mostly solar) that is fixed biologically" (Vitousek et al. 1986). Societal metabolism tracks the flow of energy and material through a society (Fischer-Kowalski and Amann 2001). As described above, Ecological Footprint is a measure of the bio-productive land area necessary to support the consumption of a given population or political-economic unit. While other indicators measure the environmental impact of production activities, the Ecological Footprint specifically targets the amount of environmental impact associated with a specific nation's consumption. In other measures, the CO2 emissions, deforestation or energy use are attributed to the nation where such environmental impacts occur. Ecological Footprint, on the other hand, tracks the environmental impact of consumption within a particular political-economic unit, regardless of where the production occurs. If deforestation in Brazil occurs to produce pig iron consumed in the US, the Ecological Footprint from the deforestation is attributed to the US, not Brazil. Imports and exports are tracked in the measure to provide an account of only the environmental impact that can be attributed to the population of the state, regardless of where the environmental impact occurs. Neither NPP or societal metabolism allows for this type of tracking of environmental impact. The Ecological Footprint also has a readily available data set not provided by the other potential measures of environmental impact.

Other authors have previously used Ecological Footprint per capita (Jorgenson 2003; York, Rosa and Dietz 2003), others have broken down the Ecological Footprint into its various components to analyze the effect of the independent variables on the separate components (Jorgenson, Rice and Crowe 2005; Prew 2005). Jorgenson et al. (2005) broke down the Ecological Footprint measure into its components and tested the effectiveness of Kentor's (2000) World-System position indicator in predicting each component of the Ecological Footprint. This paper builds on Prew (2005) to include GDP to test the concepts presented in this paper that there are intensive and extensive processes in the Ecological Footprint. GDP may be more indicative of extensive processes, while W-E Centrality should be more predictive of intensive processes. Ecological Footprint measures are taken from Wackernagel (2002a) and transformed from per capita variables to national measures. To get the National Ecological Footprint measures, each separate component, as well as the total Ecological Footprint, are multiplied by the population figure within the Ecological Footprint data set. The natural log for each measure is also computed[2].

Since missing cases during logging occurs with two of the three energy variables, a new variable is created that added CO2 emissions to nuclear power and hydro-power. Jorgenson et al. (2005) also use a slightly different Energy variable that includes biomass in addition to carbon dioxide, nuclear power and hydro power. This new variable (CO2, Nuclear and Hydro) contains no "0" data points and is also logged.

Hypotheses

This paper attempts to address two interrelated hypotheses:

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[2] For some measures (fishing grounds, fuelwood, nuclear power and hydo-power), the data contains "0"s and required "1" to be added to all of the cases before taking the logarithm to avoid missing variables. Because adding "1" to these four variables causes unusual patterns in the data and results, the analysis is conducted with both "1" added to the variable and without. The difference is slight between logging with and without adding "1" to the data, so the results will be reported from the variable without "1" added.

H1: Measures of Ecological Footprint representing intensive processes will be more closely associated with World-Economy Centrality, specifically CO2 emissions, nuclear power, and hydro power.

H2: Measures of Ecological Footprint representing extensive processes will be more closely associated with Population and GDP, specifically fuelwood, forest, built-up land, cropland, fishing grounds and grazing land.

Models

All models tested are based on the parsimonious STIRPAT model of York et. al (2003). York et. al (2003) include in the basic STIRPAT model the Natural Log of Population and the Natural Log of GDP per capita. This paper expands the STIRPAT model to include W-E Centrality, Kentor's (2000) variable as well as the control variables GINI, percent urban population (both from World Bank WDI (2001)) and the Natural Log of Land area according to Wackernagel (2002a). The inequality variable GINI, percent urban population and secondary school enrollment was used in used in Jorgenson (2005). I have included GINI and the percent urban population, but since secondary school enrollment was not significant in any of Jorgenson's (2005) models, I have excluded it here. The Natural Log of Population and total GDP, not GDP per capita, were included in the equation (see also footnote above regarding GDP per capita). For the purposes of this paper, the total effects of GDP are important for understanding a nation state's total impact. By using total GDP, it is more comparable to world-economy position, which is determined not by per capita influences but by its total world-economy strength relative to other nations. The dependant variables in this model include the total National EF and EF disaggregated into its constituent parts as found in the Living Planet Report data (2002a). The focus of this model is to get a clearer understanding of the role of

GDP and World-Economy Centrality with respect to extensive and intensive processes and to compare to Jorgenson et al. (2005). This model will test the hypotheses regarding the specific predictiveness of GDP and extensive processes as well as World-Economy Centrality and intensive processes. Each component of Ecological Footprint, as well as the combined energy footprint, is tested with the full model and also with GDP, Kentor's (2000) variable and World-Economy Centrality in separate regressions, keeping the nations constant in each model. Due to the limited number of cases in the Kentor (2000) variable, I have also tested GDP and W-E Centrality separately with Population and Land Area. By testing the effects of Logged GDP and Logged World-Economy Centrality separately, it is possible to avoid any multi-collinearity effects and discern the impacts of each variable separately, with the Natural Log of Land Area and the Natural Log of Population as control variables.

The models in this paper address the impact of World-Economy Centrality on National Ecological Footprint to discern possible specific effects with respect to extensive and intensive processes. In all, seven models were conducted[3]. Model 1 included only Population (log), Land Area (log), GDP (log) and W-E Centrality (log). Each tested the dependent variable associated with the Ecological Footprint, including the Total Ecological Footprint, Cropland, Forest, Grazing Land, Fishing Grounds, Energy (a combination of carbon dioxide, nuclear and hydroelectric), Built-up Land, Carbon Dioxide, Forest used for Fuelwood, and Water Withdrawls. The independent variables in the first model included the basic STIRPAT model, the natural log of Population, GDP and the control variable, Land Area. The second model

[3] Because of the potential multi-collinearity, multi-collinearity diagnostics are included in the regression analysis. Although the results indicate caution should be exercised, the Tolerance is .072 and .060 for Natural Log of World-Economy Centrality and Natural Log of GDP, respectively, for nearly every regression. Although highly correlated, the Tolerance does not exceed the more stringent .05 cutoff for exclusion from the equation for multicollinearity. The VIF is 13.826 and 16.747 for Centrality and GDP, respectively, in most cases. Second, Natural Log of World-Economy Centrality and Natural Log of GDP are included separately with the control variables on each National Ecological Footprint component and CO2 emissions from WDI data.

included the basic STIRPAT above with Kentor (2000). The third model substituted W-E Centrality for Kentor (2000). The fourth model included the basic STIRPAT with both Kentor (2000) and W-E Centrality. Thefith and sixth models test GDP and W-E Centrality separately with Population and Land Area. The seventh model tested Population, Land Area, GINI, Percent Urban, Kentor (2000) and W-E Centrality. There are a number of differences between the current analysis and Jorgenson et al. (2005) beyond the inclusion of the Natural Log of GDP. Jorgenson et al. (2005) uses maximum likelihood estimation (MLE) to deal with missing data, but since the W-E Centrality measure does not suffer from significant missing cases like the Kentor (2000) variable used by Jorgenson et al. (2005), I chose not to use MLE. Part of the importance of this study is to demonstrate the utility of the W-E Centrality variable without having to rely on statistical procedures to deal with missing data. Another difference between this study and Jorgenson et al. (2005) is that my data set includes Ecological Footprint data from 1999, not 2000. Finally, the data is logged to reduce skewness in the original variables[4].

The results of the analysis tend to confirm the theoretical assertions that World-Economy Centrality, GDP and Population can be found to have specific effects with respect to intensive and extensive processes.

[4] In the original Jorgenson et al. (2005) study, Kentor (2000) is not logged. In order to be comparable to the other variables in the model, Kentor (2000) is logged here. There are a couple of issues to be acknowledged here. First, despite the skewness of the original Kentor (2000) variable, logging Kentor (2000) does not appear to result in a standard distribution that meets the assumptions of regression analysis. Second, Kentor's (2000) variable appears to work much better when none of the variables are logged in the equation, but this presents a significant conceptual problem. Hierarchal networks are by their very nature logarithmic, so logging them tends to produce a standard distribution as expected. By not logging the variables in the equation, it is not clear what the regression analysis is telling us.

First, comparisons to the Jorgenson et al. (2005) study using Kentor's (2000) variable suggested that the Kentor (2000) variable does not perform better than the alternative W-E Centrality variable and has the significant drawback of nearly 40 less valid cases, limiting analysis. In fact, by limiting the cases, it can have dramatic effects on the data. For example, with the Ecological Footprint component Fuelwood, including Kentor (2000) provides an r-square of .623 with Population (log), Land Area (log), GINI (log), Urban population (%) and W-E Centrality (log). Removing Kentor (2000) and keeping the same cases provides an r-square of .622. By removing the limit on cases imposed by Kentor (2000), the r-square drops to .445. In numerous models, Kentor rarely was significant when the competing W-E Centrality was not and only under situations when it was predicted that an extensive variable would be more predictive. When Kentor and W-E Centrality were both significant, W-E Centrality typically had greater standardized betas.

As a result of the poor performance of Kentor and the serious limiting of cases in the preliminary models, I chose to exclude it from further analysis. In the final analysis, I ran four models on the Ecological Footprint components. Based on the standardized betas, Population and GDP appear to be the strongest predictors of the overall Ecological Footprint. The results are very consistent with the hypotheses. While GDP and Population were more predictive of extensive processes, W-E Centrality was more predictive of intensive processes like carbon dioxide emissions and energy. In both the Energy and Carbon Dioxide components, W-E Centrality remains significant above the .001 level and is the largest standardized beta in all models. With respect to Energy and Carbon Dioxide, GDP is only significant in Model 2, which is consistent with the hypotheses and theoretical argument that W-E Centrality is more closely related to intensive processes than GDP or other extensive measures like Population. In both the

Energy and Carbon Dioxide components, Agriculture and GINI were significant in the models where they were included. There relationship was negative, suggesting that the more agriculture and the greater the inequality in the nation, the lower the Footprint. Agricultural and inequitable societies may not have the developed consumer base due to the extent of rural poverty.

There were also some interesting interactions in the more complete models. In the full model measuring total Ecological Footprint, Arms Exports (as a percentage of total exports) and GINI (log) are significant. Arms exports also play a role in the Energy and Carbon Dioxide components of the Footprint, suggesting that arms production for export tends to increase the energy footprint and would also be associated with the intensive core processes. Interestingly, Arms Exports also plays a small but significant role in the Cropland component of the Footprint. The Cropland component demonstrates the complexity and nuance of the effects of various variables on the Ecological Footprint. Land Area and Population are significant in all the models. In the first model, GDP is significant while W-E Centrality is not. In the second model, the relationships change as Urban Population and GINI are now significant while GDP and W-E Centrality are not. In the full model, Urban Population and GINI are no longer significant, but Arms Exports and W-E Centrality are[5]. This is an interesting suggestion by the results. More Cropland is used in nations that export arms and are more central to the world trade networks. This may suggest that that intensive agriculture associated not only with corporate agriculture, but also to meet the demands for feeding meat animals in wealthier nations. The connection to Arms Exports is more difficult to discern. Arms Exporting nations may well be those that have

[5] Unfortunately, the cases are not held constant, so the number of cases varies from Model 1 to Model 4. Alternative models should be run where the cases are all held constant to see if the same pattern develops.

disproportionately core processes and likewise a taste for the more intensive oriented meat consumption.

Fuelwood and the Forest Components provide and interesting contrast. Fuelwood use appears to be more closely tied to rural populations and inequality. Fuelwood is strongly, negatively related to Urban Population and strongly, positively related to GINI. Population is only significant when Urban Population is not included. No other variables are significant. These findings fit closely with what would be expected, poor rural populations using local forests and trees for heating and cooking. The Forest component has a similar relationship with Population and Urban Population, but GINI is not significant. Instead, when Industry (% GDP) is included, it is strongly, negatively related with Forest use. GDP, and W-E Centrality in Model 3 with GDP excluded, are strongly predictive with the largest standardized betas in the models. This suggests a complex relationship between the size of the economy (GDP) and the rural nature of the society. The less industry, the greater the Forest consumption, but when substituting Services for Industry, Services are positively related with Forest use. Thus, Forest is not only associated with rural populations, but also with service economies.

Grazing Land – No population, Land Area, Urban population, GINI. (WEC in Model 1, GDP in Model 1+2).

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