Ecologically Unequal Exchange and the Environmental Effects of FDI: Empirical Analyses of Emissions and Consumption in Developing Countries, 1997-2007

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Abstract

With the current increasing trends of economic liberalization and globalization, the inflow of foreign direct investment (FDI) has grown substantially over the past three decades. Along with rapid economic development, FDI is often considered to have brought serious environmental consequences to host developing countries. Ecologically unequal exchange theorists argue that the disproportionate export flow of energy and materials from developing to developed countries allows developed countries to improve their environment and increase their consumption of environmental resources, while deteriorating the environment of developing countries and suppressing their levels of environmental consumption. This article presents empirical analyses of ecologically unequal exchange hypotheses, which postulate that the higher the level of FDI intensity, the higher the level of CO2 emissions and the lower the level of environmental consumption within developing countries. To test the hypotheses, the total CO2 emissions and per capita ecological footprint in 1999, 2003, and 2007 were regressed (OLS) on the estimated models consisting of the levels of FDI intensity and other factors supposedly responsible for the respective forms of environmental outcomes. With the results being insignificant across all tested models, findings from the present study do not support the hypotheses, leading to the conclusion that the level of FDI intensity does not necessarily have determinant effects on either CO2 emissions or environmental consumption.

Keywords: globalization, environment, CO2 emissions, ecological footprints, foreign direct investment (FDI), ecologically unequal exchange

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I. Introduction

With the current increasing trends of economic liberalization and globalization, the inflows of foreign direct investment (FDI) has grown substantially over the past three decades. According to an International Monetary Fund (IMF) report, recorded global FDI inflows increased by an average of 13 percent a year during 1990 to 1997, and remarkably by an average of nearly 50 percent a year during 1998 to 2000, reaching its first peak in 2000 (Patterson, Montanjees, Motala, & Cardillo, 2004). Although FDI inflows declined after 2000 for a couple of years, a significant increase in cross-border mergers and acquisitions (M&As) as well as the continued expansion of economic activities by the world's largest transnational corporations (TNCs) subsequently led to a rapid growth in FDI inflows from 2004 to hit the second peak in 2007 (UNCTAD, 2008).

Such a rapid increase in FDI inflows has repeatedly provoked a long contentious debate over the pros and cons of FDI on the economy of host countries. While some argued that FDI promotes economic growth and increases productivity in the economy as a whole, on the other hand, others denied such benefits of FDI by stressing its potential drawbacks such as its negative impacts on the development of local competitors (te Velde, 2006). However, extensive research, which provided theoretical rationales and robust empirical evidence, has given rise to the general consensus that FDI has the capability to promote economic growth, specifically through multiple channels including "capital formation, technology transfer, and human capital enhancement" (Ozturk, 2007).

Certainly, FDI seems to have noticeably contributed to growth of many economies, but especially to that of developing economies. According to the 2010 World Investment Report, FDI inflows to developing economies increased consecutively over the six years from 2003 to 2008, until it started to decline in 2009 following the global financial crisis (UNCTAD, 2010). To take the BRIC countries (Brazil, Russia, India, and China) as an example, during the same time period, FDI inflows to these countries have grown nearly four times from $77 billion to $281 billion (UNCTAD, 2013). As a result, these BRIC countries achieved considerable growth over the past ten years from 2001 to 2010 at the average growth rate at least twice as high as that of the OECD average (UNIDO, 2012). Particularly, the two most populous countries, China and India, had an average growth rate of 10.5 percent and 7.5 percent, respectively (UNIDO, 2012).

However, along with the rapid development of their economies, these host developing countries have increasingly experienced various forms of environment degradation. For instance, the emissions of greenhouse gases (GHG) have steadily increased in BRIC countries over the past few decades, largely propelled by the energy-intensive growth of the Chinese economy. While the share of total energy-related carbon dioxide (CO2) emissions by the U.S. and Japan declined from 23.00% and 5.72% in 1990 to 22.00% and 5.00% in 2007 respectively, it increased for every BRIC economy: China from 11.00% to 16.00%, India from 3.00% to 5.00%, Brazil from 0.94% to 1.15%, and Russia from 3.80% to 6.00% (World Bank, 2007). Nowadays, nearly half of the world total CO2 emissions come from the developing world, with the BRICs alone responsible for nearly 30% of the global total (Goldman Sachs Global Economics Group, 2007).

As the environmental degradation became prominent in these countries, growing environmentalism has often subjected TNCs to harsh criticisms that they undermine the environment of the host countries by pollution and natural resource extraction. In opposition to the traditional positive views that FDI can promote economic growth in the host countries, negative views toward FDI have once again surged, pointing to the FDI's potential negative effects on the environment. In order to address such concerns of policymakers and the general public, numerous researchers have conducted research to investigate the environmental impacts of FDI. The examination of the FDI-environment nexus has a significant importance in the face of the present controversy over this issue between the pro-FDI and anti-FDI scholars.

Thus, the primary purpose of this study is to examine the environmental effects of FDI specifically in developing countries. Similar to previous sociological studies on the environment, the present study considers the FDI-environment nexus in the context of ecologically unequal exchange. Yet, unlike these studies, the present study is distinct in that, it employs ecological footprint, as well as total CO2 emissions, in its estimation of the environmental effects of FDI. Ecological footprint, which was developed by William Rees and Mathis Wackernagel in the early 1990s, represents the consumption of environmental resources by a nation by estimating all the resources and material inputs necessary to support the lives of the population (van der Voet, van Oers, de Bruyn, de Jong, & Tukker, 2009). In light of existing literature and ecologically unequal exchange theory, what effects may FDI have on CO2 emissions and environmental consumption in developing countries? To answer the question, the present study conducts regression analyses examining the relationships between FDI, CO2 emissions, and ecological footprint in developing countries.

This essay consists of six sections, and the remainder of this essay is organized as follows: section Ⅱ offers a comprehensive review of the literature which summarizes previous studies on the growth, trade and FDI-environment nexuses; section Ⅲ discusses the theoretical framework on which the present study bases its analyses; section Ⅳ introduces the hypotheses, model specification, and data descriptions; section Ⅴ presents the empirical results from the regression analyses; and section Ⅵ provides a discussion on the research findings and some research implications.

II. Literature Review

With the surge of environmentalism, a number of researchers, mostly from the disciplines of economics and sociology, have conducted extensive research to investigate the determinants of environmental degradation. In the age of rapid economic growth and globalization, these two factors have often been considered the major causes of increasing environmental degradation. Thus, this section provides a review of the literature on the relationships between economic growth, trade, FDI and the environment.

Economic Growth and Environment

Empirical research on the relationship between economic growth and the environment has rapidly increased since the early 1990s, when empirical data on various pollutants became available through the Global Environmental Monitoring System (GEMS), the environmental data compendium of the Organization for Economic Co-operation and Development (OECD). As a pioneer study of the growth-environment nexus, Grossman and Krueger (1991) found an inverted U-shaped relationship between economic growth and pollution, which is termed the Environmental Kuznets Curve (EKC). This EKC suggested that the environment at first deteriorates during the process of economic growth but improves later after a certain level of per capita income. As the finding of the EKC became popular through the 1992 World Bank Development Report, many empirical studies followed to test the EKC hypothesis and found support of the EKC (Canas, Ferrao, & Conceicao, 2003; Kim & Beak, 2011; McPherson &

Nieswiadomy, 2005). Among the following studies, Grossman and Krueger (1995) suggested that the turning point in the EKC for the most pollutants is less than a per capita income of $8,000 (1985 US dollars), though there is no agreement in the literature on the income level at which environmental degradation starts to decline.

The emerging concept of the EKC primarily spurred an optimistic view that economic growth eventually leads to improvements in environmental quality. This optimistic view gave rise to two modernization perspectives, the economic and ecological modernization perspectives among economists and sociologists. The economic modernization perspective suggests that the demand for environmental protection and the resources and technology available for such investment increases along with the economic development (World Bank, 1992; Panayotou, 1993). Similarly, the ecological modernization perspective posits that modernization drives industries to become more ecologically rational and to gradually minimize environmental costs (Mol, 1995). For these two streams of modernization theorists, modernization accompanied by economic development is the key to solving environmental issues.

Despite the robust support of the EKC in empirical research and growing optimistic views, the existence of criticisms against the EKC should not be dismissed. In fact, many recent studies took a more cautious stand and cast doubt on the EKC's theoretical, methodological, and empirical foundation (Lieb, 2002; Perman & Stern 2003; Stern, 2004). On its theoretical ground, Mazzanti, Montini, & Zoboli (2007) criticized that the EKC is largely based on conceptual intuition, and is short of strong theoretical bases. On its methodological ground, several researchers pointed out the econometric issues in the prior EKC research, including the issues of heteroskedasticity, simultaneity, omitted variable bias, data poolability and heterogeneity in the sample selected (for more detail, consult Stern, 2004; Romero-Ávila, 2013).

With regard to its empirical support, the existing evidence of the EKC is still mixed, as the empirical results seldom find support of the EKC for some environmental indicators. According to Dinda (2004), the significant EKC is only confirmed for pollutants involving local short-term cost such as SPM, SO2, and CO, and not for the accumulated stocks of waste or for pollutants involving long-term and more dispersed costs such as CO2. The studies of ecological footprint also failed to find support of the EKC with their results indicating that the effect of economic development on environmental consumption is monotonically positive (York, Rosa, & Dietz, 2003; Wang, Kang, Wu, & Xiao, 2013). Furthermore, the existence of EKC seems more questionable in the case of deforestation (Bhattarai & Hammig, 2001; Koop & Tole, 1999).

At the same time, as opposed to the optimistic interpretation of the EKC by the modernization theorists, other scholars have tried to explain the EKC, specifically the latter downward segment of the EKC, in different ways. As an alternative explanation, Stern, Common, and Barbier (1996) argued that if the EKC were to exist in the relationship between economic growth and the environment, it may be partly or largely due to the effects of trade on the distribution of pollution-intensive industry. Thus, the researchers suggested that international trade might allow developed countries to improve their environment by shifting pollution-intensive industries from their lands to developing countries, which consequently escalates levels of environmental degradation within the latter. This is basically what ecologically unequal exchange theorists have been elaborating upon, and their arguments will be discussed further in the section Ⅲ. Prior to that, however, the following sub-section reviews the existing research on the trade-environment nexus including those on ecologically unequal exchange.

Trade and Environment

The earliest economic research on the trade-environment nexus was mostly interested in asking the question: how does environmental policy affect trade flows?. This research question generated the proposition that the stringency of environmental regulation would significantly affect the pattern and volume of trade flows, known as the Pollution Haven Effect (PHE). Early studies testing the PHE found little evidence that the environmental regulation stringency affects international trade in pollution-intensive industries (Jaffe, Peterson, Portney, & Stavins, 1995; Tobey, 1990). Nevertheless, subsequent research controlling for the endogeneity of regulation, trade flows, and investment, which plagued the early studies, found support of the PHE (Ederington, Levinson, & Minier, 2005; Levinson & Taylor, 2008). Since developed countries tend to have more stringent environmental regulations, which give them a comparative advantage in less pollution-intensive industries while giving developing countries a comparative advantage in pollution-intensive industries, apparently developed countries are more likely to import polluting goods from developing countries.

However, in contrast to the PHE, the factor endowments hypothesis suggests that developed countries, which are relatively capital abundant, tend to have a comparative advantage in polluting industries, which are often capital-intensive. Based on this hypothesis, international trade is more likely to expand capital-intensive polluting industries in capital abundant developed countries and contract the industries in capital-scarce developing countries, which consequently increases pollution within the former while decreasing it within the latter. Hence, these two conflicting hypotheses suggest that stringent environmental regulation of developed countries tends to make them polluting goods importers while their capital abundance tends to make them polluting goods exporters. According to Copeland and Taylor (1997, 2003), the pattern of international trade and its effects on the environment depend on which of these effects is stronger.

The larger share of the empirical literature has focused on the above two hypotheses, and investigated the trading relationship between developed countries and developing countries with a focus in the trade of polluting goods. The general picture arising from the existing literature suggests that more stringent environmental regulation in the developed world has led to an increase in the export of polluting goods from the developing to the developed world (Lucas, Wheeler, & Hettige, 1992; Ratnayake, 1998). In fact, Low and Yeats (1992) suggested that the share of polluting goods in total exports decreased in developed countries while it increased in developing countries over the 1965-1988 period. Moreover, reportedly pollution intensity grew more rapidly in Latin America as a whole after the OECD environmental regulation became more stringent. (Birdsall & Wheeler, 1993)

Furthermore, there have been a few economic studies examining the direct relationship between trade and the environment. Some empirical studies suggest that trade liberalization has a positive impact on the environment (Beghin & Poitier, 1995; Strutt & Anderson, 1999), while others claim the opposite (Dean 2002; Madrid-Aris, 1998). The most notable being the study by Antweiler, Copeland and Taylor (2001), which investigated the effects of international trade on sulfur dioxide concentrations by using a theoretical model to divide trade effects on pollution into the composition, scale, and technique effects. These three effects represent changes in emissions arising from the change in “the industrial composition,” “the size of the industrial pollution base,” and “the rate at which industry and households pollute” (McAusland, 2008). Based on their results, 1% increase in the international trade scale raises pollution concentrations by 0.25-0.5% via the scale effect and reduce it by 1-1.5% via the technique effect, while creating a relatively small change via the composition effect. With the overall effects reducing pollution concentrations, the researchers concluded that, “freer trade is good for the environment.” Additionally, another remarkable study, which examined the effect of international trade on carbon emissions by using data for 132 countries from 1950 to 1992, revealed a striking pattern that increased trade intensity raises carbon emissions in lower income countries but lowers it in higher income countries (Heil, 2001)

Besides economic studies, increasing number of sociological studies, particularly on ecologically unequal exchange, have also contributed to the literature on the trade-environment nexus. Ecologically unequal exchange theorists generally argue that the disproportionate export flow of energy and materials from developing to developed countries is largely responsible for the current ecological inequality, a situation in which developed countries with higher levels of environmental consumption enjoy lower levels of environmental degradation, whereas developing countries with lower levels of environmental consumption suffer from higher levels of environmental degradation (Jorgenson & Rice 2005, Rice, 2007b). In order to test the hypotheses derived from the theory, Jorgenson and Rice (2005) created a measure of “weighted export flows,” which quantifies the relative extent to which exports are sent to developed countries. By using this measure, a series of sociological studies investigated the environmental impacts of exports from developing to developed countries.

For instance, existing empirical research has reported positive correlations between weighted export flows, annual forest cover loss, (Jorgenson, 2006c; Jorgenson, Austin, & Dick, 2009) and organic water pollutant emissions (Shandra, Shor, & London, 2009), suggesting that the higher the level of exports from developing to developed countries, the higher the level of deforestation and water pollution within developing countries. Similarly, the level of primary sector exports from developing to developed countries is found to be positively associated with the level of deforestation (Jorgenson, Dick, & Austin, 2010) and the number of threatened mammals (Shandra, Leckband, McKinney, & London, 2009) within developing countries. On the other hand, other sociological studies, which found a negative correlation between weighted export flows and ecological footprint, evidence that developing countries with a higher level of export to developed countries are more likely to experience lower levels of environmental consumption (Jorgenson & Rice, 2005; Rice, 2006, 2007b). Hence, the general picture arising from these studies seems to be in support of ecologically unequal exchange.

According to my interpretation of existing literatures, international trade in general is more likely to improve the environment by bringing advanced environmental technology and capital available for environmental protection to trading countries. However, when considering developed and developing countries separately, international trade may be more beneficial to the environment of developed countries as it allows them to outsource polluting goods. While, it may be more detrimental to developing countries where the production of polluting goods may escalate as a result. Besides trade, however, FDI may also affect the environment of developing countries in a significant way by shifting the production bases and the bases for natural resource extraction from developed to developing countries. Therefore, the following sub-section provides a review of the literature on the FDI-environment nexus.

FDI and Environment

Similarly to the earliest research on the trade-environment nexus, earliest economic studies on the FDI-environment nexus also focused on the impacts of environmental regulation on the flows of investment. These studies were primarily driven by the so-called Pollution Haven Hypothesis (PHH), a premise that pollution-intensive industries would relocate from countries with more stringent to less stringent environmental regulations. Early studies tested the hypothesis both at the international (Duerkson & Leonard, 1980; Leonard, 1988) and domestic levels (Bartik, 1988; Friedman, Gerlowski, & Silberman, 1992), but neither attempts found the evidence that environmental policies play a significant role in determining the investment flows. By the end of 1990s, scholars had concluded that environmental regulation stringency would have relatively small effects on TNCs decisions on their production locations because pollution abatement costs are less than 1% of production costs for the average industry (Nordström & Vaughan, 1999). Notably, however, a couple of more recent empirical studies found support of the PHH, indicating that more stringent environmental regulations lead to lower levels of investment inflows or higher levels of investment outflows in polluting industries (Aliyu, 2005; List & Co, 2000).

After the turn of the century, economic empirical research has grown rapidly focusing more on the examination of the direct relationship between FDI and the environment, especially in terms of CO_2 emissions (e.g. He, 2006; Hoffmann, Lee, Ramasamy, & Yeung, 2005; Pao & Tsai, 2011). Although most studies are case-specific in a certain country or region, results from these studies are, to some extent, consistent in that most of them concluded that FDI has detrimental effects on the environment. For instance, Beak and Koo (2009), in their study of India and China, found positive correlations between FDI and CO_2 emissions particularly in the short run in case of India and both in the short and long run in case of China. In the case of Malaysia, Lee (2009) reported a unidirectional causal relationship running from FDI to CO_2 emissions. In a more comprehensive study using panel data for 110 developed and developing economies over the period between 1985 and 2006, Muhammad, Samia and Talat (2011) concluded that a consistent rise in FDI is contributing to the growth of CO_2 emissions.

Also in the discipline of sociology, researchers have increasingly suggested that FDI has detrimental effects on the environment, especially of developing countries. Among earliest sociological studies, Grimes and Kentor (2003) conducted panel regression analyses to estimate the effects of FDI and domestic investment on CO2 emissions in both developed and developing countries. Their results indicate that FDI stock as a percentage of GDP has an incremental effect on the level of CO2 emissions whereas gross domestic investment as a percentage of GDP has no significant effect on the level of CO2 emissions. Similarly, Jorgenson suggested an incremental effect of FDI in the manufacturing (2007a) and primary sector (2007b) on the level of CO2 emissions specifically in developing countries. In addition, Jorgenson found a positive association between the levels of FDI in the manufacturing sector, methane emissions (2006a), and organic water pollution intensity (2006b, 2007a) in developing countries. FDI in the primary sector is also found to be responsible for greater rates of deforestation in developing countries (Jorgenson, 2008; Shandra, 2007).

Findings from these recent sociological studies suggest that a higher level of FDI, partly or largely, explain various forms of environmental degradation, including carbon dioxide emissions, methane emissions, water pollution, and deforestation. Yet, to the best of my knowledge, no previous research in the FDI-environment literature has examined the relationship between FDI and ecological footprint, and therefore, the impact of FDI on environmental consumption is yet to be explored. In order to fill this gap in the literature, the present study conducts empirical analyses investigating the relationship between FDI and ecological footprint. Along with this relationship, the present study seeks to add an additional layer to the existing literature on FDI-CO2 emissions nexus by reassessing the effects of FDI on the level of CO2 emissions with different cases at a different time period. Prior to hypotheses generation, the theoretical foundation of this study is discussed in the following section.

III. Theoretical Framework

Prior research on the growth, trade, and FDI-environment nexus have often based their theoretical foundations on the long sociological tradition of dependency and world-systems theory, as well as more ecologically-oriented theories including treadmill of production, ecological modernization, and ecologically unequal exchange theory. Among them, the ecologically unequal exchange theory seems to be most relevant to the present research.

Ecologically Unequal Exchange

Ecologically unequal exchange is a school of thought, which conceptualizes the structural mechanism shaping the current patterns of disproportionate utilization of global environmental space, uneven deterioration of the natural environment, and developmental disparity between developed core and developing peripheral countries within the world-system (Hornbourg, 2009, Rice, 2007a). As implied by the theory, the vertical flow of energy and materials from developing to developed countries is a key structural mechanism through which the current ecological and developmental inequalities have been created and maintained. The theory was primarily developed by Stephen Bunker (1984), who examined the history of ecological destruction and underdevelopment of the Amazon Basin as a consequence of excessive resource extraction and exports organized in response to world-system demands.

Upon his theorization of ecologically unequal exchange, Bunker (1984) drew extensively upon Wallerstein's world-system perspective as his theoretical foundation. World-system theory is a macro-sociological perspective and a unit of social analysis developed by Immanuel Wallerstein (1974) in order to comprehend the dynamics of the "capitalist world economy" as "a total social system" (Martínez-Vela, 2001). According to Wallerstein (1974), a world-system is based upon international division of labor, which divides the world into core, periphery, and semi-periphery countries: core wealthy countries focus on the production of high value services and capital-intensive industrial manufactures, which requires import of raw materials; peripheral poor countries focus on labor-intensive primary sector production and export of their natural resources; semi-peripheral middle-income countries lie somewhere in the middle, as their exports are relatively diversified with their production of raw materials, manufactured goods, and higher value services. This international division of labor consistently reinforces the global hierarchy of economic and political power and the dominance of core countries, which in turn helps to maintain the basic relationship of extraction, production, and consumption between core, peripheral, and semi-peripheral countries, and therefore the system itself (Wallerstein, 1974).

Based upon this world-system theoretical proposition, Bunker (1984) advanced his argument by stressing the fundamental differences between extractive and productive economies in their ecological, demographic, infrastructural, and organizational dynamics in which subsequent development unfolds. According to Bunker (1984), industrial production of productive economies in developed core countries is dependent on natural resource export from extractive economies in developing peripheral countries, which is often monetarily undervalued. The inflow of underpriced commodities increases the development potential of developed core countries by complicating their social and economic organization, which accelerates production and accumulation within their borders. For extractive economies, on the other hand, the undervaluation of their primary sector export means a loss of value, which promotes the disruption of natural environment, local populations, infrastructure, and social organization within developing peripheral countries in which they are located. In the absence of social or economic basis, which can facilitate local resistance to the further exploitation organized in response to the world-system demands, developing peripheral countries tend to become increasingly inflexible and stuck in extractive cycles leading to ecological destruction and underdevelopment while developed core countries gain flexibility and ability to dictate the global demands and international trade structure (Bunker, 1984).

Building on this Bunker's argument, the theory was subsequently elaborated, expanded, or empirically tested by various groups of scholars studying ecological economics (e.g. Hornborg, 1998; Muradian & Martinez-Alier, 2001b), energy theory of value (e.g. Odum & Arding, 1991), material flows analysis (e.g. Fischer-Kowalski, 1998; Giljum & Eisenmenger, 2004), and ecological footprint analysis (e.g. Andersson & Lindroth, 2001; Jorgenson & Rice, 2005). For instance, Odum (1988), in his attempt to explain ecologically unequal exchange in terms of energy exchange between nations, conceptualized the idea of "emergy," which represents 'embodied energy' or 'energy memory' transferred largely from developing peripheral to developed core countries. According to Odum (1988), developing countries are underpaid for the energy contents embodied in their resource exports since natural resources are free gifts of nature and thus evaluated poorly on the market. Moreover, Martinez-Alier (2002) argued that export commodities of developing countries are underpriced, as their prices do not take into account the negative externalities including the environmental and social costs of extraction and production. In fact, Singer (1950) and Prebisch (1950) both found a striking empirical pattern that the price of primary commodities exported by developing countries tends to decline relative to the price of manufactured products exported by developed countries.

This undervaluation of developing countries' export commodities was primarily considered to be the result of lower income elasticity of demand for primary commodities, a massive oversupply of labor, and weaker union organization in developing countries (Roberts & Parks, 2009). Besides these internal factors, external factors such as the world-system stratification also seem to play a significant role, as businesses and policy makers in developed core countries try to secure their access to cheap and abundant natural resources by influencing developing peripheral countries through their institutions and military might if necessary (Bunker & Ciccantel, 2005). For this reason, developed countries advantageously situated at the core of the global exchange network are more likely to maintain favorable terms of trade, which allows them to import more commodities per unit of their export products, while developing countries less favorably positioned on the periphery of the global economy are in no position to prevent their terms of trade from declining or influence the patterns of international trade (Bunker & Ciccantell, 2005; Hornborg, 2003; Howell, 2007).

As a consequence of declining terms of trade for their export commodity, developing countries often boost the extraction and export of primary commodities, promoting disproportionate flow of energy and materials from extractive economies in developing peripheral countries to productive economies in developed core countries (Bunker, 1984; Roberts & Parks, 2009). In fact, many ecological economists using a materials flow accounting methodology or materials flow analysis have suggested that international trade, which may seem more or less balanced in monetary term, actually is unbalanced in physical terms; oftentimes developed countries runs an enormous trade deficit while developing countries conversely record a large trade surplus in physical terms (Bringezu & Schütz, 2001).

For instance, Fischer-Kowalski and Amann (2001) pointed out that physical imports of industrialized countries such as Germany, United Kingdom, the Netherlands and Japan exceed their physical exports whereas physical exports of Southern countries including Brazil and Venezuela surpass their physical imports. A more comprehensive empirical study examining the external trade relations of 15 European Union countries (EU-15) suggests that their physical trade is characterized by a massive trade deficit with the physical weight of their imports being four times more than that of their exports (Giljum & Eisenmenger, 2004). Moreover, Muradian and Martinez-Alier (2001b) explained this disproportionate flow of exports from developing to developed countries by examining the price and physical trade balances of 18 specific raw materials exported from Southern countries to three industrialized regions including the United States, the EU, and Japan. Based on their findings, physical exports from South to North increased dramatically for 14 of the 18 materials between the 1970s and 1990s while prices decreased from 10 to 63 percent for 16 of the 18 materials over the same period of time.

This unbalanced vertical flow of energy and materials from developing to developed countries has directly contributed to the current pattern of disproportionate utilization of global environmental space, which encompasses the stocks of natural resources and waste- or pollution-absorbing sink capacity of global ecological system (Rice, 2007a, 2007b). Through this vertical flow of exports, developed countries are able to maintain priority access to global environmental space, increasing the levels of environmental resource consumption, which in turn accelerate growth of their economy. While the over-utilization of environmental space by developed countries suppress resource consumption opportunities for developing countries, thereby hindering the subsequent development process within their borders (e.g. Hornborg, 2001; Jorgenson, 2009). In fact, the level of environmental resource consumption, often measured by ecological footprint, is strongly correlated with the level of development and world-system position; core wealthy countries score the highest in their per capita ecological footprints while semi-peripheral middle-income counties score somewhere in the middle and peripheral poor countries score the lowest (Jorgenson, 2003). As aforementioned in the literature review, prior empirical research has revealed that developing peripheral and semi-peripheral countries with relatively greater amount of exports sent to developed core countries are characterized by lower levels of environmental consumption (Jorgenson & Rice, 2005).

On top of this, other scholars also argue that the vertical flow of exports from developing to developed countries facilitates environmental "cost-shifting" or "environmental load displacement," a condition in which developed countries shift the negative environmental consequences of extraction and production supporting their higher level of environmental consumption upon developing countries (Hornborg, 2009; Muradian, O'Connor, & Martinez-Alier, 2002). This environmental "cost-shifting" have contributed to another current pattern of ecological inequality, namely uneven deterioration of the natural environment; developed countries maintain or restore the quality of their local environment while developing countries experience heightened resource depletion and increasing forms of environmental degradation including deforestation, water pollution, and soil erosion within their borders (Jorgenson 2006c; Rice, 2007a). Taking deforestation as an example, core and semi-periphery countries, which are characterized by significantly greater consumption of forest products, have experienced, on average, reforestation while peripheral countries consuming lowest amounts of forest products have experienced higher rates of deforestation over the period between 1990-2000 (Rice, 2007a).

Furthermore, ecological economists using material flow analysis have pointed out that developed countries are increasingly displacing their emissions by shifting pollution-intensive production stages from their lands onto developing countries (Machado, Schaeffer, & Worrell, 2001; Muradian & Martinez-Alier, 2001b). According to Muradian, O'Connor, and Martinez-Alier (2002), industrialized countries including Japan, the United States and West European countries are largely, in physical terms, net-importers of pollution-intensive goods coming primarily from developing countries as their total physical imports generally entail larger pollutant emissions than their total physical exports. Even in monetary terms, the share of pollution-intensive exports to total exports decreased in the EU, U.S. and Japan from 1978 to

1996, while it increased in South America and Africa, and remained constant in Southeast Asia over the same period (Muradian & Giljum, 2007). Thus, these empirical findings led to the radical claim that the developed countries owe a huge "ecological debt" to developing countries for the environmental damage that developed countries have caused through their consumption of pollution-intensive products exported by developing countries (Roberts & Parks, 2009).

In sum, international trade between the core and periphery of the global exchange network is characterized as ecologically unequal because the asymmetrical transfer of unnoticed value through the vertical flow of underpriced export commodities creates the current pattern of ecological and developmental inequality between developed core and developing peripheral countries. The exchange allows developed countries to maximize their use of global environmental space, improve their local natural environment, and create complex social and economic organization, which will consequently promote sustainable future development and human well being within their borders. Within developing countries, on the other hand, the exchange leads to limited access to global environmental space, resource depletion, ecological destruction, and disruption of social and economic organization, all of which are preludes to the underdevelopment of these countries. Based on the theory of ecologically unequal exchange and the implications from prior research, hypotheses and empirical models for the present study are generated and presented in the next section.

IV. Research Method

As aforementioned in the introduction, the present study examines the effects of FDI on both CO2 emissions and environmental consumption in developing countries. In doing so, the present study utilizes quantitative research method, which involves the development and empirical test of econometric models and statistical hypotheses. Specifically, the present study estimates and empirically tests two econometric models (emissions and consumption models) representing the functions of total CO2 emissions and per capita ecological footprint. Prior to model specification, various driving factors for CO2 emissions and environmental consumptions are discussed in the following sub-section in order to generate two separate hypotheses (one for emission effect and the other for consumption effect) for each causal factor.

Hypotheses

The particular interest of this research is the environmental effects of FDI. Although the central concern of ecologically unequal exchange is ecological and developmental consequences of international trade between the developed core and developing peripheral countries within the world-system, the theory also provides a substantial implication for the role of FDI within the mechanism of ecologically unequal exchange. As Bunker and Ciccantel (2005) have pointed out, many businesses in developed countries are eager for greater access to cheap and abundant natural resources within developing countries. Therefore, these companies often make an investment to establish a foreign affiliate in developing countries, which would facilitate the extraction and supply of cheap natural resources for their production process. As a result, many primary markets become oligopolistic, and dominated by few TNCs primarily originating from developed countries (Muradian & Martinez-Alier, 2001c). In fact, intra-firm trade within a relatively small number of large TNCs accounts for a remarkable part (over 40 percent) of international trade (Panic, 1998) Such intra-firm trade seems to be contributing to the undervaluation of primary commodities as many TNCs understate their commodity prices in order to reduce their tax payments to the local government (Muradian & Martinez-Alier, 2001a).

Moreover, scholars have also noted the shifting location of pollution-intensive industries from developed to developing countries by indicating the increasing amount of polluting-goods exports from developing to developed countries (Muradian & Giljum, 2007, Muradian & Martinez-Alier, 2001b). This seems to be largely due to the TNCs relocating their production bases onto developing countries, where they can lower their production costs by exploiting local cheap labors as well as cheap natural resources. In fact, FDI stock in the manufacturing sector increased nearly threefold during the period between 1990–2002 although it decreased in its share in total FDI stock because of more rapid growth of service sector FDI, which more than quadrupled during the same period (UNCTAD, 2004). Thus, intensifying extraction and production organized by TNCs in developing countries seem to increase forms of environmental degradation within developing countries, as existing evidence shows a substantial support for this trend (Grimes & Kentor, 2003, Jorgenson, 2006a, 2006b, 2007a, 2007b, 2008).

On the other hand, the presence of TNCs seem to have negative impacts on the level of environmental consumption because TNCs' activities in developing countries are often directed to satisfy the demand of developed countries, instead of that of host developing countries (Muradian & Martinez-Alier, 2001c). Indeed, natural resources and manufactured goods extracted or processed in developing countries are largely exported to developed countries to support their higher levels of consumption. Furthermore, according to Muradian and Martinez-Alier (2001a), the distribution of profits arising form the TNCs' activities in developing countries is often unfavorable to host developing countries as many TNCs repatriate most of their profits to their headquarters. Such unequal distribution of their profits may also negatively affects the levels of their natural resource use and consumption. Hence, the following hypotheses are derived for the respective analyses:

H_1: The higher the level of FDI intensity, the higher the level of CO2 emissions.

H_0: The level of FDI intensity does not impact the level of CO2 emissions.

H_2: The higher the level of FDI intensity, the lower the level of environmental consumption.

H_0: The level of FDI intensity does not impact the level of environmental consumption.

Besides the level of FDI intensity, the present study takes into consideration other additional factors that supposedly influence CO2 emissions and the consumption of environmental resources. These factors encompass 1) economic development, 2) population size, 3) export intensity, 4) exports sent to developed countries, 5) forest preservation, 6) energy consumption, and 7) manufacturing for CO2 emissions. While they include 1) economic development, 2) urbanization, 3) export intensity, 4) exports sent to developed countries, and 5) forest preservation for environmental consumption.

First of all, the level of economic development seems to play a significant role in increasing the levels of CO2 emissions and environmental consumption because a higher level of development come along with intensification of economic activities and accumulation of wealth. The intensified economic activity would accelerate the growth of CO2 emissions while the accumulated wealth would lead to greater mass consumption. In fact, prior empirical research indicated that the level of economic development, which is often measured by GDP per capita, is a primary determinant of CO2 emissions (Holtz-Eakin & Selden, 1995; Jorgenson, 2007a; Roberts & Grimes, 1997). Moreover, studies of ecological footprint also noted that the level of economic development is a driving factor of ecological footprint (Jorgenson, 2005; Jorgenson & Rice 2005; Rice, 2007b; York, Rosa, & Dietz, 2003; Wang, Kang, Wu, & Xiao, 2013). Thus, based on these previous studies, the following relationships are hypothesized:

H_3: The higher the level of economic development, the higher the level of CO2 emissions.

H_0: The level of economic development does not impact the level of CO2 emissions.

H_4: The higher the level of economic development, the higher the level of environmental consumption.

H_0: The level of economic development does not impact the level of environmental consumption.

Secondly, the size of population and the level of urbanization are also likely to affect the level of CO2 emissions and environmental consumption respectively. From previous studies, the size of population is known to have a positive correlation with CO2 emissions, which suggests that CO2 emissions increase as population increases (Jorgenson 2007a, Shi, 2001). Also, empirical evidence is abundant to indicate a positive correlation between the level of urbanization and environmental consumption (Jorgenson, 2004; Jorgenson & Clark, 2009; Jorgenson & Rice, 2005; Rice, 2006, 2007b; York, Rosa, & Dietz, 2003). Hence, the hypotheses for respective analyses are:

H_5: The larger the size of population, the higher the level of CO2 emissions.

H_0: The size of population does not impact the level of CO2 emissions.

H_6: The higher the level of urbanization, the higher the level of environmental consumption.

H_0: The level of urbanization does not impact the level of environmental consumption.

Thirdly, the level of export intensity is likely to increase the level of environmental degradation while decreasing the level of environmental consumption within developing countries because the production of export products often undermines the environment of exporting countries by pollution and natural resource extraction while the products are consumed by importing countries, instead of exporting countries. As aforementioned in the literature review, Jorgenson (2005) and Jorgenson and Burns (2006) reported a negative and statistically significant correlation between the level of export intensity and the level of environmental consumption. Therefore, the present study tests the following hypotheses:

H_7: The higher the level of export intensity, the higher the level of CO2 emissions.

H_0: The level of export intensity does not impact the level of CO2 emissions.

H_8: The higher the level of export intensity, the lower the level of environmental consumption.

H_0: The level of export intensity does not impact the level of environmental consumption.

Similarly, based on previous research, a higher level of exports to developed countries is considered to increase the level of environmental degradation while decreasing the level of environmental consumption within developing countries. Reportedly, Jorgenson and Rice' weighted export flow, which quantify the relative extent to which exports are sent to developed countries, is positively correlated with deforestation (Jorgenson, 2006c; Jorgenson, Austin, & Dick, 2009) and water pollution (Shandra, Shor, & London, 2009), while it is negatively correlated with ecological footprint (Jorgenson & Clark, 2009; Jorgenson & Rice, 2005; Rice, 2006, 2007b). Thus, the following relationships are hypothesized:

H_9: The higher the level of exports to developed countries, the higher the level of CO2 emissions.

H_0: The level of exports to developed countries does not impact the level of CO2 emissions.

H_{10}: The higher the level of exports to developed countries, the lower the level of environmental consumption.

H_0: The level of exports to developed countries does not impact the level of environmental consumption.

Furthermore, the present study postulate that the level of forest preservation is negatively associated with the level of CO2 emissions because forest preservation helps absorb CO2 emissions while deforestation likely increases CO2 emission. Similarly, the level of forest preservation is predicted to have a negative correlation with environmental consumption because a higher level of forest preservation suggests that forests largely remain unconsumed while a lower level of forest preservation implies that forests have possibly been cut down for consumption. Hence, the present study tests the following hypotheses:

H_{11}: The higher the level of forest preservation, the lower the level of CO2 emissions.

H_0: The level of forest preservation does not impact the level of CO2 emissions.

H_{12}: The higher the level of forest preservation, the lower the level of environmental consumption.

H_0: The level of forest preservation does not impact the level of environmental consumption.

In addition, the level of energy consumption and the relative size of the manufacturing sector are also taken into consideration in the case of CO2 emissions as Pachauri and Reisinger (2007) suggests that they are the largest and second largest sources of CO2 emissions

. For this reason, the following hypotheses are tested:

H_{13}: The higher the level of energy consumption, the higher the level of CO2 emissions.

H_0: The level of energy consumption does not impact the level of CO2 emissions.

H_{14}: The larger the relative size of the manufacturing sector, the higher the level of CO2 emissions.

H_0: The relative size of the manufacturing sector does not impact the level of CO2 emissions.

Regression Models

In order to test these hypotheses presented above, the present study conducts ordinary least squares (OLS) regression analyses using data from 1997 to 2007. Incorporating the factors discussed above in the hypotheses, the empirical models in this study take the form of Eq. (1) for CO2 emissions analyses and Eq. (2) for environmental consumption analyses as indicated below:

Eq. (1): $CO2\_emissions_{it}$

$= b_0 + b_1\ FDI\_Intensity_{it} + b_2\ Economic\_Development_{it} + b_3\ Population_{it} + b_4\ Export\_intensity_{it} + b_5\ Exports\_to\_Developed_{it} + b_6\ Forest\_Preservation_{it} + b_7\ Energy\_Consumption_{it} + b_8\ Manufacturing_{it}$

wherein the level of CO2 emissions in a country is a function of the level of FDI intensity, the level of economic development, the size of population, the level of export intensity, the level of exports to developed countries, the level of forest preservation, the level of energy consumption, and the relative size of the manufacturing sector.

Eq. (2): $Environmental\_Consumption_{it}$

$= b_0 + b_1\ FDI\_Intensity_{it} + b_2\ Economic\_Development_{it} + b_3\ Urbanization_{it} + b_4\ Export\_Intensity_{it} + b_5\ Exports\_to\_Developed_{it} + b_6\ Forest\_Preservation_{it}$

wherein the level of environmental consumption in a country is a function of the level of FDI intensity, the level of economic development, the level of urbanization, the level of export intensity, the level of exports to developed countries, and the level of forest preservation.

Countries included in the analyses

In the model above, each variable is indexed by country (i) and by time (t). The sets of countries considered in this study consist of 68 developing countries for CO2 emissions analyses and 88 developing countries for environmental consumption analyses. These counties are picked based on data availability for all the variables included in respective analyses. The definition of developing countries in the present study includes both low-income and middle-income countries based on the classification of the World Bank (n.d.a). Appendix 1 displays the lists of developing countries included in respective analyses of the present study.

Dependent Variables and Data

CO2 emissions

The dependent variables in the present study are the level of CO2 emissions and the level of environmental consumption. The level of CO2 emissions is quantified by using total CO2 emissions (kt) available at the World Bank's World Development Indicators (n.d.b). According to the World Bank (n.d.b), data for total CO2 emissions (kt) include emissions stemming from the burning of fossil fuels and the manufacture of cement. The present study employs absolute levels rather than per capita CO2 emissions because such data may not reflect the levels of CO2 emissions well for developing countries, where the rapid growth of population may excessively lower the level of CO2 emissions measured by per capita CO2 emissions. In the present study, the dependent variables are examined at three points in time, in 1999, 2003, and 2007 in order to assess the short-term, middle-term, and long-term impacts of FDI intensity. This variable is logged (natural log) in order to correct for skewness, and all other variables in this study that are logged (ln) are done so for the same reason.

Environmental Consumption

The level of environmental consumption is quantified by per capita ecological footprint. The ecological footprint is allegedly a most comprehensive unit of measurement that assesses the environmental impacts by estimating the quantity of land necessary to support consumption of natural resources and absorption of carbon dioxide waste of a nation. (Wackernagel et al., 2002). Recently, ecological footprint gained increasing attention as many scholars investigated the determinants of ecological footprint (e.g. Jorgenson, 2004, 2005; Jorgenson & Burns, 2006;

Jorgenson, Rice, & Crowe, 2005) and utilized it as a measure of environmental consumption as seen in the literature review. According to Wackernagel et al., (2002), ecological footprint is based upon the following six subcomponents: 1) Cropland: the area of cropland required to produce the crops consumed; 2) Grazing land: the area of grazing land to produce the animal products; 3) Forest: the area of forest required to produce the wood and paper; 4) Fishing: the area of sea required to produce the fish and other marine products; 5) Built-up land: the are of land required to accommodate housing and infrastructure; and 6) Energy: the area of forest required to absorb carbon emissions resulting from energy consumption. Data for this variable are gathered from the Living Planet Report in 2002 (for the year 1999) and 2006 (for the year 2003), and the Ecological Footprint Atlas in 2010 (for the year 2007), all of which are published by the Global Footprint Network. Likewise CO2 data, these data are also logged (ln).

Independent Variables and Data

FDI Intensity

The independent variable of particular interest in this study is the level of FDI intensity, which is measured by the accumulated amount of inward FDI stock as a percentage of GDP. Data for this variable, which are logged (ln), are obtained from the UNCTAD statistics database (n. d.). Importantly, data for this independent variable are averaged for each country over the three years from 1997 to 1999 for the purpose of controlling for anomalous fluctuations present in any particular year, and all other variables in this study that are averaged over the three-year period are done so for the same reason.

Economic Development

The level of economic development is incorporated in the model as a control variable and quantified by using GDP per capita (in 2005 US$). Data for this variable are taken from the

World Development Indicators (n.d.b), averaged over the three years from 1997 to 1999, and transformed by using natural logarithms (ln).

Population

For the CO2 emissions analyses, the size of population is included, and quantified by the total population in 1999, for which data are acquired from the World Development Indicators (n.d.b).

Urbanization

On the other hand, for the environmental consumption analyses, the level of urbanization is controlled for by using the data for urban population as a percentage of total population in 1999, which are obtained from the World Development Indicators (n.d.b).

Export Intensity

The level of export intensity is measured by exports of goods and services as a percentage of GDP, for which data are also obtained from the World Development Indicators (n. d.b). Data for this variable are averaged over the three-year period, and logged (ln) for correcting skewness.

Export to Developed Countries

Furthermore, the study controls for the level of exports to developed countries. Generally, this variable is often quantified by weighted export flows created by Jorgenson and Rice (2005). However, due to the data availability of Jorgenson and Rice's weighted export flows for the period of investigation, the study employs, as proximities, data for merchandise exports to high-income economies as a percentage of total merchandise exports, which are available from the World Development Indicators (n.d.b). Data for this variable are averaged over the three-year period and transformed by natural logarithms (ln).

Forest Preservation

The level of forest preservation is quantified by forest area as a percentage of total land in 1999. Like many other variables, data for this variable are collected from the World Development Indicators (n.d.b). Recognizing that forest area is one of the subcomponents of ecological footprint, the inclusion of this variable is still justifiable considering that the calculation of ecological footprint is based on the consumption of forest, which is conceptually different from the preservation of forest. In fact, ecological footprint does not have a significant correlation with forest area as apparent from the correlation table below.

Energy Consumption

In addition, for the CO2 emissions analyses, the level of energy consumption is also added to the model, and quantified by energy use (kg of oil equivalent per capita). Data for this variable are obtained from the World Development Indicators (n.d.b), and averaged over the three-year period.

Manufacturing

The relative size of the manufacturing sector in the CO2 emissions analyses is measured by manufacturing with value added as a percentage of GDP. Data for this variable is gathered from the World Development Indicators (n.d.b), and averaged over the three-year period.

Table 1 and Table 2 presented below respectively provide descriptive statistics and bivariate correlations for all the variables included in the respective analyses.

Table 1: Descriptive Statistics

Data Set for Carbon Dioxide (CO2) Emissions Analyses (N=68)					
	Mean	SD	Skewness	Min.	Max.
CO2 Emissions, 99 (ln)	9.8766	1.90016	0.465	6.71	15.01
CO2 Emissions, 03 (ln)	10.0049	1.91196	0.479	6.99	15.33
CO2 Emissions, 07 (ln)	10.2049	1.89474	0.524	7.18	15.73
FDI / GDP (ln)	2.6658	0.99216	-0.511	-0.39	4.7
GDP, per capita (ln)	7.059	0.9911	0.115	4.9	9.01
Total Population (ln)	16.7244	1.39841	0.669	13.99	20.95
Exports / GDP (ln)	3.3476	0.57537	-0.249	1.89	4.7
Exports to High-income / Total Exports (ln)	4.1942	0.2792	-1.202	3.27	4.57
Forest Area / Total Area	30.1197	22.03014	0.406	0.06	85.38
Energy Use (ln)	6.5574	0.71479	0.33	4.91	8
Manufacturing / GDP	16.18	7.197	0.418	5	34
Data Set for Environmental Consumption Analyses (N=88)					
	Mean	SD	Skewness	Min.	Max.
Ecological Footprint, per capita, 99 (ln)	0.2701	0.48473	0.344	-0.76	1.39
Ecological Footprint, per capita, 03 (ln)	0.2075	0.51261	0.413	-0.69	1.39
Ecological Footprint, per capita, 07 (ln)	0.5302	0.49975	0.39	-0.48	1.73
FDI / GDP (ln)	2.6546	1.02532	0.272	-0.39	6.58
GDP, per capita (ln)	6.8455	1.05875	0.202	4.8	9.01
Urban Pop. / Total Pop.	43.8592	19.61692	0.202	8.04	88.95
Exports / GDP (ln)	3.2782	0.59724	-0.212	1.88	4.7
Exports to High-income / Total Exports (ln)	4.1983	0.26604	-1.129	3.27	4.57
Forest Area / Total Area	29.4881	21.73148	0.457	0.06	85.38

Table 2: Correlations

Data Set for Carbon Dioxide (CO2) Emissions Analyses (N=68)

	1	2	3	4	5	6	7	8	9	10
CO2 Emissions, 99 (ln)										
CO2 Emissions, 03 (ln)	0.994									
CO2 Emissions, 07 (ln)	0.988	0.994								
FDI / GDP (ln)	-0.058	-0.062	-0.078							
GDP, per capita (ln)	0.431	0.420	0.408	-0.091						
Total Population (ln)	0.724	0.735	0.745	-0.036	-0.097					
Exports / GDP (ln)	-0.134	-0.143	-0.142	0.102	0.190	-0.417				
Exports to High-income / Total Exports (ln)	0.259	0.257	0.257	-0.011	0.170	0.305	0.080			
Forest Area / Total Area	-0.295	-0.283	-0.279	-0.030	0.143	-0.138	0.133	0.109		
Energy Use (ln)	0.566	0.542	0.520	-0.073	0.630	-0.033	0.207	-0.002	-0.128	
Manufacturing / GDP	0.516	0.513	0.491	-0.011	0.406	0.221	0.238	0.136	-0.028	0.422

Data Set for Environmental Consumption Analyses (N=88)

	1	2	3	4	5	6	7	8
Ecological Footprint, per capita, 99 (ln)								
Ecological Footprint, per capita, 03 (ln)	0.815							
Ecological Footprint, per capita, 07 (ln)	0.764	0.814						
FDI / GDP (ln)	-0.035	0.081	0.054					
GDP, per capita (ln)	0.717	0.712	0.600	-0.088				
Urban Pop. / Total Pop.	0.673	0.620	0.544	0.006	0.797			
Exports / GDP (ln)	0.330	0.348	0.319	0.094	0.386	0.211		
Exports to High-income / Total Exports (ln)	-0.006	0.044	0.058	0.055	0.137	0.054	0.097	
Forest Area / Total Area	0.011	-0.026	-0.052	0.079	0.129	0.171	0.135	0.033

V. Research Findings

Table 3 and 4 present the results for the CO2 emissions analyses and environmental consumption analyses respectively. In these tables, standardized coefficients are flagged for statistical significance, t-scores are presented in parentheses, and VIFs are reported in brackets. Findings for respective analyses are presented and discussed one at a time.

The reported total CO2 emissions analyses include a total of nine models consisting of three different base models, each of which are tested with total CO2 emissions at three different points in time; 1999, 2003, and 2007. Model 1 through 3 consists of all the variables included in Eq (1); FDI, GDP per capita, total population, exports, exports to developed countries, forest area, energy use, and manufacturing. However, the analyses exclude energy use from Model 4 through 6 and GDP per capita from Model 7 through 9. This is because the VIFs for GDP per capita and energy use are, even though within acceptable levels, relatively higher as shown in Table 3, and the multi-collinearity diagnosis found collinearity between the two variables. Since collinearity between two independent variables in the same model can cause problems in estimating the adjusted R square and the regression coefficients, Model 4 through 9 increased the accuracy in their estimation by excluding one of these two variables from the models. All the models reported in Table 3 are statistically significant with their p-values lower than .01 levels and explain more than 85 percent of variation within the cases with the adjusted R squares of all the tested models being above 0.85.

To begin with, results for FDI as a percentage of GDP are largely negative except for Model 1 and 2 and statistically insignificant across all tested models. These results, which fail to reject the null hypothesis, are inconsistent with the study's prediction and do not support the hypothesis H_1. Like FDI, results for exports sent to high-income economies are also contrary to the prediction and failed to support the hypothesis H_9 as they consistently show negative signs and statistical insignificance across all tested models. From the findings on these two variables, apparently neither the level of FDI intensity nor the level of exports to developed countries significantly affects the level of CO2 emissions within developing countries.

On the other hand, all the other variables included in the analyses seem to have an important role to play either in an increase or a decrease of CO2 emissions within developing countries. Results for GDP per capita, total population, and energy use are positive and statistically significant across all tested models, implying that these three variables are all positively correlated with CO2 emissions. These results confirm the hypothesis H_3, H_5, and H_{13}, suggesting that the higher the level of economic development, the size of population, and the level of energy consumption, the higher the level of CO2 emissions. Especially, the size of population seems to be the most influential factor among all the variables included in the analyses, as the coefficients of total population regularly show the highest value among all coefficients. Moreover, a comparison of the coefficients across models using CO2 emissions data in different years suggests that the effects of population size on the level of CO2 emissions are more robust in the long term while the effects of economic development and energy consumption levels are stronger in the short term.

Similarly, results for exports as a percentage of GDP and manufacturing as a percentage of GDP are consistently positive, but significant only in Model 6 in the case of exports and in Model 4, 5, and 7 through 9 in the case of manufacturing. These findings indicate that the level of export intensity increases the level of CO2 emissions particularly in the long term, while the relative size of the manufacturing sector likely does so especially in the short or middle term. However, the effects of export intensity and manufacturing on the level of CO2 emissions

Table 3: Results for the Regression of Total CO2 emissions on Selected Independent Variables, 1997-2007

Independent Variable	Model 1 (1999)	Model 2 (2003)	Model 3 (2007)	Model 4 (1999)	Model 5 (2003)	Model 6 (2007)	Model 7 (1999)	Model 8 (2003)	Model 9 (2007)
FDI / GDP, 97-99 (ln)	.008 (.262) [1.027]	.003 (.086) [1.027]	-.015 (-.409) [1.027]	-.004 (-.086) [1.025]	-.008 (.181) [1.025]	-.026 (.556) [1.025]	-.001 (-.033) [1.024]	-.007 (-.158) [1.024]	-.026 (-.566) [1.024]
GDP, per capita, 97-99 (ln)	.269** (5.947) [2.046]	.272** (5.456) [2.046]	.285** (5.405) [2.046]	.481** (9.202) [1.338]	.469** (8.831) [1.338]	.467** (8.775) [1.338]			
Total Population, 99 (ln)	.748** (18.065) [1.719]	.760** (16.613) [1.719]	.791** (16.331) [1.719]	.766** (12.955) [1.714]	.777** (12.933) [1.714]	.806** (13.375) [1.714]	.695** (13.703) [1.638]	.706** (12.995) [1.638]	.734** (12.807) [1.638]
Exports / GDP, 97-99 (ln)	.061 (1.546) [1.538]	.060 (1.387) [1.538]	.086 (1.888) [1.538]	.103 (1.851) [1.510]	.099 (1.758) [1.510]	.123* (2.168) [1.510]	.034 (.701) [1.518]	.033 (.638) [1.518]	.058 (1.060) [1.518]
Exports to High-income / Total Exports, 97-99 (ln)	-.009 (-.248) [1.271]	-.016 (-.415) [1.272]	-.027 (-.648) [1.272]	-.054 (-1.075) [1.239]	-.058 (-1.139) [1.239]	-.066 (-1.283) [1.239]	-.042 (-.978) [1.197]	-.036 (-.766) [1.197]	-.027 (-.560) [1.197]
Forest Area / Total Area, 99	-.189** (-5.587) [1.149]	-.179** (-4.787) [1.149]	-.180** (-4.538) [1.149]	-.262** (-5.613) [1.066]	-.246** (-5.199) [1.066]	-.242** (-5.089) [1.066]	-.139** (-3.383) [1.078]	-.128** (-2.923) [1.078]	-.126** (-2.721) [1.078]
Energy Use, 97-99 (ln)	.354** (7.982) [1.972]	.328** (6.685) [1.972]	.304** (5.853) [1.972]				.509** (11.319) [1.290]	.485** (10.059) [1.290]	.468** (9.212) [1.290]
Manufacturing / GDP, 97-99	.074 (1.891) [1.542]	.079 (1.823) [1.542]	.050 (1.086) [1.542]	.127* (2.306) [1.543]	.128* (2.286) [1.543]	.095 (5.089) [1.543]	.130** (2.725) [1.453]	.136** (2.652) [1.453]	.109* (2.024) [1.453]
R2 /	.941	.928	.920	.878	.874	.873	.906	.892	.880
Adjusted R2	.933	.918	.909	.863	.859	.858	.895	.879	.866
F	117.924	95.315	84.308	61.448	59.336	58.838	82.479	70.756	62.699

Notes: N=68; standardized coefficients flagged for statistical significance; t-values appear in parentheses; VIFs appear in brackets; * indicates $p < .05$; ** indicates $p < .01$ (two-tailed tests).

are relatively lower compared to those of economic development, population, and energy consumption.

Contrarily, with the coefficients of forest area as a percentage of total area being negative and statistically significant across all tested models, results constantly indicate a negative correlation between forest area and CO2 emissions. These findings confirm the hypothesis H_{11}, which postulates that the higher the level of forest preservation, the lower the level of CO2 emissions within developing countries. Comparing the coefficients across all tested models, the impact of forest preservation on the level of CO2 emissions seems to be relatively stronger in the short term while it decreases little by little over time.

Turning to the analyses of environmental consumption, the reported analyses covers nine models consisting of three different base models tested three times with 1999, 2003, and 2007 per capita ecological footprint. Like the CO2 emissions analyses, Model 1 through 3 incorporates all the variables included in Eq (2); FDI, GDP per capita, urban population, exports, exports to developed countries, and forest area, while Model 4 through 6 and Model 7 through 9 exclude urban population and GDP per capita respectively from their models. The exclusion of urban population and GDP per capita from respective models is due to the collinearity issue between the two variables, which was detected from the multi-collinearity diagnosis as well as the higher values of VIFs for these two variables. Reported models for the environmental consumption analyses are statistically significant with 0.01 and lower alpha levels and explain about 31 to 57 percent of variation in the cases respectively.

Firstly, like the results in the CO2 emissions analyses, results from the environmental consumption analyses suggest that neither the level of FDI intensity nor the level of exports to developed countries significantly affect the level of environmental consumption. In fact, results

Table 4: Results for the Regression of Per Capita Ecological Footprint on Selected Independent Variables, 1997-2007

Independent Variable	Model 1 (1999)	Model 2 (2003)	Model 3 (2007)	Model 4 (1999)	Model 5 (2003)	Model 6 (2007)	Model 7 (1999)	Model 8 (2003)	Model 9 (2007)
FDI / GDP, 97-99 (ln)	.011 (.154) [1.059]	.005. (.072) [1.059]	.037 (.420) [1.059]	.033 (.445) [1.035]	.021. (.290) [1.035]	.053 (.604) [1.035]	-.047 (-.589) [1.013]	-.060 (-.769) [1.013]	-.012 (-.132) [1.013]
GDP, per capita, 97-99 (ln)	.507** (3.750) [3.514]	.566** (4.312) [3.514]	.426* (2.651) [3.514]	.720** (8.937) [1.193]	.719** (9.339) [1.193]	.581** (6.183) [1.193]			
Urban Pop. / Total Pop., 99	.247 (1.937) [3.113]	.177 (1.433) [3.113]	.179 (1.183) [3.113]				.635** (7.944) [1.057]	.610** (7.689) [1.057]	.505** (5.527) [1.057]
Exports / GDP, 97-99 (ln)	.131 (1.438) [1.201]	.146 (1.899) [1.201]	.140 (1.492) [1.201]	.107 (1.346) [1.171]	.128 (1.683) [1.171]	.123 (1.318) [1.171]	.228** (2.832) [1.073]	.254** (3.175) [1.073]	.222* (2.407) [1.073]
Exports to High-income / Total Exports, 97-99 (ln)	-078 (-1.062) [1.032]	-.068 (-.960) [1.032]	-.034 (-.389) [1.032]	-.092 (-1.239) [1.021]	-078 (-1.100) [1.021]	-.044 (-.507) [1.021]	-.037 (-.470) [1.008]	-.022 (-.288) [1.008]	-.001 (-.008) [1.008]
Forest Area / Total Area, 99	-.162* (-2.200) [1.038]	-.261** (-3.656) [1.038]	-.196* (-2.228) [1.038]	-.159* (-2.133) [1.038]	-.259** (-3.610) [1.038]	-.194* (-2.216) [1.038]	-149 (-1.890) [1.036]	-247** (-3.146) [1.036]	-186* (-2.050) [1.036]
R2 /	.578	.603	.404	.559	.593	.393	.505	.511	.352
Adjusted R2	.547	.573	.359	.532	.568	.356	.475	.482	.312
F	18.515	20.472	9.132	20.77	23.849	10.628	16.749	17.163	8.899

Notes: N=88; standardized coefficients flagged for statistical significance; t-values appear in parentheses; VIFs appear in brackets; * indicates p < .05; ** indicates p < .01 (two-tailed tests).

for FDI stock as a percentage of GDP and exports to high-income economies are statistically insignificant across all tested models, despite the fact that the results for exports to high-income economies constantly show the expected negative signs. Failing to reject the null hypotheses, these findings indicate the lack of consistent relationships between the level of FDI intensity, exports to developed countries, and environmental consumption within developing countries.

Secondly, based on the results from the analyses, apparently the levels of economic development, urbanization, and export intensity are all positively correlated with the level of CO_2 emissions. As Table 4 indicates, results for GDP per capita are positive and statistically significant across all tested models, while results for urban population as a percentage of population and exports as a percentage of GDP are consistently positive but significant only in Model 7 through 9, where GDP per capita is excluded. The results particularly for GDP per capita and urban population are largely in line with prior research (Jorgenson & Rice 2005; Rice, 2006, 2007b; York, Rosa, & Dietz, 2003), while the results for exports contradict the results from previous studies, which indicated a negative correlation between exports as a percentage of GDP and ecological footprint (Jorgenson, 2005; Jorgenson & Burns, 2006). This contradiction in results may be due to the difference between the cases included in the previous studies and the present study. Overall, with the coefficients of GDP per capita being relatively higher than those of other variables, the level of economic development appears to have the most robust impact on environmental consumption among all the factors considered in the analyses. Furthermore, the findings for each variable suggests that the effects of economic development, urbanization, and export intensity are stronger either in the short or middle term, in the short term, and in the middle term respectively.

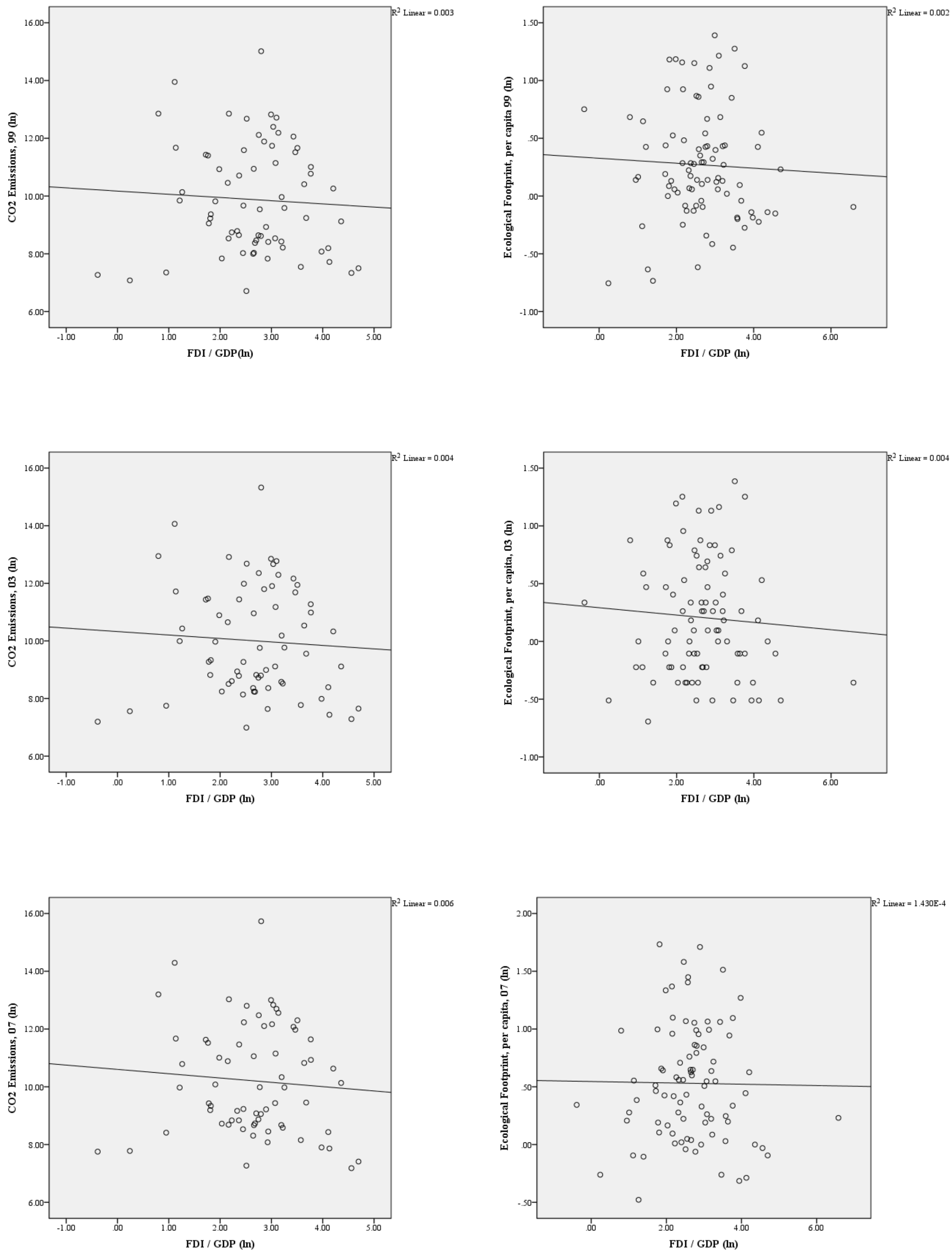
On the other hand, the results for forest area as a percentage of total area, which are negative and statistically significant in a consistent manner except Model 7, suggest that the level of forest preservation is negatively correlated with the level of environmental consumption. These results, therefore, confirm the hypothesis H_{12}, which hypothesized that the higher the level of forest preservation, the lower the level of environmental consumption within developing countries. In addition, comparing the coefficients of the variable between different models, one would find that the effects of forest preservation on the level of environmental consumption appear to be strongest in the middle term and stronger in the long term rather than short term.

VI. Discussion and Research Implications

Overall, results from the present study largely correspond with the hypotheses derived from prior research and existing knowledge on CO2 emissions and environmental consumption. GDP per capita, total population, exports as a percentage of GDP, energy use, and manufacturing as a percentage of GDP are all positively associated with CO2 emissions. While, GDP per capita, urban population as a percentage of total population, and exports as a percentage of GDP are all positively correlated with ecological footprint. By contrast, forest area as a percentage of total area indicates a negative correlation with both CO2 emissions and ecological footprint.

However, results for FDI stock as a percentage of GDP and exports sent to high-income economies, which are constantly insignificant across all tested models, contradicts the study's hypotheses and the theory of ecologically unequal exchange. In an attempt to comprehend the reasons why the findings are the way they are, the present study looks at the scatterplots graphs showing the effects of FDI on CO2 emissions (on the left) and environmental consumption (on the right) as shown in Figure 1. These graphs evidence that in general the relationships between FDI, CO2 emissions, and environmental consumption are tilted slightly toward negative although there appears to be a serious lack of any clear relationship. On top of this, the presence of a couple of outliers on both sides of FDI spectrum, which received either significantly lower or higher levels of FDI relative to their GDP, seems to be blurring the direction of these relationships. For further clarification, these outliers may need to be identified.

Figure 1: Emissions Effect (Left) and Consumption Effect (Right) of FDI, 1999-2007



Therefore, the present study takes a further step to explore the statistical data that the study utilized for its regression analyses with a focus on the top and bottom 5 countries with the highest and lowest level of FDI intensity. Table 5 presents the statistical data on FDI, CO_2 emissions, ecologically footprint and two other variables which produced most robust results in respective analyses for the top and bottom 5 countries with the highest and lowest level of FDI intensity. The highlighted points in this table are discussed as follows.

First, by looking at the data for FDI stock as a percentage of GDP only, one would notice that there is a certain difference in the level of FDI intensity among the top 5 countries as well as between the top and bottom 5 countries. Especially, Liberia, for instance, scores significantly higher in its amount of inward FDI stock relative to its GDP (720.37). This might be partly due to the extremely small size of its economy; Liberia was ranked 184th based on $2.898 billion of its GDP measured by purchasing power parity in 2013 (Central Intelligence Agency, 2014). For some countries with the extremely small size of economy, like Liberia, FDI as a percentage of GDP may not well represent their level of FDI. For this reason, for future research, the use of other FDI data such as FDI as a percentage of population may be beneficial.

Also, speaking of the data set for CO_2 emissions analyses specifically, clearly the level of CO_2 emissions widely varies even within the group of top 5 countries with the highest level of FDI intensity or within the group of bottom 5 countries with the lowest level of FDI intensity. For instance, Zambia and the Republic of Congo, which accumulated about 110 and 62 percent of their annual GDP in FDI stock respectively, generated a relatively lower level of CO_2 emissions in 1999, 2003, and 2007. Contrarily, in India and Iran, which piled only about 3 and 2 percent of their annual GDP in FDI stock respectively, the total level of CO_2 emissions was

Table 5: Data for the Countries with the Highest and Lowest Level of FDI

Data Set for Carbon Dioxide (CO2) Emissions Analyses (N=68)

		FDI / GDP, 1997-99	CO2 Emissions, 1999	CO2 Emissions, 2003	CO2 Emissions, 2007	Total Population, 1999	Energy Use, 1997-99
1	Zambia	109.61	1807.83	2101.19	1653.82	9839179	633.82
2	Angola	78.12	9156.5	9064.82	25151.95	13510616	530.5
3	Azerbaijan	67.01	28576.93	30615.78	41426.1	7982750	1432.86
4	Congo, Rep.	62.17	821.41	1085.43	1437.46	3044444	241.64
5	Nigeria	60.83	44788.74	93138.13	95209.99	119831888	730.75
64	India	3.05	1144390.03	1281913.53	1611404.48	1025014711	424.2
65	Benin	2.58	1562.14	2321.21	4499.41	6740491	342.56
66	Iran, Islamic Rep.	2.22	382713.79	418859.41	539789.73	64858754	1812.92
67	Nepal	1.27	3219.63	2951.94	2698.91	22690158	331.51
68	Gabon	0.68	1437.46	1334.79	2332.21	1195919	1264.99

Data Set for Environmental Consumption Analyses (N=88)

		FDI / GDP, 1997-99	Ecological Footprint, 1999	Ecological Footprint, 2003	Ecological Footprint, 2007	GDP per capita, 1997-99	Urban Pop. / Total Pop., 1999
1	Liberia	720.37	0.91	0.7	1.26	121	43.99
2	Zambia	109.61	1.26	0.6	0.91	602	35.26
3	Angola	78.12	0.87	1	1	1220	31.69
4	Azerbaijan	67.01	1.73	1.7	1.87	741	51.19
5	Congo, Rep.	62.17	0.92	0.6	0.96	1575	58.23
84	Burkina Faso	2.74	1.18	1	1.32	332	17.17
85	Benin	2.58	1.15	0.8	1.23	495	38.02
86	Iran, Islamic Rep.	2.22	1.98	2.4	2.68	2137	63.32
87	Nepal	1.27	0.83	0.7	3.56	281	12.89
88	Gabon	0.68	2.12	1.4	1.41	7322	79.26

significantly higher than that of other countries in all the estimated years. Thus, the level of FDI intensity appears to seldom explain the variation in the level of CO2 emissions.

On the other hand, as Table 5 displays, the size of population and the level of energy consumption seem to largely explain the variation in the level of CO2 emissions. Zambia and the Republic of Congo, which generated a relatively lower level of CO2 emissions, have a relatively smaller population and consume a relatively smaller amount of energy. India and Iran, which produced a relatively higher level of CO2 emissions, have a notably larger size of population and a relatively higher level of energy consumption. Thus, the observation confirm the findings that the larger the size of population, or the higher the level of energy consumption, the higher the level of CO2 emissions.

Likewise, the data set for environmental consumption analyses evidently demonstrates that the level of environmental consumption varies regardless of the level of FDI intensity, but rather according to the level of economic development and urbanization. Liberia and Nepal, for example, have a relatively lower ecological footprint owing to to their lower levels of economic development and urbanization. While, Iran and Gabon scores relatively higher in their ecological footprint thanks to their higher levels of economic development and urbanization.

Based on these observations, obviously the levels of economic development and urbanization can more precisely explain the variation in the level of environmental consumption compared to the level of FDI intensity.

Based upon these observations, the present study draw a conclusion that FDI in aggregate can hardly be generalized to contribute to either higher levels of environmental degradation or lower levels of environmental consumption within developing countries, at least within the scope of the analyses in this study. A part of the reasons for this case may be because FDI in different sectors may affect environmental degradation and consumption in developing countries in a different way.

Certainly, FDI in the primary or secondary sector, which are reportedly responsible for various forms of environmental degradation including GHG emissions, water pollution, and deforestation, may be detrimental to the environment of host developing countries, as previous studies have already suggested (Jorgenson, 2006a 2006b, 2007a, 2007b, 2008; Shandra, 2007). Additionally, like the primary sector export to developed countries (Jorgenson, Austin, & Dick, 2009), FDI in the primary sector also may be responsible for lower levels of environmental consumption in developing countries.

However, FDI in the tertiary sector may be less harmful for the environment of developing countries when it focuses on service industries including hotel, restaurant, finance, insurance, communication, etc. Moreover, it may rather contribute to higher levels of environmental consumption in developing countries by providing relatively higher wages than many industries in the primary sector.

In fact, although Zambia was one of the top 5 FDI dependent countries with its accumulated stock of FDI amounting to about 110 percent of its annual GDP, as of year 2000, about 52 percent of total FDI in Zambia was accumulated in the tertiary sector, while about 34 and 10 percent of total FDI were accumulated in the primary and secondary sector respectively (UNCTAD, 2008). Thus, this may well explain the reason why the level of CO2 emissions was relatively lower in Zambia despite its higher level of FDI intensity.

At any rate, since the effect of FDI could vary in its characteristics depending on its sector, origin, location, and so on, for future studies, FDI with any specific characteristics may be more appropriate and helpful for accurately estimating the impacts of FDI on the environment or any other factors on which FDI may have an substantial influence. The increasing availability of sectorial FDI data and origin-specific FDI data, which still remains a critical issue in empirical research, would enable researchers to expand the existing knowledge about FDI by examining more closely both determinants and impacts of FDI. Further research needs to be done with the improvement in model specification and variable selection, including the use of the per capita FDI and sector-wise FDI data, in order to more accurately estimate the impacts of FDI on the CO2 emissions and environmental consumption in developing countries and reveal the ways by which FDI is contributing to the support of ecologically unequal exchange between the developed and developing countries.

References

Aliyu, M. A. (2005). Foreign direct investment and the environment: Pollution haven hypothesis revisited, Presented at *the Eighth Annual Conference on Global Economic Analysis*, Lübeck, Germany.

Andersson, J. O., & Lindroth, M. (2001). Ecological unsustainable trade. *Ecological Economics*, *37*, 113–22.

Antweiler, W., Copeland, B. R., & Taylor, M. S. (2001). Is free trade good for the environment?. *American Economic Review*, *91 (4)*, 877-908.

Bartik, T. J. (1988). The effects of environmental regulation on business location in the United States. *Growth Change*, *19 (3)*, 22–44.

Beak, J., & Koo, W. W. (2009). A dynamic approach to FDI-environment nexus: The case of China and India. *Journal of International Economic Studies*, *13 (2)*, 87-108.

Beghin, J., & Poitier, M. (1995). Trade liberalization and the environment in the pacific basin: coordinated approaches to Mexican trade and environment policy. *American Journal of Agricultural Economics*, *77 (3)*, 778–85.

Bhattarai, M., & Hammig, M. (2001). Institutions and the Environmental Kuznets Curve for deforestation: a cross-country analysis for Latin America, Africa, and Asia. *World Development*, *29 (6)*, 995 – 1010.

Birdsall, N., & Wheeler, D. (1993). Trade policy and industrial pollution in Latin America: Where are the pollution havens?. *The Journal of Environment & Development*, *2 (1)*, 137-49.

Bringezu, S., & Schütz, H. (2001). Material use indicators for the European Union, 1980–1997: Economy-wide material flow accounts and balances and derived indicators of resource use. *EUROSTAT Working Paper, No. 2/2001/B/2*, Wuppertal Institute, Wuppertal.

Bunker, S. G. (1984). Modes of extraction, unequal exchange, and the progressive underdevelopment of an extreme periphery: The Brazilian Amazon. *American Journal of Sociology*, *89 (5)*, 1017-64.

Bunker, S. G., & Ciccantell, P. (2005). *Globalization and the race for resources.* Baltimore, MD: The Johns Hopkins University Press.

Canas, A., Ferrao, P., & Conceicao, P. (2003). A new Environmental Kuznets Curve? Relationship between direct material input and income per capita: evidence from industrialised countries. *Ecological Economics*, *46*, 217–29.

Central Intelligence Agency (2014). Liberia. *The World Factbook*. Retrieved from https://www.cia.gov/library/publications/the-world-factbook/geos/li.html

Copeland, B. R., & Taylor, M. S. (1997). A simple model of trade, capital mobility and the environment. *National Bureau of Economic research (NBER)*, *Working Paper 5898*.

Copeland, B. R., & Taylor, M. S. (2003). *Trade and the environment: Theory and evidence.* Princeton, NJ: Princeton University Press.

Dean, J. M. (2002). Testing the impact of trade liberalization on the environment: Theory and evidence. *Canadian Journal of Economics*, *35 (4)*, 819-842.

Dinda, S. (2004). Environmental Kuznets Curve hypothesis: A survey. *Ecological Economics*, *49*, 431–455.

Duerkson, C., & Leonard, H. J. (1980). Environmental regulations and the location of industries: An international perspective. *Columbia Journal of World Business*, *15 (2)*, 52–68.

Ederington, J., Levinson, A., & Minier, J. (2005). Footloose and pollution-Free. *Review of Economics and Statistics*, *87 (1)*, 92-99.

Fischer-Kowalski, M. (1998). Society's metabolism: The intellectual history of material flow analysis, part I, 1860–1970. *Journal of Industrial Ecology*, *2 (1)*, 61–78.

Fischer-Kowalski, M., & Amann, C. (2001). Beyond IPAT and Kuznets Curves: Globalization as a vital factor in analysing the environmental impact of socio-economic metabolism. *Population and Environment*, *23 (1)*, 7–47.

Friedman, J., Gerlowski, D. A., & Silberman, J. (1992). What attracts foreign multinational corporations? Evidence from branch plant location in the United States. *Journal of Regional Science*, *32*, 403–18.

Giljum, S., & Eisenmenger, N. (2004). North-south trade and the distribution of environmental goods and burdens: A biophysical perspective. *The Journal of Environment & Development*, *13 (1)*, 73–100.

Goldman Sachs Global Economics Group. (2007). *Global investment research: BRICs and beyond.* Retrieved from http://www.goldmansachs.com/our-thinking/archive/archive-pdfs/brics-book/brics-full-book.pdf

Grimes, P., & Kentor, J. (2003). Exporting the greenhouse: Foreign capital penetration and CO2 emissions 1980–1996. *Journal of World-Systems Research*, *9 (2)*, 261–75.

Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American free trade agreement. *National Bureau of Economic research (NBER), Working Paper 3914*.

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment, *Journal of Economics*, *110*, 353–77.

He, Jie. (2006). Pollution haven hypothesis and environmental impacts of foreign direct investment: The Case of industrial emission of sulfur dioxide (SO2) in Chinese provinces, *Ecological Economics*, *60 (1)*, 228-45.

Heil, M. T. (2001). International trade intensity and carbon emissions: A cross-country econometric analysis. *The Journal of Environment & Development, 10 (1)*, 35-49.

Hoffmann, R., Lee, C. G., Ramasamy, B., & Yeung, M. (2005). FDI and pollution: A Granger causality test using panel data. *Journal of International Development*, *17 (3)*, 311-17.

Holtz-Eakin, D., & Selden, T.M. (1995). Stoking the fires?: CO2 emissions and economic growth. *Journal of Public Economics*, *57*, 85–101.

Hornborg, A. (1998). Towards an ecological theory of unequal exchange: Articulating world system theory and ecological economics. *Ecological Economics*, *25*, 127–36.

Hornborg, A. (2001). *The Power of the Machine: Global inequalities of economy, technology and environment.* Walnut Creek, CA: Alta Mira Press.

Hornborg, A. (2003). Cornucopia or zero-sum game? The epistemology of sustainability. *Journal of World-Systems Research*, *9*, 205-18.

Hornborg, A. (2009). Zero-sum world: Challenges in conceptualizing environmental load displacement and ecologically unequal exchange in the world-system. *International Journal of Comparative Sociology*, *50*, 237-62.

Howell, G. (2007). The north-south environmental crisis: An unequal ecological exchange analysis. *New School Economic Review*, *2 (1)*, 77-99.

Jaffe, A. B., Peterson, S. R., Portney, P. R., & Stavins, R. N. (1995). Environmental regulation and the competitiveness of US manufacturing: What does the evidence tell us? *Journal of Economic Literature*, *33*,132–63.

Jorgenson, A. K. (2003). Consumption and environmental degradation: A cross-national analysis of the ecological footprint. *Social Problems*, *50 (3)*, 374-94.

Jorgenson, A. K. (2004). Uneven processes and environmental degradation in the world-economy. *Human Ecology Review*, *11*, 103–13.

Jorgenson, A. K. (2005). Unpacking international power and the ecological footprints of nations: A quantitative cross-national study. *Sociological Perspectives*, *48 (3)*, 383-402.

Jorgenson, A. K. (2006a). Global warming and the neglected greenhouse gas: A cross-national study of the social causes of methane emissions intensity, 1995. *Social Forces*, *84 (3)*, 1779-98.

Jorgenson, A. K. (2006b). The transnational organization of production and environmental degradation: A cross-national study of the effects of foreign capital penetration on water pollution intensity, 1980–1995. *Social Science Quarterly*, *87*, 711–30.

Jorgenson, A. K. (2006c). Unequal ecological exchange and environmental degradation: A theoretical proposition and cross-national study of deforestation. *Rural Sociology*, *71*, 685-712.

Jorgenson, A. K. (2007a). Does foreign investment harm the air we breathe and the water we drink?: A cross-national study of carbon dioxide emissions and organic water pollution in less-developed countries, 1975 to 2000. *Organization Environment*, *20 (2)*, 137-156.

Jorgenson, A. K. (2007b). The effects of primary sector foreign investment on carbon dioxide emissions from agriculture production in less developed countries, 1980-1999. *International Journal of Comparative Sociology*, *48 (1)*, 29-72.

Jorgenson, A. K. (2008). Structural integration and the trees: An analysis of deforestation in less-developed countries, 1990-2005. *Sociological Quarterly*, *49*, 503-27.

Jorgenson, A. K. (2009). The sociology of unequal exchange in ecological context: A panel study of lower-income countries, 1975–2000. *Sociological Forum*, *24 (1)*, 22–46.

Jorgenson, A. K., Austin, K., & Dick, C. (2009). Ecologically unequal exchange and the resource consumption/environmental degradation paradox: A panel study of less-developed countries, 1970–2000, *International Journal of Comparative Sociology*, *50 (3-4)*, 263–84.

Jorgenson, A. K., & Burns, T. J. (2007). The political-economic causes of change in the ecological footprints of nations, 1991–2001: A quantitative investigation. *Social Science Research*, *36 (2)*, 834–53.

Jorgenson, A. K., & Clark, B. (2009). The economy, military, and ecologically unequal exchange relationships in comparative perspective: A panel study of the ecological footprints of nations, 1975–2000. *Social Problems*, *56 (4)*, 621-46

Jorgenson, A. K., Dick, C., & Austin, K. (2010). The vertical flow of primary sector exports and deforestation in less-developed countries: A test of ecologically unequal exchange theory. *Society & Natural Resources*, *23 (9)*, 888–97.

Jorgenson, A. K., & Rice, J. (2005). Structural dynamics of international trade and material consumption: A cross-national study of the ecological footprints of less-developed countries. *Journal of World-Systems Research*, *11*, 57-77.

Kim, H. S., & Beak, J. (2011). The Environmental consequence of economic growth revisited. *Economics Bulletin*, *31*, 1198-21.

Koop, G., & Tole, L. (1999). Is there an Environmental Kuznets Curve for deforestation? *Journal of Development Economics*, *58*, 231-44.

Lee, C. G. (2009). Foreign direct investment, pollution and economic growth: evidence from Malaysia. *Applied Economic*, *41 (13)*, 1709-1716.

Leonard, J. H. (1988). *Pollution and the struggle for the world product Multinational Corporations, Environment, and International Comparative Advantage.* New York, NY: Cambridge University Press.

Levinson, A., & Taylor, S. M. (2008). Unmasking the pollution haven effect. *International Economic Review*, *49 (1)*, 223–54.

Lieb, C. M. (2003). The Environmental Kuznets Curve: A survey of the empirical evidence and of possible causes. *University of Heidelberg, Department of Economics, Discussion Paper Series No. 391.*

List, J. A., & Co, C. Y. (2000). The effects of environmental regulations on foreign direct investment. *Journal of Environmental Economics and Management, 40 (1)*, 1-20.

Low, P., & Yeates. A. (1992). Do ’dirty’ industries migrate?. *International Trade and the Environment, World Bank discussion paper*, *No. 159*, 89-104.

Lucas, R. E. B., Wheeler, D., & Hettige, H. (1992). Economic development, environmental regulation, and the international migration of toxic industrial pollution 1960-88. *Background paper for World Development Report 1992*.

Machado, G., Schaeffer, R., & Worrell, E. (2001). Energy and carbon embodied in the international trade of Brazil: An input-output approach. *Ecological Economics*, *39 (3)*, 409–24.

Madrid-Aris, M. E. (1998). International trade and the environment: Evidence from the North-America free trade agreement (NAFTA). Presented at *First World Congress, Environment Resource Economics*, Venice, Italy.

Martínez-Vela, C. A. (2001). World systems theory. paper prepared for *ESD.83 Research Seminar in Engineering Systems*, Massachusetts Institute of Technology.

Mazzanti, M., Montini, A., & Zoboli, R. (2007). Economic dynamics, emission trends and the EKC hypothesis: New evidence using NAMEA and provincial panel data for Italy. *FEEM Working Paper*, *No. 24*.

McAusland, C. (2008). Globalisation's direct and indirect effects on the environment. Presented at *OECD/ITF Global Forum on Transport and Environment in a Globalising World*, Guadalajara, Mexico.

McPherson, M. A., & Nieswiadomy, M. L. (2005). Environmental Kuznets Curve: threatened species and spatial effects. *Ecological Economics*, *55 (3)*, 395–407.

Muhammad, S., Samia, N., & Talat, A. (2011). Environmental consequences of economic growth and foreign direct investment: evidence from panel data analysis. *MPRA Paper*, *No. 32547*.

Muradian, R., & Giljum, S. (2007). Physical trade flows of pollution-intensive products: Historical trends in Europe and the world. in A. Hornborg, J. R. McNeill & J. Martinez-Alier (Eds.), *Rethinking environmental history: World-system history and global environmental change* (pp. 307–25). Walnut Creek, CA: AltaMira Press.

Muradian, R., & Martinez-Alier, J. (2001a). Globalization and poverty: An Ecological Perspective. *World Summit Papers of the Heinrich Böll Foundation, No. 7*.

Muradian, R., & Martinez-Alier, J. (2001b). South-north materials flow: History and environmental repercussions. *Innovation*, *14 (2)*, 171–87.

Muradian, R., & Martinez-Alier, J. (2001c). Trade and the environment: From a 'Southern' perspective. *Ecological Economics*, *36*, 281–97.

Muradian, R., O'Connor, M., & Martinez-Alier, J. (2002). Embodied pollution in trade: Estimating the ‘‘environmental load displacement’’ of industrialized countries. *Ecological Economics*, *41*, 51–67.

Nordström, H., & Vaughan, S. (1999). Trade and environment (Special studies No. 4). *World Trade Organization.* Geneva, Switzerland. Retrieved from https://www.wto.org/english/tratop_e/envir_e/environment.pdf

Odum, H. T. (1988). Self-organization, transformity, and information. *Science*, *242*, 1132–9.

Odum, H. T., & Arding, J. E. (1991). Emergy analysis of shrimp mariculture in Ecuador. Working paper prepared for Coastal Resources Center, University of Rhode Island, Narragansett, R. I.

Ozturk, I. (2007). Foreign direct investment – growth nexus: A review of the recent literature. *International Journal of Applied Econometrics and Quantitative Studies*, *4 (2)*, 79-98.

Pachauri, R. K., & Reisinger, A. (2007). *Climate change 2007: Synthesis report.* Intergovernmental Panel on Climate Change. Geneva, Switzerland.

Panayotou, T. (1993). Empirical tests and policy analysis of environmental degradation at different stages of economic development. *International Labour Office*, *Technology and Employment Programme*, *Working Paper WP238*, Geneva.

Panic, M. (1998). Transnational corporations and the nation state. in R. Kozul-Wright & R. Rowthorn (Eds.), *Transnational Corporations and the Global Economy* (pp. 244–76). Basingstoke, London: Macmillan Press Ltd.

Pao, H-T., & Tsai, C-H. (2011). Multivariate granger causality between CO2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product):

Evidence form a panel of a BRIC (Brazil, Russian Federation, India, and China) countries. *Energy*, *36*, 685-93.

Patterson, N., Montanjees, M., Motala, J., & Cardillo, C. (2004). Foreign direct investment: Trends, data availability, concepts, and recording practices. *International Monetary Fund.*

Perman, R., & Stern, D. I. (2003). Evidence from panel unit root and cointegration tests that the Environmental Kuznets Curve does not exist. *Australian Journal of Agricultural and Resource Economics*, *47*, 325–47.

Prebisch, R. (1950). The economic development of Latin America and its principal problems. *Economic Commission for Latin America, United Nations, Department of Economic Affairs*. Lake Success, NY: United Nations Publication.

Ratnayake, R. (1998). Do stringent environmental regulations reduce international competitiveness?: Evidence from an Inter-industry analysis. *International Journal of the Economics of Business*, *5*, 77-96.

Rice, J. (2006). Ecological unequal exchange: International trade and uneven cross-national social and environmental processes. (A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of philosophy). *Washington State University*, *Department of Sociology*.

Rice, J. (2007a). Ecological unequal exchange: Consumption, equity and unsustainable structural relationships within the global economy. *International Journal of Comparative Sociology*, *48*, 43-72.

Rice, J. (2007b). Ecological unequal exchange: International trade and uneven utilization of environmental space in the world system. *Social Forces*, *85 (3)*, 1369-92.

Roberts, J. T., & Grimes, P. K. (1997). Carbon intensity and economic development 1962–1991: A brief exploration of the Environmental Kuznets Curve. *World Development*, *25 (2)*, 191–8.

Roberts, J. T., & Parks, B. C. (2009). Ecologically unequal exchange, ecological debt, and climate justice: The history and implications of three related ideas for a new social movement. *International Journal of Comparative Sociology*, *50*, 385-409.

Romero-Ávila, D. (2008). Questioning the empirical basis of the Environmental Kuznets Curve for CO2: New evidence from a panel stationarity test robust to multiple breaks and cross-dependence. *Ecological Economics*, *64 (3)*, 559–74.

Shandra, J. M. (2007). Economic Dependency, Repression, and Deforestation: A Quantitative, Cross-National Analysis. *Sociological Inquiry*, *77 (4)*, 543–71.

Shandra, J. M., Leckband, C., McKinney, L. A., & London, B. (2009). Ecologically unequal exchange, world polity, and biodiversity loss: A cross-national analysis of threatened mammals. *International Journal of Comparative Sociology*, *50 (3-4)*, 285-310.

Shandra, J. M., Shor, E., & London, B. (2009). World polity, unequal ecological exchange, and organic water pollution: A cross-national analysis of developing nations. *Human Ecology Review*, *16*, 53-63.

Shi, A. (2003). The impact of population pressure on global carbon dioxide emissions, 1975–1996: Evidence from pooled cross-country data. *Ecological Economics*, *44 (1)*, 29–42.

Singer, H. (1950). The distributions of gains between investing and borrowing countries. *American Economic Review*, *40*, 473-85.

Stern, D. I. (2004). The rise and fall of the Environmental Kuznets Curve. *World Development*, *32 (8)*, 1419–39.

Stern, D. I., Common, M. S., & Barbier, E. B. (1996). Economic growth and environmental degradation: a critique of the Environmental Kuznets Curve. *World Development*, *24*, 1151–60.

Strutt, A., & Anderson, K. (1999). Will trade liberalization harm the environment? The case of Indonesia to 2020. Presented at *World Bank Conference on Globalization Policy and Environment*, Washington, DC.

Tobey, J. (1990). The effects of domestic environmental policies on patterns of world trade: An empirical test. *Kyklos*, *43*,191–209.

UNCTAD. (2004). *World investment report 2004: The shift towards service*. New York: United Nations Publication. Retrieved from http://unctad.org/en/Docs/wir2004_en.pdf

UNCTAD. (2008). *World investment report 2008: Transnational Corporations and the Infrastructure Challenge*. New York: United Nations Publication. Retrieved from http://unctad.org/en/Docs/wir2008_en.pdf

UNCTAD. (2010). *World investment report 2010: Investing in a Low-Carbon Economy*. New York: United Nations Publication. Retrieved from http://unctad.org/en/Docs/wir2010_en.pdf

UNCTAD. (2013). *Global investment trend monitor: The rise of BRICS FDI and Africa*. New York: United Nations Publication. Retrieved from http://unctad.org/en/PublicationsLibrary/wir2013_en.pdf

UNCTAD. (n.d.). *UNCTADstat*. Retrieved from http://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx

UNIDO. (2012). *Structural change, poverty reduction and industrial policy in the BRICS.* Retrieved from http://www10.iadb.org/intal/intalcdi/PE/2013/10846.pdf

Wackernagel, M., Schulz, N. B., Deumling, D., Linares, C. A., Jenkins, M., Kapos, V., Monfreda, C., Loh, J., Meyers, N., Norgaard, R., & Randers, J. (2002). Tracking the ecological overshoot of the human economy. Proceedings of *the National Academy of Sciences*, *99*, 9266–71.

Wallerstein, I. (1974). *The modern world system I: Capitalist agriculture and the origins of the European world-economy in the sixteenth century.* New York: Academic Press.

Wang, Y., Kang, L., Wu, X., & Xiao, Y. (2013). Estimating the Environmental Kuznets Curve for ecological footprint at the global level: A spatial econometric approach. *Ecological Indicators*, *34*, 15–21

World Bank. (1992). *World development report 1992: Development and the environment.* New York, NY: Oxford University Press. Retrieved from https://openknowledge.worldbank.org/handle/10986/5975

World Bank. (2007). *The Little Green Data Book 2007.* Washington, DC. Retrieved from http://siteresources.worldbank.org/INTDATASTA/64199955-1178226923002/21322619/LGDB2007.pdf

World Bank. (n.d.a). *Country and Lending Groups*. Retrieved from http://data.worldbank.org/about/country-and-lending-groups

World Bank. (n.d.b). *World Development Indicators*. Retrieved from http://databank.worldbank.org/data/views/variableSelection/selectvariables.aspx?source=world-development-indicators

York, R., Rosa, E., & Dietz, T. (2003). Footprints on the earth: the environmental consequences of modernity. *American Sociological Review*, *68*, 279–300.

te Velde, D. W. (2006). Foreign direct investment and development: An historical perspective. *Overseas Development Institute,* Background paper for *World Economic and Social Survey for 2006.* Retrieved from http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/850.pdf

van der Voet, E., van Oers, L., de Bruyn, S., de Jong, F., & Tukker, A. (2009) Environmental impact of the use of natural resources and products. *Leiden University*, *Institute of Environmental Sciences (CML)*, *Department Industrial Ecology*, *CML report 184*.

Appendix 1: Countries

Countries Included in the CO2 Emissions Analyses		
● Low income countries		
Bangladesh	Benin	Cambodia
Congo, Dem. Rep.	Ethiopia	Kenya
Mozambique	Nepal	Tajikistan
Tanzania	Togo	Zimbabwe
● Lower-middle income countries		
Armenia	Bolivia	Cameroon
Congo, Rep.	Cote d'Ivoire	Dominican Republic
Egypt, Arab Rep.	El Salvador	Georgia
Ghana	Honduras	India
Indonesia	Kyrgyz Republic	Moldova
Mongolia	Morocco	Nicaragua
Nigeria	Pakistan	Philippines
Senegal	Sri Lanka	Sudan
Ukraine	Uzbekistan	Vietnam
Yemen, Rep.	Zambia	
● Upper-middle income countries		
Albania	Algeria	Angola
Argentina	Azerbaijan	Belarus
Brazil	China	Colombia
Costa Rica	Ecuador	Gabon
Hungary	Iran, Islamic Rep.	Jordan
Kazakhstan	Macedonia, FYR	Malaysia
Mexico	Panama	Romania
South Africa	Thailand	Tunisia
Turkey	Turkmenistan	Venezuela, RB

Countries Included in the Environmental Consumption Analyses		
● Low income countries		
Bangladesh	Benin	Burkina Faso
Burundi	Cambodia	Central African Republic
Chad	Congo, Dem. Rep.	Ethiopia
Guinea	Kenya	Liberia
Madagascar	Malawi	Mali
Mozambique	Nepal	Niger
Rwanda	Sierra Leone	Tajikistan
Tanzania	Togo	Uganda
Zimbabwe		
● Lower-middle income countries		
Armenia	Bolivia	Bulgaria
Cameroon	Congo, Rep.	Cote d'Ivoire
Dominican Republic	Egypt, Arab Rep.	El Salvador
Georgia	Ghana	Honduras
India	Indonesia	Kyrgyz Republic
Lao PDR	Mauritania	Moldova
Mongolia	Morocco	Nicaragua
Nigeria	Pakistan	Papua New Guinea
Philippines	Senegal	Sri Lanka
Sudan	Syrian Arab Republic	Ukraine
Uzbekistan	Vietnam	Yemen, Rep.
Zambia		
● Upper-middle income countries		
Albania	Algeria	Angola
Argentina	Azerbaijan	Belarus
Brazil	China	Colombia
Costa Rica	Ecuador	Gabon
Hungary	Iran, Islamic Rep.	Jordan
Kazakhstan	Macedonia, FYR	Malaysia
Mauritius	Mexico	Panama
Peru	Romania	South Africa
Thailand	Tunisia	Turkey
Turkmenistan	Venezuela, RB	