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The Effects of Global Economic and Cultural Integration on the Environment

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The Effects of Global Economic and Cultural Integration on the Environment

DISSERTATION

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DOCTOR OF PHILOSOPHY

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by

Steven A. Mejia

Dissertation Committee:
Professor Evan Schofer, Co-Chair
Professor Ann Hironaka, Co-Chair
Professor David J. Frank

2022

DEDICATION

To

my friends and family

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ABSTRACT OF THE DISSERTATION

The Effects of Global Economic and Cultural Integration on the Environment

By

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Doctor of Philosophy in Sociology

University of California, Irvine, 2022

Professor Evan Schofer, Co-Chair

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Perhaps the greatest challenge facing the international community is the environmental problem. The three chapters in this dissertation investigate the global cultural and economic processes shaping ambient air pollution and the emission of various forms of greenhouse gases. The first chapter investigates the issue of ambient air pollution. This form of emission is associated with increased preventable deaths, mortality, and asthma complications. The second and third chapter investigate two types of greenhouse gas emissions. The second chapter analyzes nitrous oxide emissions, which are an extremely potent greenhouse gas emission and contribute to stratospheric ozone depletion. The third chapter analyses carbon dioxide emissions. Each chapter investigates the extent various aspects of globalization help explain cross-national and longitudinal variation in these emissions. The first chapter analyzes the effect of global

cultural processes across a country's position in the stratified world economy. The second and third chapter analyze the effect of the world economy, with a particular focus on foreign direct investment. Using fixed effects panel regression models in all three analyses, I find in the first chapter that the effect of world culture on ambient air pollution is contingent on a country's position in the world-system. In the second and third chapter, I find that foreign capital penetration is positively associated with nitrous oxide emissions and carbon dioxide emissions, respectively. Each of these analyses engage longstanding scholarly dialogues regarding the effects of globalization on environmental change.

INTRODUCTION

Perhaps the greatest challenge facing humanity today is the environmental problem. Of particular focus here is the issue of ambient air pollution and the emission of greenhouse gas emissions into the atmosphere. Ambient air pollution generally is outdoor air pollution. Greenhouse gas emissions are forms of emission that contribute to a greenhouse effect in Earth's atmosphere. A greenhouse effect in general terms is when energy from the sun enters the Earth's atmosphere but said atmosphere prevents the energy from returning to space. Greenhouse gas emissions contribute to this greenhouse effect and thus influence the Earth's climate. With the accumulation of greenhouse gas emissions in the atmosphere, more heat is trapped in the Earth's atmosphere. More heat being trapped in the atmosphere warms the planet over time.

Ambient air pollution is major social issue for a variety of reasons. First, ambient air pollution exposure is responsible for 6.5 million deaths per year (World Bank 2021). Second, ambient air pollution is also identified as a leading risk factor for the global disease burden (Brauer et. al. 2015). Third, exposure to ambient air pollution contributes to the development of numerous health complications such as cardiac arrest and mortality (Dockery et. al. 1993; Pope et. al. 1995; Pope et. al. 2002; Toren et. al. 2007; Hoek et. al. 2002). Fourth, around 40 percent of the world's population relies on biomass (i.e. wood, dung, vegetation) to meet their energy needs, which contributes to the generation of ambient air pollution.

Investigating the anthropogenic sources of greenhouse gas emissions is also important. The problem of anthropogenic greenhouse gas emissions is quite intuitive, but many social scientists point to the broader consequences of rises in the Earth's average temperature. For

example, Ripple et. al. (2019) posit that the fate of humanity is currently at stake, especially as we are dangerously close to crossing tipping points in the Earth's climate. Crossing tipping points in the Earth's climate could create a "hothouse Earth" that is beyond the control of humans, which would then have dramatic implications for life on earth. Quite simply, climate change and global warming are arguably the greatest threats to humanity and the planet.

This research investigates the extent numerous features of globalization explain cross-national and longitudinal variation in these environmental outcomes. One aspect of globalization is the world economy. Social scientists have long sought to understand how the modern world economy is affecting global social change. Shortly after World War Two, many social scientists expressed optimism regarding the role of the world economy and economic development more generally in improving social welfare throughout the world. For example, Rostow (1960) in the *Stages of Economic Growth: A Non-Communist Manifesto* proposed a stages of development growth model, where he directly and indirectly suggested that, with foreign direct investment and foreign credit, countries throughout the world may be able to eventually accumulate enough domestic savings to "take off" into self-sustaining growth and achieve living standards similar to countries such as the United States, the United Kingdom, and so forth. Other classic literature suggested that integration into the world economy through trade would benefit countries as they pursue their "comparative advantage" in the world economy (e.g. Ricardo 1817; Smith 1776 [1977]). Neoclassical economic thought generated even further optimism regarding the role of world economic processes in contributing to development and progress throughout the world. For example, the Harrod-Domar model of economic growth suggests that investment is a key predictor of economic growth, regardless of whether investment is from domestic or foreign

sources (e.g. Solow 1956; Todaro and Smith 2020; Ravallion 2015; Firebaugh 1992, 1996; c.f. Dixon and Boswell 1996a). Some developing countries may not have the domestic savings necessary to reach their economic growth goals. Thus, foreign direct investment is thought of as a way of filling a country's "savings gap," thereby contributing to economic growth. World-systems analysis (Wallerstein 1974, 2004) and related dependency theory (e.g. Chase-Dunn 1975; Frank 1967, 1979; Cardoso and Falleto 1979; Dos Santos 1970; Bornschier and Chase-Dunn 1985) proposed that these various forms of integration into the world economy may actually generate detrimental effects, especially in less-developed countries. At the heart of dependency theory arguments is that less-developed countries are economically dependent on external sources (i.e. high-income countries, foreign investors and creditors, global financial institutions) to foster their own economic growth or occupy subordinate positions in stratified world economy (Wallerstein 1974, 2004) that hinder their ability to develop.

There are numerous forms of global economic integration that have attracted considerable attention by comparative international social scientists. Numerous studies investigate the effects of trade dependence for less-developed countries (e.g. Delacroix and Ragin 1981; Wimberley 1990; Wimberley and Bello 1992; Clark and Beckfield 2009; Clark 2010; Jorgenson 2006, 2011, 2012; Rice 2007; Kentor 2001; Kentor and Boswell 2003). Others investigate the impacts of debt dependence for developing countries (Walton and Ragin 1990; Bradshaw and Huang 1991; Bradshaw et. al. 1993; Shen and Williamson 1997, 1999; Buchmann 1996; Bradshaw and Schafer 2000; Clark and Snawder 2019). World economic integration in the context of foreign direct investment has arguably garnered the most theoretical debate and empirical inquiry amongst these various forms of global economic integration. Of particular

relevance to dependency theory is *foreign capital penetration*, which is commonly measured as inward FDI stock as a percentage of GDP (Dixon and Boswell 1996a, 1996b; Bornschier and Chase-Dunn 1985; Kentor 1998, 2001; Kentor and Boswell 2003). Comparative international social scientists engaging dependency theory have debated and investigated the relationship between foreign capital penetration and a variety of social, economic, and political outcomes (e.g. Shandra et. al. 2004, 2005; Bornschier and Chase-Dunn 1985; Firebaugh 1992, 1996; Dixon and Boswell 1996a, 1996b; Kentor 1998, 2001; Kentor and Boswell 2003; Curwin and Mahutga 2014; Clark and Kwon 2018; Clark and Kentor 2021). Overall, these studies have sought to help advance our understanding of how the world economy is affecting global social change, with a particular focus on countries within the Global South.

Chapter Two and Chapter Three investigate the effect of foreign capital penetration on two forms of greenhouse gas emissions in less-developed countries, respectively: total nitrous oxide emissions and total carbon dioxide emissions. These analyses build on the limitations of previous research by analyzing much more expansive cross-national and longitudinal country-level data and utilizing more powerful econometric methods than previous research on related topics. In Chapter 2, I find that foreign capital penetration (inward FDI stocks in all economic sectors as a % of GDP) is positively associated with total nitrous oxide emissions, where a one percent increase in this predictor variable is associated with a 0.01 percent increase in this extremely potent greenhouse gas emission that also contributes to stratospheric ozone depletion. In Chapter 3, I find that foreign capital penetration is also positively associated with carbon dioxide emissions, net of relevant statistical controls. These

two analyses thus provide even stronger empirical support for the ecostructural orientation of foreign investment dependency theory than previous research that investigates similar relationships.

The emergence of a world society and concomitant world culture in recent decades is another important feature of globalization. A long line of pioneering work by John W. Meyer and colleagues have suggested that a world society or global social structure has consolidated in the period after World War Two (Meyer et. al. 1997). As a logical extension, there is also a culture evident in this world society (Meyer et. al. 1997; Boli and Thomas 1997, 1999; Frank, Hironaka, and Schofer 2000) that is influenced by Enlightenment ideas of making progress in society (Chabtott 2003, 2015). A long line of social scientific work in the world society theory tradition investigates how the culture of this world society helps explain many puzzling empirical trends observed around the world in various realms (Schofer and Meyer 2005; Frank 1997; Frank et. al. 2000; Meyer et. al. 1997; Frank and Meyer 2002; Frank, Longhofer, and Schofer 2007; Hironaka 2014; Schofer and Hironaka 2005; Frank, Meyer, and Miyahara 1995; Cole 2005, 2011; Ramirez, Soysal, and Shanahan 1997; Schofer and Longhofer 2011; Longhofer and Schofer 2010; Longhofer et. al. 2016). A growing body of literature integrates world-systems analysis/dependency theory and world society theory to help advance our understanding of global environmental change (Jorgenson, Dick, and Shandra 2011; Shorette 2012; Longhofer and Jorgenson 2017; Tester 2020).

Chapter 1 of this dissertation contributes to this emerging body of world society literature. In this chapter, I investigate whether the relationship between world society embeddedness, measured through the natural logarithm of environmental international non-

governmental organization (EINGO) counts, and ambient air pollution is contingent on a country's position in the world-system. Using fixed effects panel regression models, I find that world society embeddedness does matter for environmental outcomes in the case of ambient air pollution. However, this effect differs in semi-peripheral and peripheral countries. More specifically, world society embeddedness does not produce a beneficial effect in peripheral countries.

CHAPTER 1

Global Environmentalism and the World-System: A Cross-National Analysis of Air Pollution

A key issue in transnational and environmental sociology is the anthropogenic sources of air pollutants. Much empirical attention focuses on climate change-inducing greenhouse gases such as carbon dioxide and methane emissions (Jorgenson and Clark 2012; Jorgenson 2006). In contrast to climate change and greenhouse gases, much less attention is directed to the study of ambient air pollution (AAP) which refers to concentrations of suspended chemicals, metal, soil, or dust particles in the air. Quantitative cross-national analyses of the issue are extraordinarily rare, with much of the existing literature analyzing national cases, resulting in a dearth of scholarly knowledge about the factors shaping air pollution worldwide. This limited attention is surprising given the human health consequences of global AAP levels.

Part of a larger world society, the global environmental regime has increasingly taken up air pollution as a central issue. In 1987, concerns over the human health impact of air pollution culminated in the first edition of the *Air Quality Guidelines for Europe*. These guidelines provided a basis to reduce and eliminate air pollution exposure while guiding national and local authorities in their policy decisions. Incorporating new scientific data and risk assessment methodology, the 1997 *Air Quality Guidelines* gathered over 100 experts to prepare documents and participate in scientific discussion, leading to the derivation of guideline values for pollutants such as AAP. The 2005 *Air Quality Guidelines* extended on these concerns, evaluated progress towards air pollution goals, and formulated steps for improvement. Other global institutions, especially environmental international non-governmental organizations (EINGOs), play a crucial

role in monitoring compliance with air pollution guidelines thereby maintaining public and political awareness to air pollution issues (WHO 1987). In addition to other environmental agents, EINGOs aid in funding air pollution technologies, while aiding in conservation strategies (WHO 1987). Despite increasing international attention on this issue, we know very little whether it has any impact on global air pollution levels. Additionally, there are reasons to suspect that the global environmental regime might have different effects across the globally stratified economy (Shorette 2012).

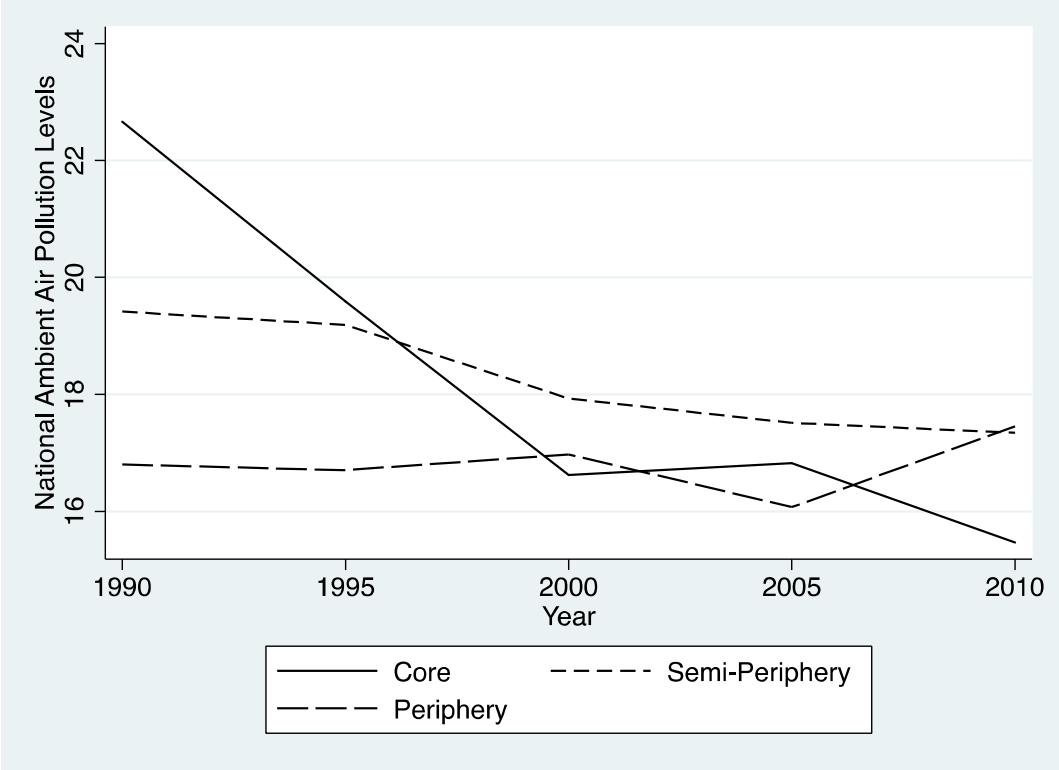
This chapter addresses this issue through a cross-national analysis of air pollution levels between 1990-2010 at 5-year intervals. I begin with a background on ambient air pollution sources and trends. I draw on world society theorization regarding global institutions, global political economic perspectives, and a synthesis of the two to inform my hypotheses regarding the relationship between ambient air pollution, the global environmental regime, and the mediating effects of the world-system. Discussion of these theoretical perspectives is followed by a description of my data, dependent and independent variables, and methods. I then turn to my findings before discussing analysis implications and directions for future research.

AMBIENT AIR POLLUTION

Pro-environmental efforts involve identifying the mechanisms that contribute to its degradation. AAP emissions are rooted in activities related to energy and agriculture production (WHO 2016). The use of coal, dung, wood, biomass, natural gas, and electricity to cook and heat homes represents the largest emitter of AAP (WHO 2016). Additionally, emissions from fossil fuel combustion in industry, transportation, and energy generation is another primary source of AAP. Agriculture poses as a non-energy related contributor as agricultural practices, livestock

production, and the use of nitrogen fertilizers impact AAP levels (Bauer, Tsigaridis, and Miller 2016).

Figure 3.1 Ambient Air Pollution Levels by World-System Position



A key goal of global efforts is to lower AAP levels to World Health Organization guidelines and interim targets. Figure 1 illustrates progress towards these goals by presenting trends from 1990-2010 at 5-year intervals. While there are some increases at the global level, an uneven distribution across development levels is evident. Additionally, countries in specific regions experience sharp *increases*. International reports suggest that these differences in AAP levels are in part a result of reliance on the natural environment for fuel in impoverished households, and rapid economic development in developing countries (UNEP 2016).

Analyzing cross-national air pollution trends is vital for a variety of reasons. First, AAP

has deleterious consequences on world scale population health. AAP is associated with 3.2 million deaths per year and 76 million disability-adjusted life years lost per year worldwide (Lim et. al. 2012). Also, 87% of the world's population lives in areas that exceed the World Health Organization's guideline of fewer than 10 microns per cubic meter. AAP also contributes to 800,000 deaths per year making it the 13th cause of mortality worldwide (Brauer et. al. 2015). Overall, the impact of AAP on the health and wellness of the global population cannot be overstated.

AAP also has implications for human health outcomes. Research suggests air pollution is associated with a 26% increase in mortality (Dockery et. al. 1993; Pope et. al. 1995). Additionally, AAP exposure is associated with increased odds of cardiopulmonary mortality, cardiac arrest, and cardiovascular mortality (Hoek et. al. 2002; Pope et. al. 2002; Toren et. al. 2007). Susceptible populations, such as elders and children, have increased asthma complications from exposure compared to general populations (Anderson, Thundiyl, and Stolbach 2012; Arena et. al. 2006). In light of AAP trends and their implications for global health, I originate an in-depth cross-national longitudinal analysis of AAP through engagement of major perspectives in environmental sociology.

GLOBAL ENVIRONMENTAL CHANGE

Cross-national research on the environment mainly incorporates neo-institutional or political economic perspectives. Although highlighting contrary global-level processes, a new vein in environmental sociology shows the usefulness of integrating these frameworks (Jorgenson, Dick, and Shandra 2011; Shorette 2012; Henderson and Shorette 2017; Jorgenson

and Longhofer 2017). Institutionalist perspectives argue nation-states are embedded in an exogenous progressive world culture that pressures nation-states to adopt pro-environmental policies and practices across all developmental levels (Boli and Thomas 1997). Political economic approaches, however, emphasize the globally stratified economy where nation-state mobility is structured by trade relationships (Chase Dunn 1989). A nation-state's prospects for economic development are shaped by their position in the global hierarchy thereby shaping exposure to environmental harm (Mahutga 2006). I review both perspectives on the environment and draw on recent theoretical frameworks that integrate both of these perspectives.

World Society Perspectives on Environmental Degradation

One approach in globalization and environmental sociology focuses on the institutional character of macro-social and environmental change (Meyer et. al. 1997a). Whereas other macro-level theories of environmental change conceptualize actors as material-seeking, this perspective emphasizes the social context they are embedded in (Meyer et. al. 1997a). More specifically, nation-states, organizations, and non-state actors are viewed as socially constructed actors embedded in a transnational system of norms such as rationality, universalism, and modernity (Shorette et. al. 2017).

Protection of the environment is another salient norm in world society. From this perspective, the increasing trend of global institutions dedicated to environmental protection signify the emergence of a "global environmental regime" that shapes state and non-state actors (Meyer et. al. 1997b). Frank (1997) illustrates this top-down approach to macro-environmental change, showing that ties to world society are a better predictor of nation-state environmental

treaty participation rather than environmental degradation, political opportunity, scientific capacity, or affluence. World society linkages also explain the rise of environmental organizing in less-developed countries (Longhofer and Schofer 2010). Overall, a body of research suggests environmental world society diffuses environmental norms to societies, explaining cross-national homogeneity on the environment in a variety of domains.

Another vein in world society and environment literature examines the implications of the global environmental regime for actual environmental outcomes. While early critiques centered around whether global institutions where merely "myth and ceremony" or "window-dressing," a growing body of literature suggests there are positive implications for the environment (Meyer and Rowan 1977; Buttel 2000; Schofer and Hironaka 2005). Ties to the global environmental regime and world society, through INGOs or an index of multiple world society proxies, does predict reduced CO2 emissions, deforestation, NO2 emissions, water pollution, and fertilizer and pesticide use (Jorgenson et. al. 2011; Hironaka 2014; Schofer and Hironaka 2005; Shorette 2012). Additionally, INGO presence is shown to partially mitigate the effects of foreign direct investment on water pollution, deforestation, and CO2 emissions, while reducing the harms of economic development, and forest lost related to palm oil production in peripheral countries (Jorgenson et. al. 2011; Jorgenson and Longhofer 2017; Henderson and Shorette 2017).

In this analysis, I build upon this body of literature arguing that global normative pressures of environmentalism do have implications for concrete outcomes. Rather than a linear connection, the global environmental regime produces a "bee-swarm" of pro-environmental agents such as environmental laws, treaties, ministries, and environmental social movements that

affect environmental change (Hironaka 2014). Following past research, I focus on the role of

EINGOs as a proxy for a multiplicity of international influences and pro-environmental agents in the global environmental regime (Hironaka 2014). Thus, I expect that *as a country's ties to environmental international non-governmental institutions increases, their ambient air pollution levels will decrease.*

World-Systems Perspectives on Environmental Degradation

Global political economic perspectives highlight how world-system dynamics shape cross-national development and environmental inequalities. Developed "core" countries exploit less-developed "peripheral" countries, as surplus value is extracted from the periphery and relocated in the core. Semi-peripheral countries also exploit periphery countries and are upwardly mobile, maintaining a stable global economy (Wallerstein 1974). A global division of labor also characterizes the world-system. Core countries occupy an advantaged position in the global economy, focusing on highly-profitable, capital-intensive production processes. Peripheral countries occupy a disadvantaged position in the global economy and focus on low profit, extractive economies that often employ politically-coerced low-wage labor (Chase-Dunn 1989; Mahutga 2006; Mahutga and Smith 2011). Development in semi-peripheral countries involves a mixture of peripheral and core-like processes. World-system dynamics are linked to a variety of nation-level outcomes such as development (Chase-Dunn 1975; Kentor and Boswell 2003) and urbanization (Smith 1996). Overall, structural world-system characteristics are central

to understanding developmental outcomes.

World-system processes are also linked to nation-states environmental profiles. Specifically, this perspective highlights the environmental exploitation that accompanies the New International Division of Labor [NIDL]. Global capitalism and industry rely on natural resource extraction and fossil fuel consumption (Clark and York 2005). The structure of the NIDL, however, *outsources* environmentally harmful development practices to the global south thereby allowing core countries to increase their sink capacity while shifting their consumption patterns to less-developed countries (Mahutga 2006; Frey 2003). The restructuring of global capitalism is coupled with foreign direct investment by way of transnational corporations, who often finance environmentally harmful production processes in non-core countries. Research highlights the environmental harm of semi-peripheral and peripheral position on forest patterns, greenhouse gas emissions, mammal and bird biodiversity, ecological footprints, carbon dioxide, and methane emissions(Burns, Kick, and Davis 2003; Grimes and Kentor 2003; Roberts, Grimes and Manale 2003; Shandra, Shandra, and London 2010; Jorgenson 2006). In summary, world-system analytical perspectives find that a country's position in the stratified world economy shapes national development characteristics and environmental outcomes through a variety of mechanisms.

Environmentalism Across World-System Zones

I draw on recent theoretical innovations in environmental sociology that incorporate world society and world-systems perspectives to formulate the integrated theory of global environmentalism (Shorette 2012). Specifically, this perspective suggests that country position in

the world-system moderates the effect of global cultural integration (Shorette 2012). Although world-systems and world society theory are seen as competing theories with different assumptions, this perspective and other empirical work suggest the utility of incorporating them (Jorgenson et. al. 2011; Shorette 2012; Longhofer and Jorgenson 2017; Henderson and Shorette 2017; Meyer 2008). I elaborate on the compatibility of these theories and their mechanisms below.

World society and world-systems theory both differ in their locus of macro-historical change. World society theory points to a world polity that encompasses all nation-states providing cultural blueprints for state and non-state actors, producing national homogeneity. World-systems perspectives, however, highlight the relationship *between* nation-states to understand cross-national inequalities. Although world society and world-system perspectives highlight different global-level processes, the integrated theory of global environmentalism suggests that macro-realist and phenomenological processes can and do likely occur at the same time, highlighting their theoretical compatibility (Shorette 2012; Meyer 2008).

Scholars have long discussed the frequent disconnect between institutionalized policies and treaties with their intended outcome (Meyer and Rowan 1977). Political economic scholars emphasize the role of powerful economic interests hindering initiatives to protect the environment and influencing international organizations, and the differing political economic conditions by world-system zone (Gould, Pellow, and Schnaiberg 2004; Beckfield 2003; Smith 1994). For this perspective, lacking environmental regulation is a result of political economic forces in semi-peripheral and peripheral countries (Burns, Kick, and Murray 1994). World society scholars, in contrast, highlight differing institutional capacity across the world-system to

abide by commitments to protect the environment. Without an international enforcement agency to enforce commitments, the sole responsibility of abiding by environmental treaties and policies relies on the nation-state. Domestic institutional capacity, however, differs across the world-system, where core countries have the highest institutional capacity and diminishing across semi-peripheral and peripheral countries, resulting in the limited effect of international organizations and policies.

The integrated theory of global environmentalism suggests that a combination of economic incentives and institutional capacity explain the differing effect of the global environmental regime, where it is effective in core countries but differs in non-core countries. Economic incentives and institutional capacity, however, are conditioned by position in the world-system. Core countries, given their advantaged position in the global economy, are less reliant on extractive economies and industry for economic development, resulting in less economic incentives to disregard environmental policies and treaties. Core countries have the highest institutional capacity to abide by environmental policies resulting in improved environmental outcomes. Semi-peripheral countries rely on environmentally harmful extractive economies and industry for economic development more than core countries, creating more economic incentive to disregard normative pressures of environmentalism. Institutional capacity also drops in semi-periphery countries, resulting in increased decoupling compared to core countries. Peripheral countries are particularly affected by environmentally harmful extractive economies and industry resulting in the highest economic incentive to disregard environmental policies and treaties. This is coupled with lacking institutional capacity of peripheral countries to

implement policies.

Concrete mechanisms underlying this interaction of global political economic and institutional forces are difficult to identify. As Hironaka (2014) specifies, a "smoking gun" is difficult to pinpoint in global social change. Regardless, I postulate some possible mechanisms for the interaction of these two forces. The increased economic incentive to violate international treaties can be tied to global trade structures and the transnational organization of industrial and agricultural production. Of relevance here is ecological unequal exchange and environmental load displacement traditions. Ecological unequal exchange refers to the withdrawal of resources from, and outsourcing of harmful production (e.g. industry and agriculture) and waste to less-developed countries through trade relationships between nation-states (Jorgenson 2016; Jorgenson and Kuykendall 2008; Austin 2012). These unequal trade relationships also help improve the domestic carrying capacity of more powerful, developed countries (Rice 2007). Developing countries thus serve as a natural resource tap and waste sink for developed countries. In a related vein is the "pollution haven hypothesis," where transnational corporations finance environmentally harmful industrial and agricultural production in less-developed countries competing for foreign investment to stimulate economic development (OECD 1999; Chase-Dunn 1975; Dixon and Boswell 1996). Transnational corporations often invest in countries with weak environmental standards and enforcement (Roberts and Parks 2007). Thus, governments, with the threat of capital flight from investors and transnational corporations, might have more economic incentive to concede to transnational corporation interests at the expense of the environment (Gibson et. al. 2000). Prior research suggests that non-core countries are less likely to adopt environmental policies and treaties that are pertinent to transnational corporate interests

(Roberts and Parks 2007). Further, foreign direct investment is associated with increased government corruption, where transnational corporations can bribe government officials to get exemptions from environmental treaties (Egner and Winner 2005). Overall, countries outside the core have more economic incentive to concede to capitalist interests compared to normative pressures to protect the environment, given structures in global trade and the international organization of production.

In summary, embeddedness in global culture through ties to EINGOs does have implications for environmental outcomes. This association, however, is mediated by country position in the world economy, which conditions economic incentives and institutional capacity to implement environmental policies and practices. Non-core countries are affected by political economic interests, making nation-states more responsive to transnational corporate interests in place of protecting the environment. Thus, I expect that *EINGOs will matter for core countries, but the effect size is smaller in semi-peripheral and peripheral countries.*

Next, I evaluate theorization of EINGOs expected beneficial effect on AAP levels, and whether this association is moderated by country position in the globally stratified economy. I now turn to a description of my data, dependent and independent variables, and methods used to assess these aforementioned propositions. I then conclude by summarizing key findings, discussion of these results, implications for policy, limitations, and directions for future research.

DATA

To address the arguments described above, I analyze cross-national and longitudinal country-level data on ambient air pollution. I include all countries that have data within the 5-

year point estimates between 1990-2010. Data from my analysis comes from two sources. Data on environmental international non-governmental organizations comes from the Union of International Associations, an organization that traces international organizations for 300 countries and territories (Yearbook of International Organizations 1990-2010). All other variables come from the World Bank's *World Development Indicators* (World Bank 2015). This results in a sample of 144 countries in the sample. Table 1 provides descriptive statistics and correlation matrix for the below variables included in my analysis.

DEPENDENT VARIABLE

Ambient Air Pollution

Air pollution is measured as the average level of exposure of a nation's population to suspended particles measuring less than 2.5 microns in aerodynamic matter or PM 2.5 (World Bank 2015). This variable is measured in micrograms per cubic meter and national air pollution levels range from 4.11 to 54.15 in my sample. Ambient air pollution levels are calculated by taking mean annual concentrations of PM 2.5 and weighting them by national-level rural and urban population. Thus, the measure is the population-weighted mean annual concentrations of ambient air pollution. This data is used as a general measure of air quality for cross-national comparison such as the World Health Organization's air pollution mortality estimates. This measure is also used by the World Bank to calculate the economic damages of air pollution, by the United States Environmental Protection Agency, and the International Agency for Research on Cancer monograph. The World Health Organization recommends that a nation's air pollution

levels do not surpass 10 micrograms per cubic meter (World Health Organization 2005).

INDEPENDENT VARIABLES

Environmental International Non-Governmental Organizations

Environmental International Non-Governmental Organizations are measured as the total amount of environmental INGOs in which citizens of a country hold individual membership, where membership is individual citizens that pay dues. For example, a country with an individual member in Greenpeace constitutes one tie to world society**.** I log this variable to account for skewness. Logged counts of EINGOs range from 0 to 3.61 in my sample. There are multiple ways to measure ties to the global environmental regime. Some scholars utilize an index of environmental international non-governmental organizations, ministries, and treaties, or use network centrality measures (e.g. Schofer and Hironaka 2005; Longhofer and Jorgenson 2017). While each proxy of world society ties has benefits and limitations, logged counts of environmental INGOs is a generally accepted measure of the many pro-environmental agents in the global environmental regime and used in previous research (Schofer and Longhofer 2010; Hironaka 2014; Jorgenson et. al. 2011; Henderson and Shorette 2017). This data comes from the Union of International Association's *Yearbook of International Organizations* (UIA 2011).

World-System Trichotomy

World-systems scholars use a variety of mechanisms to model the world-system trichotomy of core, semi-peripheral, and peripheral countries such as GDP, GNI, and military power (Shorette 2012; Babones 2005; Chase-Dunn 1989). Although each mechanism has

specific strengths and weaknesses, I construct the world-system trichotomy by drawing on network analyses of the global economy to place countries in world-system trichotomy (Mahutga and Smith 2011; Clark and Beckfield 2011). These analyses provide lists of countries in respective core, semi-peripheral, and peripheral zones of the world-system trichotomy. I initially use Mahutga and Smith's (2011) piece to construct the world-system trichotomy, but I increased the number of countries in the analysis by comparing to Clark and Beckfield's (2011) analysis. I include a table of countries and their position in the world-system in the Appendix.

EINGOs and World-System Position Interaction

I interact EINGOs by world system zones semi-periphery and periphery, with core as the reference category. These interactions use the data for EINGOs and world-system position outlined above. These interaction terms will test the effect of ties to global institutions on a country's air pollution levels in the core, semi-periphery, and periphery. Specifically, this allows me to test my main propositions of interest.

CONTROL VARIABLES

Gross Domestic Product per Capita at Constant US Dollars

I include Gross Domestic Product per Capita to control for a country's economic development. I am logging this variable to minimize skewness. This measure comes from the World Bank and is measured in constant US dollars (World Bank 2015).

Total Population

I control for total population in all models. I obtain this data from the World Bank (2015) and log to minimize skewness. This data is measured in thousands and is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. Research in the structural human ecology tradition shows that population levels are strongly implicated in environmental outcomes and there is a positive association with other types of air pollutants (e.g. York, Rosa, and Dietz 2003; York and Rosa 2012).

Industry, value added (% of GDP)

I control for the extent a country's domestic economy involves manufacturing and extractive economies. Manufacturing includes mining, manufacturing, construction, electricity, water, and gas sectors. This data comes from the World Bank (2015). Processes associated with industrial practices are strongly implicated in air pollution emissions (Brauer et. al. 2016).

Agriculture, value added (% of GDP)

I also control for the extent of a country's domestic economy revolves around agriculture. This includes forestry, hunting, fishing, and the cultivation of crops and livestock. This data comes from the World Bank (World Bank 2015) and I log for skewness. Emissions related to agriculture are another major source of air pollution (Brauer et. al. 2016).

Table 3.1 Descriptive Statistic and Correlation Matrix (*N*=591)

	S.D.	Mean	Min	Max
Ambient Air Pollution	9.162183	17.30125	4.524874	54.15091
GDP p.c.	1.554968	8.045637	4.595442	11.54116
Population	1.776787	16.11657	11.03339	21.01422
Industry	.3458108	3.407665	2.176331	4.336872
Agriculture	.904888	2.312492	.0381554	4.123955
EINGO	.9057156	1.88055	0	3.610918
Core	-	.1878173	0	1
Semi-Periphery	-	.3147208	0	1
Periphery	-	.5143824	0	1

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) AAP	1.000								
(2) GDP p.c.	-0.175	1.000							
(3) Population	0.358	-0.148	1.000						
(4) Industry	0.120	0.163	0.214	1.000					
(5) Agriculture	0.148	-0.902	0.127	-0.261	1.000				
(6) EINGO	-0.027	0.548	0.461	0.054	-0.486	1.000			
(7) Core	0.014	0.677	0.080	-0.013	-0.577	0.470	1.000		
(8) Semi-Periphery	0.049	0.131	0.055	0.091	-0.143	0.142	-0.326	1.000	
(9) Periphery	-0.068	-0.655	-0.101	-0.064	0.590	-0.486	-0.495	-0.625	1.000

METHODS

I conduct a longitudinal cross-national regression of air pollution using a fixed effects model with robust standard errors across all models. Random and fixed effects models are commonly used in macro-sociological research to address heterogeneity bias or the time-invariant variables omitted from regression models (Halaby 2004). Random effects models simulate these time-invariant variables as part of the error term while a fixed effects model estimate time-invariant variables (Nielson and Anderson 1995). A Hausman test is generally

used to adjudicate between a random effects and fixed effects model (Halaby 2004). In this analysis, the Hausman test indicated a significant difference between point estimates, suggesting a preference for fixed effects. In unreported models, I conduct analyses with random-effects models. Results are the same. These models are available upon request. Fixed effects models are presented in Table 2.

As outliers and influential cases are a standard issue in longitudinal cross-national data, I conduct added-variable plots to identify outliers in the analysis. Conducting added-variable plots illustrates the relationship between the independent and dependent variables, while controlling for other variables (Frees 2004). I identified and removed one outlier from the analysis, which is Singapore at 1990.

FINDINGS

Table 3.2 Fixed Effects Panel Regression Models of Ambient Air Pollution, 1990-2010

	Model 1	Model 2	Model 3	Model 4
GDP p.c.	0.693	1.044**	1.039**	0.989**
	(0.413)	(0.368)	(0.374)	(0.352)
Population	3.158*	2.349*	4.383**	4.137**
	(1.215)	(1.183)	(1.430)	(1.508)
Agriculture	3.522***	3.952***	3.038***	2.692***
	(0.760)	(0.650)	(0.596)	(0.590)
Industry		5.045***	4.530***	4.205***
		(0.751)	(0.750)	(0.752)
EINGO			-1.107***	-3.350***
			(0.295)	(0.772)
EINGO x Semi-Periphery				2.243*
				(0.872)
EINGO x Periphery				2.556**
				(0.873)
Constant	-47.27*	-55.22**	-82.07***	-74.88**
	(20.14)	(19.76)	(22.73)	(24.63)
Observations	591	591	591	591
R^2 within	.10	.21	.25	.28
R^2 between	.12	.13	.14	.14
R^2 overall	.13	.14	.15	.13

Robust standard errors across all models; two-tail test
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Findings for this analysis are reported in Table 2. Model 1 is treated as a baseline model, including total population, the size of a country's agricultural sector, and GDP per capita. Model 2 includes the aforementioned control variables, and the size of a country's industrial sector.

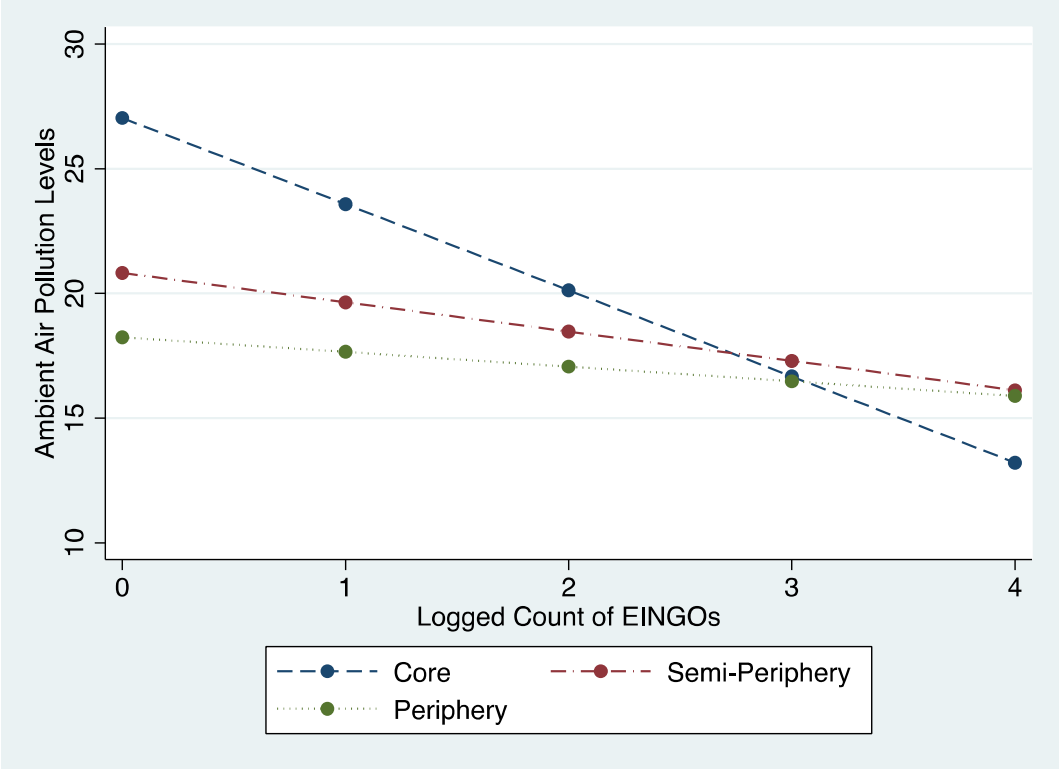
Model 3 includes baseline controls, and independent variable of EINGOs. Model 4 also includes baseline controls, independent variables of EINGOs, the interaction term for EINGOs and semi-peripheral countries, and EINGOs by peripheral countries interaction term.

I begin my discussion of findings by summarizing the relationship between AAP levels and control variables. GDP per capita is positive and statistically significant across most models, providing mix evidence for the effects of economic development on AAP levels. Total population is positive and statistically significant across all models. This suggests that increases in a nation's total population is associated with increased air pollution levels. Generally, these results are consistent with cross-national research that accounts for demographic factors on environmental issues (Jorgenson and Burns 2007; Shandra 2007). The size of a country's domestic agricultural sector, measured by value added in agriculture as a percentage of GDP, is positive and statistically significant across all models. This suggests that as a country's domestic agricultural economy increases, their AAP levels increase. The size of a country's domestic industrial sector is also positive and statistically significant across all models. This finding provides evidence that as the size of a country's domestic industrial sector increases, their AAP levels increase.

I now turn to my independent variables of interest. The direct effect of EINGOs is negative and statistically significant across all models. This supports world society expectations that as ties to EINGOs increases, AAP levels decrease. From a world society perspective, the norms and values codified in international non-governmental organizations embody world scripts of environmentalism (Meyer 1997a; Boli and Thomas 1997). Adding to previous research, these findings suggest that ties to world society through EINGOs has implications for environmental

outcomes through a host of pro-environmental actors in the global environmental regime (Schofer and Hironaka 2005; Shandra 2007; Jorgenson et. al. 2011; Shorette 2012; Henderson and Shorette 2017). Now I turn to my measures of the integrated theory of global environmentalism in Model 4.

Figure 3.2 Predicted Values of EINGOs Effect on Ambient Air Pollution by World-System Position



Model 4 tests the effect of EINGOs in semi-peripheral and peripheral countries, with core countries as the reference category. The main term for EINGOs is negative and statistically significant with a coefficient of -3.350. The addition of a positive and statistically significant interaction term of 2.243 for semi-peripheral countries adds to a net effect of -1.107. An F-test of

the net effect of EINGOs in semi-peripheral countries is statistically significant. The interaction term for peripheral countries and EINGOs is positive and statistically significant with a coefficient of 2.556. Coupled with the main effect of EINGOs, the net effect of EINGOs in peripheral countries is –0.794. An F-test of the net effect of EINGOs in peripheral countries does not reach statistical significance. These findings follow expectations from the integrated theory of global environmentalism. Specifically, EINGOs have an effect in core countries but this effect is reduced in semi-peripheral and peripheral countries. From this perspective, a combination of economic incentives and institutional capacity explain the differing effect of ties to EINGOs across the globally stratified economy (Shorette 2012). Lacking economic incentives and institutional capacity result in a reduced effect of the global environmental regime in semi-peripheral and peripheral countries for AAP.

DISCUSSION AND CONCLUSION

A chief contribution of this analysis is that the effect of the global environmental regime on AAP levels is moderated by a countries position in the world-system. As air pollution represents a global health crisis, there are a myriad of pro-environmental agents increasingly focused on its reduction. Measured through ties to EINGOs, I find that these global institutions do produce their intended outcome. While additionally effective in core countries, this association changes in semi-peripheral and peripheral countries.

These findings have significant implications for world society theory, and environmental sociology. For world society scholars, the historical increase in institutions devoted to environmental protection signify a shift in global cultural understandings of the environment.

While there is skepticism of the practical implications of this regime, this analysis adds to literature suggesting the institutionalization of environmental concerns does affect actual outcomes (Schofer and Hironaka 2005; Jorgenson et. al. 2011; Shorette 2012). Global institutional structures create workspaces and formal organizations to address environmental problems while codifying and dispersing environmental norms to state and non-state actors.

This analysis also explores the boundaries of theorization on the interaction of global political economic and cultural processes. Past research suggests that, given their disadvantaged position in the globally stratified economy, non-core countries have incentive to pursue economic growth over environmental protection, thereby explaining the diminished effect of the global environmental regime (Shorette 2012). The case of air pollution provides nuance to this perspective due to multiple AAP sources outside of industry. One is the nature of rural and farming sustenance lifestyles, which make up the majority of AAP emissions. As reliance on agriculture, poverty, and rural populations are key predictors of biomass use, it is likely the reduced effect of pro-environmental agents is related to dynamics outside of global political economic processes such as the population dispersion in a country. For example, people living in rural areas compromise two-thirds of India's population and mainly rely on biomass for energy use (World Bank 2016; Rohra and Taneja 2016). In addition to rural populations being more difficult to access, coordination between rural and urban areas can make policy, treaty, and organizational efforts more difficult to implement, monitor, and evaluate.

In addition to advancing theorization on the environment, these findings have dramatic implications for policy. First, it underscores the importance of including remote populations in policy efforts of providing clean cooking and stoves in light of access difficulties. Additionally,

efforts can be made to educate rural communities on the harmful effects of indoor cooking and openly burning agricultural waste. Efforts revolving biomass burning can add to other policy concerns of cleaner burning fuels for transport and freight, emissions standards for vehicles, industry, and power generation facilities. Overall, a combination of policy efforts can help lead to more sustainable practices.

In light of these findings and contributions to major perspectives in environmental sociology, there are some limitations to my analysis. First, the research design limits the ability to identify specific causal mechanisms of the interaction of global economy and culture. The limited effect of international policies and treaties is well documented but social scientists debate the mechanisms underlying this observation. Although the mechanisms of social change are hard to pinpoint, case studies, more complex statistical analysis, and qualitative comparative analyses could benefit this line of research as it can parcel out these mechanisms. Despite these limitations, this analysis aims to motivate future research in environmental macro-sociology that integrates macro-level theories of environmental change. While there is ample evidence for global political economic and cultural perspectives separately, this analysis underscores the need for more empirical investigations in this new area of analysis.

CHAPTER 2

Foreign Direct Investment and the Neglected Greenhouse Gas: A Cross-National Analysis of Nitrous Oxide Emissions in Developing Countries, 1990-2014

The "climate crisis" and stratospheric ozone depletion are among the most pressing issues facing us today. The climate crisis generally refers to global warming and its associated consequences, while stratospheric ozone depletion is damage to the stratospheric ozone layer that prevents ultraviolet (UV) rays harmful to living organisms from reaching Earth's surface. Nitrous oxide emissions (N_2O) greatly contribute to both issues. Nitrous oxide emissions are an extremely potent greenhouse gas with a global warming potential 298 times that of carbon dioxide on a 100-year timescale (IPCC 2014). This means 1 million metric tons of nitrous oxide emissions are equivalent to about 298 million metric tons of carbon dioxide emissions. N_2O emissions also trigger ozone-depleting reactions upon reaching the stratosphere. What is more, N_2O emissions are now considered a top ozone-depleting emission (Ravishankara, Daniel, and Portman 2009). Additionally, nitrous oxide emissions have increased for many of the world's nations over recent decades (WRI 2015). These rises in N_2O emissions are especially alarming as many scientists warn the climate crisis could cause untold human suffering unless there are major transformations to global society (Ripple et. al. 2017; Ripple et. al. 2019). The ozone layer supports life on earth and absorbs UVB rays linked to skin cancer, cataracts, and marine life damage (EPA 2019). Altogether, the importance of analyzing the anthropogenic causes of nitrous oxide emissions cannot be overstated considering its impact on the climate crisis and stratospheric ozone depletion.

Comparative international research often neglects nitrous oxide emissions. Additionally,

much social scientific research fails to consider the extent activities of transnational corporations operating in developing countries generate N_2O emissions. The majority of cross-national research on the anthropogenic causes of greenhouse gas emissions focuses on carbon dioxide emissions (e.g. Dietz and Rosa 1997; Roberts and Grimes 1997; Roberts, Grimes, and Manales 2003; Shandra et. al. 2004; Schofer and Hironaka 2005; Jorgenson, Dick, and Shandra 2011; Jorgenson and Clark 2012) and methane emissions (Burns, Davis, and Kick 1997; Rosa, York, and Dietz 2004; Jorgenson 2006; Jorgenson and Birkholz 2010). Existing comparative international research on nitrous oxide emissions focuses on the broad class of nitrogen oxides (NO_x) that generally includes N_2O (Hironaka 2014; Jorgenson, Dick, and Mahutga 2007; Mollenhaver and Tschoke 2010). The few analyses that consider the effect of foreign direct investment dependence on nitrous oxide emissions are cross-sectional by design (e.g. Dick and Jorgenson 2009). Cross-sectional models are unable to account for heterogeneity bias or the time-invariant variables omitted from ordinary least squares regression (Wooldridge 2010). Additionally, panel data, such as the data used in this analysis, tends to have more sample variation, thereby generating more precise parameter estimates (Hsiao 2007). Lack of comparative international research on nitrous oxide emissions and foreign direct investment dependence is often attributed to lacking N_2O estimates for many of the world's nations, leading to a dearth of scholarly knowledge on the relationship between multinational corporations and this neglected greenhouse gas.

I attempt to address this paucity in research by drawing on recently available nitrous oxide emission estimates and testing hypotheses from a refined ecostructural theory of foreign direct investment dependence (FDI). I begin the analysis with a description of the anthropogenic

sources of nitrous oxide emissions. I then draw on foreign direct investment dependency theorization before turning to a refined ecostructural orientation of foreign capital dependency theory that attempts to better link foreign investment and nitrous oxide emissions. Following the presentation of the sample, data, dependent variable, independent variable, and control variables, I turn to a discussion of the methods used to conduct the analysis and a summary of major findings. I conclude the analysis with a discussion of key findings and their implications for sociological theorization on the environment, analysis limitations, and directions for future research.

THE ANTHROPOGENIC CAUSES OF NITROUS OXIDE EMISSIONS

Anthropogenic nitrous oxide emissions are rooted in numerous activities. One major source is the application of nitrogen-rich synthetic fertilizers to crops. Nitrogen is essential for life on Earth. Technological advances now allow for the creation of synthetic reactive nitrogen that is applied to crops as a fertilizer to increase food production. Increased nitrogen-based fertilizer use helps feed the world's growing population but microbial processes of denitrification and nitrification transform extra nitrogen into harmless dinitrogen (N_2) and the greenhouse gas nitrous oxide (Ussiri and Lal 2012). Other prominent sources are fossil fuel combustion in transportation and power plants. Industrial processes are also implicated in nitrous oxide emissions. The production of nitric acid and adipic acid, the former being used to make synthetic fertilizers and the latter to make nylons/synthetic products, contribute to nitrous oxide emissions. Overall, the anthropogenic sources of nitrous oxide emissions are indeed diverse.

FOREIGN DIRECT INVESTMENT DEPENDENCY THEORY AND DEVELOPMENT

Foreign direct investment dependency theory is a long-standing tradition in comparative international sociology generally formulated during the national development debates of the 1960s and 1970s. Modernization theory also rose to prominence in this era, asserting nation-states are autonomous societies progressing through unilinear stages of development. Development and underdevelopment are thus rooted in a nation-state's internal characteristics. World-systems analysis and dependency theory provide a more critical explanation of global developmental inequalities, with the former orientation building off concepts advanced by the latter perspective. Dependency theorists argue rich "core" countries are highly developed due to their advantageous position in the stratified world economy, while poor "peripheral" country's development is stunted by their interaction with the core (Emmanuel 1972; Frank 1967; Amin 1976). World-systems analysis expands on dependency theorization and focuses on the world-system as a whole compared to dependency theorists focus on the nation-states, with a world-system being an entity with a single division of labor (Wallerstein 1974). The modern world economy is a world-system organized by competitive and unequally powerful nation-states. Core countries generally employ high-wage labor and focus on capital-intensive manufacturing. Peripheral countries primarily utilize low-wage, often politically coerced labor, and focus on low-profit extractive economies (Chase-Dunn 1989). Semi-peripheral countries occupy the middle strata of the global economy, are a mixture of core and peripheral production processes, and also exploit peripheral countries (Wallerstein 1974). Core and semi-peripheral exploitation of peripheral countries help maintain the hierarchical structure of the world-system as semi-

peripheral countries aspire to core status. Some mechanisms help reproduce the tripartite global system such as powerful core states that can better serve the interests that control them (Bornschier and Chase-Dunn 1985). Core countries also employ coercion in peripheral zones, which have historically constituted serfdom, slavery, and colonization. For world-systems analysis and dependency theory, transnational corporations (TNCs or MNCs) represent a more opaque form of peripheral exploitation by core countries and the many powerful economic groups headquartered in high-income countries.

The 1980s debt crisis sparked further debate about the implications of transnational corporations operating in developing countries. Many developing countries faced a debt trap, prompting global financial institutions like the World Bank and International Monetary Fund to institute structural adjustment programs to help countries repay debt. These structural adjustment programs allowed for debt re-scheduling but included provisions for export intensification and creating favorable conditions for transnational conditions such as cheap labor, low taxes, and lax labor and environmental laws (Robinson 2009). The logic of these measures assumes increased foreign capital will help stimulate economic growth, thereby allowing for debt repayment (e.g. OECD 1999). World-systems analysis and dependency theory, however, suggest multinational firms increase income inequality and retard economic growth. Bornschier and Chase-Dunn (1985) provide an account by which transnational corporations harm a host country's economic and development prospects. It is important to note, however, that this formulation assumes capital accumulation and ever-increasing economic growth drive the capitalist world-economy (Bornschier and Chase-Dunn 1985). Economic stagnation in core countries is postponed partially by the high wages paid in such countries, which helps diversify the economy and create new

investment opportunities. In developing countries, transnational corporations benefit from income inequality. Peripheral elites are often the only market that can afford the commodities produced by transnational corporations and often aim to acquire the status symbols used in the core (Bornschier and Chase-Dunn 1985). It is speculated that, even with a more balanced income distribution in peripheral countries, the poor would still not form a sizeable market for transnational corporations. Thus, income inequality is more profitable for transnational firms (Bornschier and Chase-Dunn 1985). Additionally, foreign control over a host economy stunts economic growth over the long run through the transfer of energy from peripheral countries to the Global North (Bunker 1985; Bunker and Ciccantell 2005; O'Hearn 1989). While there have been some critiques of dependency theory (c.f. Firebaugh 1992; Firebaugh 1996), much cross-national research supports dependency theory expectations (e.g. Alderson and Nielson 1999; Bornschier, Chase-Dunn, and Rubinson 1978; Chase-Dunn 1975; Bradshaw and Huang 1991; Bradshaw et. al. 1993; Dixon and Boswell 1996; Kentor 1998; Kentor 2001; Kentor and Boswell 2003; London and Smith 1988; London and Williams 1990; Wimberly and Bello 1992; Viyani and Kaltani 2007; Sanderson and Kentor 2008; Hall and Bass 2012).

THE ECOSTRUCTURAL ORIENTATION OF FOREIGN CAPITAL DEPENDENCY THEORY

I draw on the ecostructural orientation of foreign direct investment dependency theory to assess the environmental implications of foreign-owned firms operating in developing countries (Grimes and Kentor 2003; Jorgenson 2006; Jorgenson et.al. 2007). Ecostructural refers to the "potential environmental implications of collective human activities" (Jorgenson et. al. 2007:

373). I also attempt to further refine this approach to better link transnational corporations and nitrous oxide emissions. The processes underlying the aforementioned relationship are rooted in the technologies derived in the mid 20th century Green Revolution.

Much scholarship suggests transnational firms have co-opted Green Revolution technology. The Green Revolution refers to the technological transfer of high-yielding varieties (HYV) of seeds that can require high-intensity use of synthetic fertilizers and produce intensified cropping patterns to developing countries, with increased agricultural production being a major goal (McMichael 2012; Robinson 2009). The integration of farmers into the global economy helped switch agricultural production from basic domestic needs to highly profitable, off-season produce for exports to rich countries, often through the influence and control of multi-national corporations (Longo and York 2008; Jorgenson and Kuykendall 2008; McMichael 2012; Wilkinson 2009; UNCTAD 2009; Robinson 2018; OECD/FAO 2019). The highly-profitable, off-season fruits and vegetables foreign-owned firms focus on tend to require large amounts of synthetic fertilizer application, making the use of such inputs more likely than traditional, more sustainable farming practices as TNCs have a built-in incentive to ignore environmental externalities in favor of short-term profits (Altieri 1998; Jorgenson and Kuykendall 2008; Chase-Dunn 1975; Bornschier and Chase-Dunn 1985; Jorgenson, et al. 2007).

There are also other reasons to believe non-core production is associated with increased nitrous oxide emissions. Another major source of N_2O emissions is fossil fuel combustion. It is speculated the poor infrastructure typical of developing countries can increase overall fossil fuel combustion. Less-developed countries often lack the tax revenue to maintain roads and railways, while the transportation vehicles used by transnational firms tend to be outdated and energy

inefficient (Grimes and Kentor 2003; Jorgenson et. al. 2007; Jorgenson et. al. 2011). A combination of these factors can lead to increased fossil fuel consumption relative to production in core countries, thereby generating increased nitrous oxide emissions. In addition to transnational firms operating in the Global South being more polluting, developing countries are often desperate to attract foreign capital to stimulate economic development and thus may lower environmental regulations to create more favorable conditions for foreign investors (Dixon and Boswell 1996; Leonard 1988). For example, Roberts and Parks (2007) find developing countries are less likely to ratify environmental treaties that are related to transnational firm activities. Additionally, multinational firms are in the position to move production processes to countries with more favorable labor and environmental regulations, which could arguably further incentivize developing countries to further concede to foreign capital (Jorgenson and Kick 2006). Overall, multiple processes parcel of larger global political-economic dynamics can contribute to anthropogenic nitrous oxide emissions.

Cross-national research generally supports the ecostructural orientation of foreign direct investment dependence theory. Foundational work by Grimes and Kentor (2003) finds a statistically significant positive relationship between accumulated FDI stocks as a percentage of GDP and carbon dioxide emissions. Additional research observes similar conclusions in the context of carbon emissions, methane emissions, water pollution, fertilizer use, deforestation, pesticide use, natural resource rents, nitrous oxide emissions, and other air pollutants (Jorgenson 2007b, Jorgenson 2008; Jorgenson 2007c; Jorgenson 2006; Jorgenson and Kuykendall 2008; Jorgenson 2010; Jorgenson et. al. 2007; Dick and Jorgenson 2009; Long, Stretsky, and Lynch 2017). In light of the above theorization and past empirical findings, I expect *foreign direct*

investment dependency is positively associated with total nitrous oxide emissions.

I now turn to a brief description of the sample, data, dependent variable, independent variable, control variables, and methods used to evaluate the above theorization. I then summarize key analysis findings. I conclude the analysis with a discussion of these results, limitations, and future research directions.

THE ANALYSIS

Sample

Below is a brief description of the sample of country-level data. I include observations for developing countries in which data are available for the dependent variable, independent variable, and control variables to maximize the use of all available data. The sample consists of 1-24 observations on 106 countries from 1990-2014. The overall sample size is 1779. I provide a list of countries with their respective observations by year that are included in the dataset in the Appendix.

Data

I analyze unbalanced cross-national and longitudinal country-level datasets on nitrous oxide emissions to test a refined ecostructural orientation of foreign direct investment dependency theory. Data for the analysis comes from three sources. Nitrous oxide emissions data comes from the World Resources Institute Climate Analysis and Indicator Tool (WRI 2015).

Data on FDI stocks comes from the United Nations Conference on Trade and Development (UNCTAD 2019). The rest of my data comes from the World Bank's *World Development Indicators* (World Bank 2015). Less-developed countries are identified if they are in the bottom three quartiles of the World Bank's income classification of countries (World Bank 2015). Descriptive statistics and correlation matrix are presented in Table 1. Please note all of the variables in the following description are log-transformed.

Table 3.3 Descriptive Statistics and Correlation Matrix ($N = 1779$)

	S.D.	Mean	Min	Max
Total N_2O	1.32	1.91	.001	6.08
GDP p.c.	2.07	23.4	18.1	29.9
Population	1.90	16.1	11.1	21.03
Agriculture	.65	2.76	1.009	4.14
Industry	.35	3.29	2.04	4.25
Trade Intensity	.48	4.23	2.62	5.39
Food Exports	1.05	2.98	0	5.901
Domestic Investment	.80	3.24	.589	5.11
FDI Stocks	.93	2.95	.265	5.36

Note: GDP p.c. = Gross Domestic Product per Capita; Population is total population; Agriculture = value added in agriculture as a percentage of GDP; Industry = value added in industry as a percentage of GDP; Trade intensity = trade as a percentage of GDP; Food Exports = Food exports as a percentage of merchandise exports; Domestic Investment = domestic investment as a percentage of GDP; FDI stocks = Total FDI stocks as a percentage of GDP

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Total N_2O	1.00								
(2) GDP p.c.	0.78	1.00							
(3) Population	0.87	0.84	1.00						
(4) Agriculture	-.003	-0.42	0.03	1.00					
(5) Industry	0.32	0.54	0.36	-0.45	1.00				
(6) Trade Intensity	-0.55	-0.32	-0.51	-0.21	0.11	1.00			
(7) Food Exports	-0.34	-0.41	-0.35	0.22	-0.54	0.02	1.00		
(8) Domestic Investment	0.02	0.30	-0.003	-0.50	0.13	0.29	0.08	1.00	
(9) FDI Stocks	-0.20	-0.01	-0.28	-0.40	0.07	0.49	0.02	0.39	1.00

Dependent Variable

The dependent variable of the analysis is total anthropogenic nitrous oxide emissions. The response variable is measured in million metric tons of carbon dioxide equivalent using 100-year global warming potentials found in the IPCC Second Assessment Report (IPCC 1996). This measure comes from the World Resources Institute Climate Analysis and Indicator Tool (WRI 2015). I also employ this measure as the scale of emissions is the primary human contributor to the climate crisis (IPCC 2007).

Independent Variable of Interest

FDI Stocks is the total value of capital and reserves provided by foreign enterprises to a host country in all sectors of the economy and is measured as a percentage of GDP (UNCTAD 2019). FDI Stocks is a standard measure of foreign direct investment dependence theory (e.g. Brady, Kaya, and Beckfield 2007; Long et. al. 2017; Hall and Bass 2012).

Control Variables

GDP per capita accounts for a country's level of economic development and is measured

in constant U.S. dollars. In addition to being a standard control variable in cross-national research, political economic theories such as the treadmill of production theory argue economic development positively affects environmental degradation (Schnaiberg 1980; Schnaiberg and Gould 1994; Gould, Pellow, and Schnaiberg 2008). This data comes from the World Bank's *World Development Indicators* (World Bank 2015).

Total Population is included in all models. I obtain this data from the World Bank's *World Development Indicators* (World Bank 2015). This data is measured in thousands and based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. Research in the structural human ecology tradition and previous cross-national research suggests population levels are positively associated with environmental degradation (e.g. Dietz and Rosa 1997; Dietz, Rosa, and York 2007; Mejia 2019).

Value added in agriculture measures the extent a country's domestic economy revolves around agriculture. This includes forestry, hunting, fishing, and the cultivation of crops and livestock. This data also comes from the World Bank's *World Development Indicators* (World Bank 2015). As agricultural processes are a major driver of anthropogenic nitrous oxide emissions, it is important to control for domestic agricultural economic sectors (Ussiri and Lal 2012).

Value added in industry accounts for the extent a country's domestic economy involves manufacturing and extractive processes. Manufacturing includes mining, manufacturing, construction, electricity, water, and gas sectors. This data comes from the World Bank's *World Development Indicators* (World Bank 2015). Previous research suggests industry is also implicated in nitrous oxide emissions (Ussiri and Lal 2012).

Trade as a percentage of GDP measures a country's integration into the global economic trading system. This measure is expressed as the sum of exports and imports of goods/services as a share of GDP (World Bank 2015). This data is also from the *World Development Indicators* (World Bank 2015). Neo-liberal perspectives often assert global economic integration through trade will transfer advanced technologies to developing countries that can lead to more sustainable forms of development (e.g. Perkins and Neumayer 2009). World-systems and dependency scholars, however, assert international trade can pressure developing pressure to lower their environmental standards to be competitive in the global economy (Jorgenson et. al. 2011; Jorgenson and Kick 2006).

Food exports as a percentage of merchandise exports captures the extent merchandise exports are comprised of commodities in specific Standard International Trade Classification sections. The sections included in this measure include food and live animals, beverages and tobacco, animal and vegetable oils and fats, oil seeds, oil nuts, and oil kernels (World Bank 2015). This data comes from the World Bank's *World Development Indicators*.

Domestic investment measures the effect of resources spent within a country to encourage development. It is measured as domestic credit to the private sector as a percentage of GDP. This data is gathered from the World Bank's *World Development Indicators* (World Bank 2015).

Methods

I conduct the analysis using fixed effects panel regression models with correction for first-order autocorrelation across all models. Fixed effects and random effects models are

commonly used in comparative international research to address heterogeneity bias or the time-invariant variables omitted from ordinary least squares regression models. Fixed effects and random effects models transform the data to eliminate unobserved time-constant effects (α_i). Fixed effects models undertake a "within" transformation which time-demeans the data to eliminate α_i. Random effects models quasi-demean the data to address unobserved heterogeneity. The general fixed effects model is as follows:

$$y_{it} = \beta_0 + \beta_k x_{it1} + \ldots + \beta_k x_{itk} + \alpha_i + \varepsilon_{it} \text{ for } t = 1, \ldots, T \text{ and } i = 1, \ldots, N.$$

Subscript *i* represents each unit of analysis (i.e. country), subscript *t* represents the time period, and α_i represents the combined effect on y of all unobserved variables that are constant over time. To eliminate the fixed effect, α_i, Stata computes the mean for the dependent variable and each time-varying independent variable for each cross-sectional unit *i.* The case-specific means are then subtracted from the observed value of each variable:

$$y^* = y_{it} - \bar{y}_i \quad \text{and } x^* = x_{it} - \bar{x}_i$$

Thus, the time-demeaned equation is as follows:

$$y^*_{it} = \beta_0 + \beta_1 x^*_{it1} + \ldots \beta_k x^*_{itk} + \varepsilon^*_{it} \text{ for } t = 1, \ldots, T \text{ and } i = 1, \ldots, N.$$

Finally, Stata conducts a pooled OLS regression using all time-demeaned variables (Wooldridge

2010).

In this analysis, fixed effects models are more appropriate than random effects models for multiple reasons. While random effects models are more efficient than fixed effect models, random effects models are inconsistent in the presence of covariance between unobserved time-invariant variables and explanatory variables (Wooldridge 2010). Fixed effects models are more robust than random effect models because they allow for arbitrary correlation between unobserved time-constant variables and explanatory variables, and are consistent in the presence of such covariance (Wooldridge 2010). Another reason fixed effects models are more suited for this analysis is that the main explanatory variable of interest varies over time. The robustness of fixed effects models comes at the price of being unable to include time-constant independent variables in the analysis as they are "wiped out" during the "within" transformation. This drawback is not a concern in the present reported analysis as the dependent variable, independent variable, and control variables vary over time. Results of the Hausman test give further reason to use fixed effects models over random effects models. A Hausman test is commonly used to adjudicate between fixed effect and random effect models. The Hausman test assesses whether the explanatory variables and unobserved time-constant variables are correlated based on the differences in fixed effects and random effects model estimates (Wooldridge 2010). The Hausman test for the analysis is statistically significant, suggesting a preference for a fixed effects model. Fixed effects models are also considered superior to cross-sectional models for multiple reasons. One reason is that they can account for heterogeneity bias. Another reason is

panel models usually have more degrees of freedom and sample variation, thereby improving the efficiency of estimates (Hsiao 2007). In sum, fixed effects models are quite appropriate for this analysis.

There are some issues common to cross-national longitudinal analyses that I attempt to account for. One issue is heteroskedasticity. Heteroskedasticity is when the variance of the error term is not constant given the explanatory variables (Wooldridge 2009). The statistics used to test hypotheses under the Gauss-Markov assumptions are not valid in the presence in the presence of heteroskedasticity (Wooldridge 2009). This is because the estimators of the variances are biased without the homoskedasticity assumption. Thus, the OLS standard errors are no longer valid for constructing confidence intervals and *t* statistics as OLS standard errors are based on these variances (Wooldridge 2009). I conduct a Breusch-Pagan/ Cook-Weisberg heteroskedasticity test for the analysis using "dummy variable regression," which is essentially identical to a fixed effects estimator (Wooldridge 2009: 485). The results of the heteroskedasticity test are statistically insignificant. Another issue is multicollinearity. Multicollinearity is the high correlation between two or more explanatory variables (Wooldridge 2010). However, the "problem" of multicollinearity is not well-defined. Two independent variables can be highly correlated but what ultimately matters is how "big [coefficients] are in relation to their standard deviation" (Wooldridge 2009: 97). I add independent variables one by one to the baseline model to assess the stability of parameter estimates and they remain largely unchanged across all models. Additionally, high correlation among explanatory variables that are not of particular interest is largely irrelevant (Wooldridge 2009: 98). As foreign direct investment stocks is the explanatory variable of interest and in light of the other aforementioned

diagnostics performed, I conclude multicollinearity is not an issue in this analysis. First-order autocorrelation is another issue in panel regression models. First-order autocorrelation (or serial correlation) is when consecutive error terms are correlated over time. The usual ordinary least squares regression standard errors are invalid in the presence of serial correlation (Wooldridge 2009). Thus, the *t* statistics are no longer valid for testing single hypotheses (Wooldridge 2009). I conduct a Wooldridge test for autocorrelation in panel data and to test the null hypothesis of no first-order autocorrelation. A statistically significant test indicates presence of first-order autocorrelation. The results are significant. Thus, I include a correction for first-order autocorrelation in all models. Outliers are another common issue in cross-national longitudinal regression analyses. I conducted added-variable plots in Stata to identify influential outliers. No influential outliers were identified.

FINDINGS

Table 3.4 Unstandardized Coefficients for Total Nitrous Oxide Emissions in Less-Developed Countries, 1990-2014: Fixed Effects Panel Regression Analysis

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
GDP p.c.	0.04***	0.04***	0.04***	0.04***	0.03***	0.03***
	(0.01)	(0.01)	(0.009)	(0.009)	(0.01)	(0.01)
Population	0.04*	0.04**	0.05**	0.06***	0.06***	0.05**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Agriculture, value added	-0.01	-0.02	-0.02	-0.02	-0.02	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Industry, value added		-0.02	-0.01	-0.01	-0.01	-0.009
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Trade Intensity			-0.04*	-0.04**	-0.04**	-0.05**
			(0.01)	(0.01)	(0.01)	(0.01)
Food Exports				-0.009	-0.01	-0.009
				(0.006)	(0.006)	(0.006)
Domestic Investment					0.007	0.003
					(0.01)	(0.01)
FDI Stocks						0.01*
						(0.007)
Constant	0.34***	0.34***	0.33***	0.33***	0.33***	0.33***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Observations	1779	1779	1779	1779	1779	1779
R^2 within	.37	.37	.38	.38	.38	.39

Standard errors in parentheses; two-tail test
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Analysis findings are reported in Table 2. Model 1 serves as a baseline model and includes GDP per capita, total population, and value-added in agriculture as a percentage of GDP. Model 2 builds on the aforementioned model by including value-added in industry as a percentage of GDP. Model 3 adds trade intensity, while Model 4 incorporates food exports as a

percentage of merchandise exports. Model 5 adds domestic investment as a percentage of GDP, while Model 6 incorporates the main variable of interest, foreign direct investment stocks as a percentage of GDP.

I begin the discussion of findings by summarizing the relationship between control variables and nitrous oxide emissions. Economic development, measured through GDP per capita, is positive and statistically significant across all reported models. This suggests that economic development is positively associated with nitrous oxide emissions. Additionally, a one percent increase in GDP per capita is associated with a 0.03 percent increase in nitrous oxide emissions in Model 6. Total Population is also positive and statistically significant across all included models. This suggests that population is positively associated with nitrous oxide emissions, with a one percent increase in population associated with a 0.05 percent increase in nitrous oxide emissions, according to Model 6. Domestic agricultural economic sectors is surprisingly negative and statistically insignificant in Models 1-6. Value added in industry as a percentage of GDP is also surprisingly negative and statistically insignificant. I find statistically significant results for trade intensity, measured through trade as a percentage of GDP. This significant relationship is negative, however, with a one percent increase in trade intensity being associated with a 0.05 percent decrease in N_2O emissions in Model 6. Domestic investment as a percentage of GDP is positive in Models 4-6 but does not reach statistical significance in any of these models. I now turn to the main independent variable of interest: total foreign direct investment stocks as a percentage of GDP.

Model 5 includes foreign direct investment stocks as a percentage of GDP. This measure

is positive in direction and is statistically significant at the .05 p-value threshold. This suggests that foreign capital dependency positively affects nitrous oxide emissions in developing countries. Additionally, a one percent increase in FDI stocks as a percentage of GDP is associated with a 0.01 percent increase in total nitrous oxide emissions. These findings support the eco-structural orientation to foreign direct investment dependency and add to a large vein of literature highlighting the environmental implications of the transnational organization of production (Grimes and Kentor 2003; Jorgenson 2007a; Jorgenson 2007b, Jorgenson 2008; Jorgenson 2007c; Jorgenson 2006; Jorgenson and Kuykendall 2008; Jorgenson 2010; Jorgenson et. al. 2007; Dick and Jorgenson 2009; Long, Stretsky, and Lynch 2017). Indeed, global food production is largely controlled and directed by transnational firms headquartered in high-income countries (Altieri 1998; Wilkinson 2009; McMichael 2012). I discuss the theoretical implications of this finding below.

DISCUSSION AND CONCLUSION

A key contribution of this analysis is that foreign capital dependency is positively associated with total nitrous oxide emissions in developing countries from 1990-2014. I thus find support for a refined ecostructural theory of foreign direct investment dependency that attempts to better link transnational firms operating in the global south and N_2O emissions. There are also additional findings worth noting. Results suggest economic development and total population positively affect nitrous oxide emissions. I also find trade intensity negatively affects nitrous oxide emissions. I find little support for assertions that domestic and industrial economic sectors, food exports, and domestic investment affect nitrous oxide emissions.

These findings help advance environmental sociology literature and research in global political economy. Much theorization and research on the implications of the transnational organization of production for greenhouse gas emissions revolves around carbon dioxide emissions (e.g. Grimes and Kentor 2003; Jorgenson 2007a; Jorgenson 2007b; Jorgenson et. al. 2011). This is expected given carbon dioxide emissions are the principal anthropogenic greenhouse gas affecting the Earth's radiative balance. However, nitrous oxide emissions operate quite differently than carbon dioxide emissions. While fossil fuel combustion contributes to nitrous oxide emissions, the largest source of N_2O emissions is the application of nitrogen-rich synthetic fertilizers to crops (EPA 2019). This analysis attempts to slightly refine and contribute to past formulations of the ecostructural theory of foreign capital dependency to understand the relationship between transnational firms operating in the Global South and nitrous oxide emissions (Grimes and Kentor 2003; Jorgenson 2006; Jorgenson et. al. 2007; Jorgenson and Kuykendall 2008). Indeed, transnational firms largely control and direct the transnational organization of agricultural production (Longo and York 2008; McMichael 2012; Wilkinson 2009; Robinson 2009). As MNCs have a built-in incentive to maximize returns on investment instead of ecological considerations (Robinson 2009), MNCs are more likely to engage in the high-intensity use of synthetic fertilizers rather than environmentally sustainable farming practices, thereby generating N_2O emissions. Overall, this analysis aims to contribute to past theoretical innovations in this research agenda and help advance understanding of the collective human activities driving environmental degradation.

There are some limitations to this analysis. A major limitation of this analysis is the use of FDI stocks as a percentage of GDP in *all* economic sectors. By far the largest source of

nitrous oxide emissions is the application of synthetic fertilizers in agricultural production. It is reasonable to argue that accumulated stocks of foreign investment in the primary sector (e.g. agriculture, grazing) as a percentage of GDP could have a larger effect on nitrous oxide emissions than FDI stocks in the secondary sector as a percentage of GDP (e.g. industry) when using standardized coefficients in statistical analyses. However, this analysis is unable to parcel out the effect of foreign investment stocks in different economic sectors as this data is not available for the analysis timeframe.

There are numerous directions for future research. As noted earlier, one reason comparative international research often neglects nitrous oxide emissions is lacking estimates for many of the world's countries. The availability of N_2O estimates opens up a plethora of avenues for subsequent research. One is focusing on specific regions. It is speculated that transnational agri-firms are increasingly targeting the East Asia and Pacific macro-region (e.g. Wilkinson 2009). Thus, future analyses of foreign direct investment dependence and the environment could focus on specific macro-regions. In a slightly related vein, future research could also test propositions from ecological unequal exchange. Given the transnational organization of agricultural production and increasingly recognized "fertilizer" treadmill (McMichael 2012; Houser and Stuart 2019), future cross-national research should test propositions from the treadmill of production theory and ecological modernization theory in a global sample of countries, developed countries, and developing countries in addition to specific macro-regions. The urgency of the climate crisis also mandates the incorporation of other comparative international research agendas such as the world society tradition (Meyer et. al. 1997). Nitrous oxide emissions are continuing to rise at unprecedented rates (WRI 2015). However, nitrous

oxide emissions are a central issue in the global environmental regime and past research suggests embeddedness in environmental world society results in decreased environmental degradation (e.g. Hironaka 2014; Mejia 2019). Of course, environmental harm continues at unprecedented rates but even slight reductions in nitrous oxide emissions could be beneficial given its high global warming potential and impact on stratospheric ozone depletion.

CHAPTER 3

Does Foreign Capital Dependence Affect Carbon Dioxide Emissions in Less-Developed Countries? A Cross-National Analysis, 1980-2014[1]

Social scientists have long investigated the environmental impacts of foreign investment for developing countries. Numerous studies find a significant positive association between foreign investment dependence and carbon dioxide emissions in less-developed countries (e.g. Grimes and Kentor 2003; Kentor and Grimes 2006; Jorgenson 2007a; Jorgenson 2007b; Jorgenson, Dick, and Shandra 2011). However, there are numerous limitations to some of the aforementioned analyses that investigate the effect of foreign investment dependence on carbon dioxide emissions in developing countries. One limitation of some of the existing literature on the relationship between foreign investment dependence and carbon dioxide emissions in less-developed countries is that they utilize cross-sectional models, which are unable to account for unobserved heterogeneity (Wooldridge 2010).[2] Another limitation of existing research on the relationship between foreign capital dependence and carbon dioxide emissions is that the number of countries and observations in the reported panel regression models is quite small (e.g. Jorgenson 2007b; Jorgenson, Dick, and Mahutga 2007; Jorgenson et. al. 2011).[3] The limitations of some of the previous research on the foreign capital dependence and carbon dioxide emissions relationship is often due to data limitations. However, there is increased panel data on foreign direct investment and carbon dioxide emissions in addition to more powerful regression models that account for country heterogeneity and first-order autocorrelation (Wooldridge 2009). Considering the urgency of climate change and global warming, an updated analysis of the relationship between foreign capital dependence and total carbon dioxide emissions in less-

developed countries that addresses the limitations of previous research is indeed warranted.[4]

This analysis addresses the issues outlined in the preceding discussion. I begin with a brief description of the theoretical approach used in this analysis, which is the longstanding theory of foreign capital dependence (e.g. Bornschier and Chase-Dunn 1985; Chase-Dunn 1975). I then derive the following proposition from the theory of foreign capital dependence: *foreign capital penetration is positively associated with carbon dioxide emissions in less-developed countries.* I test the aforementioned proposition using fixed effects (FE) panel regression models with a correction for first-order autocorrelation. I find that foreign capital penetration is positively associated with carbon dioxide emissions in less-developed countries, which supports the proposition derived from the theory of foreign investment dependence. Similar to previous research, I find that economic development, total population, urbanization, and export intensity exert a positive statistically significant effect on carbon dioxide emissions in less-developed countries, while domestic investment (gross capital formation as a % of GDP) is inversely associated with carbon dioxide emissions in less-developed countries.

The organization of this chapter is as follows. I begin with a brief discussion of foreign capital dependency theory and the environment. Then, I state the proposition derived from the theory of foreign capital dependency. Next, I describe the dataset, response variables, explanatory variables, and methodological approach used in the current study. I then summarize the results of the analysis in the *Results* section. Lastly, I elaborate on the significance of the findings in the discussion and conclusion.

FOREIGN CAPITAL DEPENDENCY THEORY

Social scientists typically draw on the longstanding theory of foreign capital dependence when investigating the effects of foreign investment in less-developed countries (e.g. Dixon and Boswell 1996a, 1996b; Chase-Dunn 1975). Generally, the theory of foreign capital dependence argues that a variety of global political-economic processes partially tied to the initial attraction of foreign investment affect the economic, social, and political structure of a host country, when then affects the outcome of interest (Chase-Dunn 1975; Kentor 2001). There is much theoretical debate and empirical investigations concerning the effect of foreign investment on economic growth, income inequality, child mortality, infant mortality, and other outcomes (Dixon and Boswell 1996a; c.f. Firebaugh 1992, 1996; Dixon and Boswell 1996b; Kentor and Boswell 2003; Kentor 1998; Curwin and Mahutga 2014; Bornschier, Chase-Dunn, and Rubinson 1978; Chase-Dunn 1975; Bornschier and Chase-Dunn 1985; Bornschier 1980; Bradshaw 1987; Shandra et. al. 2004, 2005; Sanderson and Kentor 2008, 2009). Overall, a large and rich body of social science research investigates the impacts of foreign investment for developing countries.

Foreign Investment Dependence and the Environment: The Ecostructural Orientation of Foreign Capital Dependency Theory

Social scientists have increasingly investigated the effects of foreign investment on a variety of environmental outcomes in less-developed countries. More specifically, I draw on the "ecostructural orientation" of foreign capital dependency theory, where ecostructural means the "potential environmental implications of collective human activities…" (Jorgenson et. al. 2007:

373; Grant, Jones, and Bergesen 2002; Jorgenson 2003; Grimes and Kentor 2003; Jorgenson and Kuykendall 2008; Long, Stretesky, and Lynch 2017; Mejia 2021a). The "ecostructural orientation" of foreign investment dependency theory provides numerous theoretical reasons to expect a *positive relationship between foreign capital penetration and carbon dioxide emissions in less-developed countries*.

Some of the aforementioned theoretical reasons are rooted in global political-economic processes. In recent decades, less-developed countries have faced pressure from global financial institutions such as the World Bank and International Monetary Fund to create more favorable conditions for foreign investors, where "favorable conditions" sometimes translates into relaxing environmental regulations for transnational corporations (McMichael 2012; Jorgenson et. al. 2007). Although scholarly debate continues (e.g. Firebaugh 1992, 1996; Dixon and Boswell 1996a; Kentor 1998; Curwhin and Mahutga 2014), foreign investment is often regarded as a way to stimulate economic growth in less-developed countries. Thus, government officials might lower environmental regulations to attract foreign investment, especially as they are often in desperate need of investment (Frey 2003). Real or perceived threats of capital flight can lead to further concessions to foreign investors and transnational corporations in the form of environmental regulations, which then affects outcomes such as carbon dioxide emissions (Wallerstein 2005; Jorgenson 2007b). Overall, there are a variety of global political economic processes underlying a potential relationship between foreign investment and CO_2 emissions in less-developed countries.

There are also other reasons to expect that foreign capital dependence is associated with

increased CO_2 emissions in developing countries. One is related to the production processes that foreign investment finances. Scholars posit that a "large portion of foreign investment in less-developed countries finances highly polluting, ecologically inefficient, and labor-intensive manufacturing processes and facilities outsourced from developed countries" (Jorgenson 2007a:139; Roberts, Grimes, and Manale 2003). Additionally, partly because of the more relaxed labor regulations, transnational corporations use energy from power generation facilities that are ecologically inefficient and outdated (Kentor and Grimes 2006; Grimes and Kentor 2003). Also, transnational corporations used outdated, ecologically inefficient, and environmentally unfriendly transportation vehicles to transport goods (Grimes and Kentor 2003; Jorgenson 2007b). The use of environmentally unfriendly transportation vehicles in countries with spotty infrastructure can increase the use of fossil fuels relative to vehicles in high-income countries, thereby generating more CO_2 emissions than the same activity in a high-income country (Grimes and Kentor 2003). Similarly, foreign investment can finance agricultural production equipment such as tractors that are more ecologically unfriendly than agricultural production equipment in high-income countries, which can lead to more CO_2 emissions relative to agricultural production in the core (Jorgenson 2007a).

The findings of previous research give further reason to expect a positive relationship between foreign capital dependence and carbon dioxide emissions. In a pioneering study, Grimes and Kentor (2003) found that foreign capital dependence exerts a statistically significant effect on carbon dioxide emissions. Other research finds that primary sector foreign investment exerts a statistically significant effect on carbon dioxide emissions from agriculture production (Jorgenson 2007a). Further, utilizing panel regression models, Jorgenson (2007b) and Jorgenson

et al. (2011) find that foreign capital dependence exerts a positive statistically significant effect on carbon dioxide emissions in developing countries. Overall, there are a variety of reasons to expect that:

Proposition of Interest: Foreign capital penetration is positively associated with carbon dioxide emissions in less-developed countries.

DATA

I use two sources of country-level data to test the proposition derived from the "ecostructural" orientation of the theory of foreign capital dependence. The data on foreign direct investment stocks comes from the United Nations Conference on Trade and Development (UNCTAD 2020). The rest of the data comes from the World Bank's *World Development Indicators* (World Bank 2020). I identify less-developed countries if they are not classified as "high-income" in the World Bank's income classification of countries (World Bank 2021), which is quite common (e.g. Mejia 2022, Mejia 2021a, 2021b, 2021c). Table 1 provides descriptive statistics and correlation matrix.

Table 3.5 Descriptive Statistics and Correlation Matrix

	S.D.	Mean	Min	Max
Total CO_2 emissions, ln	2.401217	8.881321	3.496598	16.14687
FDI stocks as a percentage of GDP, ln	1.068192	2.645721	.0102448	6.673178
Real GDP per capita (2010 USD$), ln	1.04197	7.406493	4.880119	9.920047
Total Population, ln	1.723459	16.10772	10.86006	21.03389
Urban Population (% of Total)	19.90647	43.58722	4.339	91.604
Trade (exports + imports) as a percentage of GDP, ln	.5413658	4.171728	.1547942	6.278028
Gross Capital Formation (% of GDP)	12.77187	23.27219	-2.424358	219.0694
Foreign Direct Investment Rate	.444632	.1564016	-13.82088	13.0955

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Total CO_2 emissions, ln	1.000							
(2) FDI stocks as a percentage of GDP, ln	0.010	1.000						
(3) Real GDP per capita (2010 USD$), ln	0.544	0.285	1.000					
(4) Total Population, ln	0.785	-0.175	0.012	1.000				
(5) Urban Population (% of Total)	0.498	0.264	0.760	0.070	1.000			
(6) Trade (exports + imports) as a percentage of GDP, ln	-0.201	0.468	0.183	-0.495	0.086	1.000		
(7) Gross Capital Formation (% of GDP)	0.091	0.133	0.191	-0.071	0.073	0.350	1.000	
(8) Foreign Direct Investment Rate	-0.032	-0.092	-0.034	-0.041	-0.008	0.041	0.065	1.000

DEPENDENT VARIABLE

The dependent variable is *total carbon dioxide emissions* (ln) measured in kilotons. I gather this data from the World Bank's *World Development Indicators* (World Bank 2020). I take the natural logarithm of this variable to address excessive skew. I focus on total carbon dioxide emissions as the scale of anthropogenic greenhouse gas emissions is key contributor to climate change and global warming in addition to much of the previous research on the foreign investment/ carbon dioxide emissions relationship focuses on total carbon dioxide emissions. Additionally, numerous cross-national studies focus on total carbon dioxide emissions (e.g.

Schofer and Hironaka 2005; Jorgenson et. al. 2011; Mejia 2021b).

INDEPENDENT VARIABLE OF INTEREST

Foreign capital penetration is operationalized as inward foreign direct investment stocks in all economic sectors as a percentage of a country's GDP, which captures the extent foreign investors dominate a host country's economy (Dixon and Boswell 1996a; Kentor and Boswell 2003; Jorgenson 2007a; Mejia 2021a). I retrieve this data from the United Nations Conference on Trade and Development (UNCTAD 2019). Please note that I add one to this variable before taking the natural logarithm to avoid negative values. I take the natural logarithm of this variable to address excessive skew.

OTHER RELEVANT VARIABLES

Economic Development

Economic development is measured as the natural logarithm of real GDP per capita in $US dollars. I take the natural logarithm of this variable to address excessive skew. In addition to being a standard control variable in cross-national research, multiple sociological theories posit that *economic development is positively associated with carbon dioxide emissions in developing countries.* For example, the classical "treadmill of production" theory (e.g. Schnaiberg 1980; Schnaiberg and Gould 1994) suggests that economic development is a key predictor of environmental harm. Additionally, technological advances can affect the "eco-efficiency" of production processes. However, treadmill of production theorists and other scholarship suggests

that increases in the "eco-efficiency" of production actually increase the consumption of energy/resources (e.g. Clark and Foster 2001; York 2006; Jevons 1906). Much cross-national research finds that economic development is positively associated with carbon dioxide emissions, other greenhouse gas emissions, and environmental outcomes more broadly (e.g. Jorgenson and Clark 2012; Mejia 2021a; Mejia 2021b; Grimes and Kentor 2003). Also, structural human ecology posits that economic development is also a key predictor of environmental harm (e.g. Dietz and Rosa 1997). *I thus expect to find that economic development is positively associated with carbon dioxide emissions in developing countries*.

Total Population

I also control for *total population* (ln). I take the natural logarithm of this variable to address excessive skew. Please note that population is based on the de facto definition of population, which counts all residents as citizens regardless of a resident's legal status/citizenship (World Bank 2020). Controlling for a country's population levels is "critical when investigating environmental outcomes measured by scale" such as total carbon dioxide emissions (Jorgenson 2007a: 144). Also, structural human ecology suggests that, in addition to economic development, population is another major predictor of environmental outcomes (e.g. York et. al. 2003). Additionally, the relationship between total population and environmental outcomes is one of the most established relationships in the comparative international social sciences. I thus expect to find that *total population is positively associated with carbon dioxide emissions in developing countries*.

Urbanization

I control for a country's level of urbanization, which is measured as urban population as a % of total population (World Bank 2020). Urban political-economy theorists suggest that *urbanization is associated with increased carbon dioxide emissions* as urban areas can be sites of economic development, which then affects carbon dioxide emissions. (Molotch 1976; Logan and Molotch 2007). Also, controlling for a country's level of urbanization when investigating carbon dioxide emissions is quite standard in cross-national research (e.g. York et. al. 2003). Much research finds that urbanization exerts a positively statistically significant effect on carbon dioxide emissions (e.g. Jorgenson 2007b). I thus expect to find that *urbanization is positively associated with carbon dioxide emissions in developing countries*.

Trade

I also control for a country's level of *trade openness*, which is operationalized as *trade (exports + imports) as a percentage of a country's GDP*. I take the natural logarithm of this variable to address excessive skew. I also add 1 before taking the natural logarithm to avoid negative values. Some scholars posit that global political economic integration in the form of trade will positively affect carbon dioxide emissions as developing countries may lower their environmental regulations to be more competitive in the global economy (Schofer and Hironaka 2005; Mejia 2021b). Other scholarship suggests that integration into the global economy through trade can diffuse modern environmental values to developing countries in addition to less-developed countries being able to import superior technology that can improve the eco-efficiency

of production (e.g. Perkins and Neumayer 2008). With much empirical work finding that trade openness is positively associated with environmental outcomes (e.g. Mejia 2021b). I expect that *trade openness is positively associated with carbon dioxide emissions in developing countries*.

Domestic Investment

It is also important to control for *domestic investment* when investigating the impacts of foreign investment for developing countries (Jorgenson et. al. 2007; Dixon and Boswell 1996a; Firebaugh 1992). I measure domestic investment as gross capital formation as a percentage of GDP. This data is from the World Bank's *World Development Indicators* (World Bank 2020). Some scholars suggest that domestic investors are more likely to invest in environmentally friendly production processes than foreign investors (Young 1997). Also, some social scientists posit that industry tied to domestic investors is less environmentally harmful than industry tied to foreign investors (Jorgenson 2006b). I thus expect that *domestic investment is inversely associated with carbon dioxide emissions in developing countries*.

Foreign Investment Rate

I also control for *foreign investment rate*, which is inward foreign direct investment flow divided by inward foreign direct investment stock. Firebaugh (1992:125) writes "Investment rate should be included routinely in panel and rate models." Some social scientists might argue that including foreign investment rate as a regressor when investigating the impacts of foreign investment dependence in developing countries is no longer necessary. However, I opt for a

more conservative approach and include foreign investment rate as a regressor.

METHODOLOGICAL APPROACH: FE MODELS WITH AR[1] CORRECTION

In this analysis, I employ FE panel regression models with a correction for first-order autocorrelation. The FE estimator is the pooled OLS estimator of the following equation (Wooldridge 2010):

$$y_{it}\text{-}\bar{y}_i = \beta_0 + \beta_1 (x_{it1}\text{-}\bar{x}_{i1}) + \ldots + \beta_k (x_{itk}\text{-} \bar{x}_{ik}) + (a_i - a_i) + (u_{it}\text{-} \bar{u}_i) \text{ for } t = 1, 2, \ldots T; i = 1, 2,\ldots, N \quad (1)$$

Where $\bar{y}_i = T^{-1} \sum_{t=1}^{T} y_{it}$, $\bar{u}_i = T^{-1} \sum_{t=1}^{T} u_{it}$, $\bar{x}_{i1} = T^{-1} \sum_{t=1}^{T} x_{it1}$, and so forth for each time-varying explanatory variable. With the FE transformation, country heterogeneity (a_i) is "wiped out" (Wooldridge 2010). I include a correction for first-order autocorrelation (using the *xtregar* command in Stata version 14) as the Wooldridge test for autocorrelation in panel data (*xtserial* command in Stata version 14) was statistically significant.

I use FE panel regression models in this analysis over generalized least squares (GLS) random effects (RE) models. GLS RE models are another method to address country heterogeneity. RE estimation is the pooled ordinary least squares estimation of the following equation:

$y_{it} - \lambda\bar{y}_i = \beta_0 (1 - \lambda) + \beta_1(x_{it1} - \lambda\bar{x}_{i1}) + \ldots + \beta_k(x_{itk} - \lambda\bar{x}_{ik}) + (v_{it} - \lambda\bar{v}_i)$ for $t = 1,\ldots,T$; $i = 1,\ldots, N$.

(2)

Where lambda (λ) = $1 - [\sigma_u^2 / \sigma_u^2 + T\sigma_a^2]^{1/2}$, $\bar{y}_i = T^{-1} \sum_{t=1}^{T} y_{it}$, $\bar{v}_i = T^{-1} \sum_{t=1}^{T} v_{it}$, $\bar{x}_{i1} = T^{-1} \sum_{t=1}^{T} x_{it1}$, and so forth for each explanatory variable. σ_u^2 is the variance of the idiosyncratic error term. The composite error term (v_{it}) is $u_{it} + a_i$. σ_a^2 is the variance of the time-constant country-level effects (a_i). There are pros and cons to GLS RE and FE models. GLS RE models are more efficient and allow for the inclusion of time-constant variables. However, a major assumption of GLS RE models is that the covariance between time-invariant variables and explanatory variables is zero (Wooldridge 2009). A Hausman test is commonly used to adjudicate between FE models and GLS RE models (Wooldridge 2010; Baltagi 2008). The Hausman test was statistically significant, indicating that FE models should be used instead of GLS RE models (Wooldridge 2010). I thus proceed with using FE panel regression models in this analysis.

I conclude that there are no influential outliers in the analysis after analyzing added-variable (AV) plots.

RESULTS

Table 3.6 Unstandardized Coefficients for the Regression of Total Carbon Dioxide Emissions (ln) on Foreign Direct Investment Stocks as a Percentage of GDP (ln) and Other Selected Explanatory Variables: Fixed Effects Regression with AR(1) Disturbances, 1980-2014

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
FDI stocks as a percentage of GDP, ln	0.0712***	0.0450***	0.0671***	0.0745***	0.0713***	0.0449***
	(0.0120)	(0.0122)	(0.0121)	(0.0121)	(0.0120)	(0.0123)
Real GDP per capita (2010 USD$), ln	0.841***	0.712***	0.839***	0.845***	0.841***	0.716***
	(0.0367)	(0.0389)	(0.0365)	(0.0367)	(0.0367)	(0.0387)
Total Population, ln	0.147***	0.133***	0.135***	0.147***	0.147***	0.120***
	(0.0205)	(0.0203)	(0.0210)	(0.0205)	(0.0205)	(0.0208)
Urban Population (% of Total)		0.0263***				0.0261***
		(0.00291)				(0.00289)
Trade (exports + imports) as a percentage of GDP, ln			0.0468*			0.0514*
			(0.0206)			(0.0209)
Gross Capital Formation (% of GDP)				-0.00124*		-0.00165**
				(0.000543)		(0.000551)
Foreign Direct Investment Rate					-0.00266	-0.00328
					(0.00685)	(0.00675)
Constant	0.149***	0.212***	0.169***	0.143***	0.144***	0.223***
	(0.0411)	(0.0405)	(0.0412)	(0.0410)	(0.0411)	(0.0406)
Observations	2832	2832	2832	2832	2832	2832
R^2 within	0.5158	0.5298	0.5192	0.5161	0.5158	0.5345

Standard errors in parentheses; two-tail test

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

I report the analysis findings in Table 2. I report 6 models. Model 1 is treated as a simple baseline model, which includes FDI stocks as a percentage of GDP, GDP per capita, and total population. Models 2 through 5 include all the covariates from Model 1 and one additional statistical control. The additional covariate in Model 2 is urban population as a percentage of total population and trade (exports + imports) as a percentage of GDP is the additional control variable in Model 3. Gross capital formation as a percentage of GDP is the additional statistical control in Model 4, while FDI rate is the additional predictor variable in Model 5. Model 6 is the most fully saturated model and includes all the covariates from the preceding models. In each model, standard errors are in parentheses while unstandardized coefficients are flagged for statistical significance.

I now turn to Table 2. The unstandardized coefficients for foreign direct investment stocks as a percentage of GDP are positive in direction and statistically significant across all the models reported in Table 2. Similarly, the unstandardized coefficients for GDP per capita, total population, urban population as a percentage of total population, and trade (exports + imports) as a percentage of GDP are positive in direction and statistically significant across all the models these variables are included in. I find a negative significant association between gross capital formation as a percentage of GDP and total carbon dioxide emissions in Model 4 and 6. The unstandardized coefficient for foreign direct investment rate does not reach statistical significance.

DISCUSSION

In this analysis, I help advance the macrosociological literature that investigates the environmental impacts of foreign investment in less-developed countries. Foremost, I address the limitations of previous research that investigates the relationship between foreign capital dependence and carbon dioxide emissions in less-developed countries. I employ more powerful regression models than the methodological approach used in previous studies on the foreign investment/CO_2 emissions relationship in developing countries in addition to having a larger sample size than the studies that do analyze cross-sectional longitudinal data. I use FE panel regression models with a correction for first-order autocorrelation to test the proposition derived from the ecostructural theory of foreign capital dependence, which is that *foreign capital penetration is positively associated with CO_2 emissions in developing countries*. I find empirical support for the proposition derived from the ecostructural orientation of foreign capital dependence.

The contribution of this analysis are as follows. Foremost, I engage social scientific conversations regarding the effects of global political-economic integration in the form of foreign investment on greenhouse gas emissions. Social scientists have long investigated the relationship between foreign capital dependence and environmental outcomes such as carbon dioxide emissions (e.g. Grimes and Kentor 2003; Kentor and Grimes 2006; Jorgenson 2007a; Jorgenson 2007b; Jorgenson et. al. 2007). I find that foreign capital penetration is positively associated with carbon dioxide emissions in developing countries with more powerful regression models than some previous research and more expansive cross-sectional longitudinal data than

most of the same research. I thus further validate the theoretical predictions of the ecostructural orientation of foreign capital dependency theory, which underscores the relevance of this theoretical paradigm in advancing our understanding of the anthropogenic sources of greenhouse gas emissions and incorporating FDI stocks as a percentage of GDP as a control variable in future analyses of the anthropogenic sources of greenhouse gas emissions. Also, the finding that domestic investment is inversely associated with carbon dioxide emissions underscores that the source of investment *does* matter for environmental outcomes, which is a key claim of dependency research (Dixon and Boswell 1996a). This analysis is especially timely considering the urgency of addressing climate change and global warming in addition to the general lack of empirical attention to the foreign capital dependence and carbon dioxide emissions relationship in recent years.

There are other important findings worth discussing. Consistent with the theoretical predictions of the treadmill of production theory (e.g. Schnaiberg 1980; Schnaiberg and Gould 1994) and the structural human ecology tradition (e.g. Dietz and Rosa 1997), I find that economic development is positively associated with CO_2 emissions in less-developed countries. Also, I find that total population is associated with increased CO_2 emissions in developing countries, which is also in line with the theoretical predictions of the structural human ecology tradition and is consistent with the findings of much empirical work (e.g. York et. al. 2003; Mejia 2020; Mejia 2021a; Mejia 2021b). Further, I also find that urbanization is positively associated with CO_2 emissions in developing countries, which supports the theoretical expectations of urban political-economy theorists (e.g. Molotch 1976; Logan and Molotch 2007) and also aligns with the findings of previous empirical studies (e.g. Jorgenson and Clark 2012).

I find that another form of global political economic integration, export intensity, is positively associated with carbon dioxide emissions in less-developed countries. I also find that domestic investment is inversely associated with CO_2 emissions in less-developed countries. Overall, I contribute to a variety of scholarly conversations in the comparative international social sciences and social sciences more broadly.

There are some limitations to this analysis that are worth noting. The biggest limitation of this analysis is that the FDI data I use in this study is FDI in *all* economic sectors. It makes intuitive sense that FDI in different economic sectors such as the primary sector and secondary sector might have different effects on carbon dioxide emissions in developing countries. Indeed, previous research on the FDI/ CO_2 emissions relationship in less-developed countries finds empirical support for such intuition (Jorgenson 2007a; Jorgenson et. al. 2007). To the author's knowledge, however, FDI data in different economic sectors is unavailable for the temporal scope of the analysis. Future research should incorporate FDI data in different economic sectors if it ever becomes available again to parcel out the effect of FDI in different economic sectors on CO_2 emissions in developing countries. Doing so can help advance our understanding of the factors that affect CO_2 emissions, which are a major contributor to climate change and global warming. Indeed, climate change and global warming are perhaps the greatest challenges facing humanity in the 21st century.

There are numerous directions for future research that I plan to undertake. First, I plan on investigating the effect of foreign capital dependence on other major greenhouse gas emissions such as methane emissions and nitrous oxide emissions in less-developed countries. Previous research on the foreign capital dependence and methane emissions relationship in developing

countries is cross-sectional by design (e.g. Jorgenson 2006a). Recently, there is increased cross-sectional longitudinal data on methane emissions, so I plan to estimate the effect of foreign capital dependence on methane emissions in developing countries using more powerful regression models than previous research. I also plan on replicating recent scholarship on the foreign capital dependence/nitrous oxide emissions relationship (Dick and Jorgenson 2009; Mejia 2021a). Nitrous oxide emissions are an extremely potent greenhouse gas emission and contribute to stratospheric ozone depletion (Mejia 2021a). It is thus crucial to replicate the aforementioned studies.

CONCLUSION

The central finding of this analysis is that I provide even stronger empirical support for the tenets of foreign investment dependency theory than previous research on the foreign investment/ carbon dioxide emissions nexus in developing countries. Additional findings are quite consistent with previous cross-national research, where I find that economic development, population, urban population as a percentage of total population, and trade openness are positively associated with CO_2 emissions. Another relevant finding is that domestic investment is inversely associated with CO_2 emissions in developing countries.

FOOTNOTES

1. Please note that I refer to developing countries and less-developed countries interchangeably throughout the chapter.

2. Please note that I refer to foreign capital penetration and foreign capital dependence interchangeably throughout the chapter.

3. In this analysis, I also have much more countries than previous research (data on 109 developing countries). For example, Jorgenson (2007b) reports having 37 less-developed countries while Jorgenson et. al. (2011) report having 36 developing countries in their analysis of the effects of secondary sector foreign investment on total carbon dioxide emissions in developing countries.

4. See Jorgenson et. al. (2007) for analyses that focus on carbon dioxide emissions per capita.

CHAPTER 5

Summary and Conclusion

The environment is a defining issue of the modern era. The three chapters of this dissertation seek to investigate the extent processes of world society and the world economy help explain cross-national and longitudinal variation in numerous environmental indicators. Chapter 1 focuses on ambient air pollution. Chapter 2 analyses nitrous oxide emissions. Chapter 3 analyses carbon dioxide emissions. Exposure to ambient air pollution has dramatic implications for human health and the environment overall. Nitrous oxide emissions are an extremely potent greenhouse gas emission with a global warming potential of 298 over 100 years. One pound of nitrous oxide emissions is thus equivalent to around 298 pounds of carbon dioxide emissions. Nitrous oxide emissions also contribute to stratospheric ozone depletion, where the ozone layer makes life on Earth possible. Carbon dioxide emissions are the primary driver of human-induced climate change and account for a large proportion of all the greenhouse gas emissions emitted into Earth's atmosphere.

Chapter 1 investigates the effect of world society on ambient air pollution across a country's position in the stratified world economy. Numerous social scientists in the world society tradition (Meyer et. al. 1997; Boli and Thomas 1997, 1999; Frank et. al. 2000) have sought to explain the dramatic increase in pro-environmental efforts in the decades after World War Two, where numerous studies suggest that there has been a shift in our cultural understandings of the environment in world society from a natural resource to a global ecosystem that needs protection (Frank 1997; Meyer et. al. 1997b; Schofer and Meyer 2005;

Hironaka 2014). Some social scientists initially questioned whether environmental world society has implications for actual environmental outcomes (e.g. Buttel 2000), but a growing body of studies indicate that the culture of world society does have concrete implications for environmental outcomes (e.g. Schofer and Hironaka 2005; Shandra et. al. 2004; Mejia 2021c; Hironaka 2014; Shorette 2012; Henderson and Shorette 2017; Shandra et. al. 2009; Jorgenson, Dick, and Shandra 2011; Longhofer and Jorgenson 2017). In addition, recent theoretical innovations suggest that the effect of world culture may be contingent on a country's position in the world-system (Shorette 2012; Tester 2020). In Chapter 1, I engage this emerging body of social scientific literature by exploring whether these arguments help explain cross-national and longitudinal variation in ambient air pollution. I find that world society embeddedness does produce beneficial effects on ambient air pollution in core and semi-peripheral countries, but this effect loses statistical significance in peripheral countries. Recent work suggests that the limited effect of world society embeddedness in non-core countries may be attributed to political-economic processes. However, I posit that the diminished effect of world society may be attributed to demographic processes as main sources of ambient air pollution are from the burning of biomass and other natural resources.

Chapter 2 and 3 investigate the environmental impacts of foreign direct investment. Another key feature of globalization is the increase in foreign direct investment after World War Two. A long line of work in the social sciences has sought to understand how the in flow of financial resources in the context of foreign direct investment is affecting social, economic, and political change, with a particular focus on developing countries

(e.g. Chase-Dunn 1975; Bornschier 1980; Bornschier and Chase-Dunn 1985; Firebaugh 1992, 1996; Dixon and Boswell 1996a, 1996b; Kentor 1998, 2001; Kentor and Boswell 2003; Curwin and Mahutga 2014; Clark and Kwon 2018; Clark and Kentor 2021). In recent years, a growing body of literature investigates the environmental impacts of foreign direct investment. One body of literature investigates the relationship between foreign capital penetration (inward FDI stocks as a percentage of GDP) and various forms of greenhouse gas emissions. Chapter 3 investigates the relationship between foreign capital penetration and carbon dioxide emissions in less-developed countries, where I provide even stronger empirical evidence for the ecostructural orientation of foreign investment dependency theory than previous research (e.g. Chase-Dunn 1975; Bornschier and Chase-Dunn 1985; Jorgenson et. al. 2007; Grimes and Kentor 2003; Kentor and Grimes 2006; Long, Stretesky, and Lynch 2017). In this chapter, I find that foreign capital penetration is positively associated with carbon dioxide emissions, where a one percent increase in this covariate is associated with a 0.04 percent increase in carbon dioxide emissions. Chapter 2 investigates the relationship between foreign capital penetration and total nitrous oxide emissions in less-developed countries, where I use much more expansive cross-national longitudinal data and powerful econometric methods than previous research (e.g. Dick and Jorgenson 2009). Although a long line of social scientific inquiry of the foreign direct investment and environment relationship focuses on sector specific relationships, I find that inward FDI stocks in all economic sectors (weighted by GDP) exerts a statistically significant harmful effect on nitrous oxide emissions. The effect is quite small in practical terms (a one percent increase in inward FDI stocks in all economic sectors is associated with a 0.01 percent increase in nitrous

oxide emissions). However, with nitrous oxide emissions being an incredibly potent greenhouse gas emission, even a small increase in this type of emission can have dramatic implications for the climate and stratospheric ozone depletion. Overall, Chapter 2 and Chapter 3 help advance our understanding of specific aspects of the world economy are affecting global environmental change.

LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

The three chapters presented in this dissertation engage longstanding scholarly discussions in the comparative international social sciences but it is still important to discuss the limitations of the analyses and directions for future research.

One limitation in all three analyses stems from the research design. In Chapter 1, 2, and 3, I gather country-level cross-sectional and longitudinal data from a variety of commonly used sources. I employ econometric methods in all three studies to analyze the cross-national longitudinal data. The use of these methods allows for generalizability across a large sample of countries and time periods. However, there are some intuitive limitations to these analyses. The first limitation is that causality cannot be inferred from these studies, where I am only able to safely infer that there are statistical associations between the variables analyzed in each study. This statement leads to the second limitation of the analyses of this dissertation. I find evidence for statistical associations in the three studies. However, the analyses cannot parcel out *what* is driving the statistical associations. For example, in Chapter 2, I find that foreign capital penetration (inward FDI stocks as a percentage of GDP) is positively associated with total nitrous oxide emissions, net of relevant statistical controls. The study analyses quite expansive

panel data, where there are data on over 100 developing countries and over 1500 observations.

However, despite the pros of this analysis, I am unable to speak to exactly how foreign direct investment is affecting nitrous oxide emissions. For example, it could be that primary sector foreign direct investment is contributing to this unique greenhouse gas emission that stems primarily from agricultural activities. Similar limitations apply to Chapter 1. I find that EINGOs do not exert an effect on ambient air pollution in peripheral countries. There is much social scientific conversation regarding the potential limitations of world culture in affecting environmental change in less-developed countries (e.g. Shorette 2012; Hironaka 2014; Schofer and Hironaka 2005; Mejia 2020; Tester 2020; Mejia 2021b; Mejia 2022). There is also much debate as to *why* world culture sometimes does not generate environmental change in less-developed countries (Shorette 2012; Mejia 2020; Tester 2020; Hironaka 2014). Chapter 1 attempts to delve into such questions. However, it is a major limitation of the analysis is that it cannot directly answer such questions. It could be that there are processes related to international economic dependence (e.g. Shorette 2012), corruption (Mejia 2020), or rather that more time is needed for the various processes of world culture translate to improve environmental conditions (Hironaka 2014; Schofer and Hironaka 2005).

The limitations of this analysis spark directions for future research. First, qualitative case-study research is needed that delves into some of the complex statistical relationships I report in the three chapters. For example, in the context of Chapter 2 and 3, the social scientific literature on the environmental impacts of foreign direct investment in less-developed countries would

benefit from case-study investigations of the environmental practices of foreign firms, like Frey (2003). With rigorous qualitative research on such dynamics, social scientists can make better informed theoretical formulations regarding potential relationships between foreign direct investment and environmental outcomes. Similarly, the world society and environment literature would also benefit from qualitative case-study research that seeks to investigate why world culture produces beneficial effects in some groups of countries and diminished in other income-based classifications of countries.

Despite these limitations, this dissertation makes fundamental contributions to our understanding of the global foundations of environmental degradation, which is arguably the paramount issue of our time.

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Appendix A: Countries Included in Chapter 1

Core: Australia, Austria, Belgium, Canada, Denmark, England, Finland, France, Germany, Greece, Iceland, Iran, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Saudi Arabia, Singapore, Spain, Sweden, Switzerland, United States of America, United Arab Emirates

Semi-Peripheral: Albania, Algeria, Bosnia and Herzegovina, Brazil, Bulgaria, Chile, Jamaica, Jordan, South Korea, Latvia, Lebanon, Libyan, Lithuania, Macedonia, Malaysia, Maldives, Mexico, Moldova, Oman, Panama, Poland, Portugal, Romania, Russia, Seychelles, Slovakia, Slovenia, South Africa, Turkey, Uruguay, Venezuela

Periphery: Angola, Antigua & Barbuda, Armenia, Cape Verde, Colombia, Comoros, Congo Democratic Republic, Costa Rica, Cote d'Ivoire, Djibouti, Dominica, Dominican Republic, Ecuador, El Salvador, Eritrea, Ethiopia, Fiji, Gabon, Ghana, Grenada, Guatemala, Guinea-Bissau, Guyana, Honduras, India, Indonesia, Kazakhstan, Kenya, Kiribati, Serbia, Solomon Islands, Sudan, Suriname, Swaziland, Tajikistan, Tanzania, Thailand, Timor and Leste, Togo, Tonga, Trinidad and Tobago, Tunisia, Ukraine, Uzbekistan, Vanuatu, Vietnam, Yemen, Zambia, Zimbabwe

Appendix B: Countries Included in Chapter 2

Afghanistan (2008-2014), **Albania** (1996-2014), **Algeria** (1990-2014), **Antigua-Barbuda** (1999,2000,2005,2007,2009, 2010-2013), **Argentina** (1990- 2014), **Armenia** (1997, 1999-2014), **Azerbaijan** (1996-2014), **Bangladesh** (1990-2011), **Belarus** (1998-2014), **Belize** (1990-2013), **Benin** (1992-2014), **Bhutan** (1991-2012), **Bolivia (**1990-2013), **Bosnia-Herzegovina** (2003-2013), **Botswana** (2000-2014) **Brazil** (1990-2014), **Bulgaria** (1996-2014), **Burkina Faso** (1995-2014), **Burundi** (1993-2013), **Cambodia** (2000-2013), **Cameroon** (1990-2014), **Cape Verde** (1990-2011), **Central African Republic** (1993-2013), **China** (1990- 2014), **Colombia** (1990-2013), **Comoros** (1995-2009), **Costa Rica** (1990- 2013), **Cote d'Ivoire** (1995-2014), **Croatia** (1995-2014), **Djibouti** (1990,1991), **Dominica** (1990- 2012), **Dominican Republic** (2001-2014), **Ecuador** (1990-2014), **Egypt** (1990-2014), **El Salvador** (1990-2013), **Eritrea** (2000,2001, 2003), **Ethiopia** (1993-2008), **Fiji** (1990-2013), **Gabon** (1993-2009), **Georgia** (1996-2014), **Ghana** (1992-2013), **Grenada** (1990-2008), **Guatemala** (2001-2014), **Guinea** (1995-2008), **Guinea-Bissau** (1995, 2003, 2004, 2005), **Guyana** (1997-2005), **Honduras** (1990-2012), **India** (1990-2014), **Indonesia** (2003-2013), **Iran Islamic Republic** (1997-2006), **Jamaica** (1993-1997, 2002-2013), **Jordan** (1990-2014), **Kazakhstan** (1995-2013), **Kenya** (1990-2014), **Kyrgyzstan** (1995-2013), **Lebanon** (1997-2013), **Lesotho** (2000-2012), **Macedonia** (1994-2014), **Madagascar** (1990-2013), **Malawi** (1990-2014), **Malaysia** (1990-2014), **Maldives** (1995-2014), **Mali** (1990-2012), **Mauritania** (2005, 2007-2012), **Mauritius** (1990-2014), **Mexico** (1990-2014), **Moldova** (1994-2014), **Mongolia** (1996-2014), **Morocco** (1990-2013), **Mozambique** (1994-2014), **Namibia** (2000-2013), **Nepal** (1990-2013), **Nicaragua** (1994-2014), **Niger** (1995-2014), **Nigeria** (1991-2013), **Pakistan** (1990-2014), **Panama** (1990-2012), **Papua New Guinea** (1990-2004), **Paraguay** (1991-2014), **Peru** (1991-2012), **Philippines** (1990-2014), **Romania** (1996-2014), **Russia** (1996-2013), **Rwanda** (1997-2005), **Sao Tome-Principe** (2000-2011), **Senegal** (1990-2014), **Sierra Leone** (2000, 2002), **South Africa** (1992-2014), **Sri Lanka** (1990-2014), **Swaziland** (2000-2007), **Syria AR** (1990, 1992, 1995-2007), **Tajikistan** (2000), **Tanzania UR** (1997-2013), **Thailand** (1990-2014), **Togo** (1990-2013), **Tonga** (1990-2014) **Tunisia** (1990-2013), **Turkey** (1990-2014), **Turkmenistan** (1997-2000), **Uganda** (1994-2009), **Ukraine** (1996-2014), **Vanuatu** (2000, 2006, 2007, 2009-2011), **Venezuela** (1990-2012), **Vietnam** (1997-2013), **Yemen** (1991, 1995-2006), **Zambia** (1993-2013) **Zimbabwe** (1990-1999, 2004).

Appendix C: Countries Included in Chapter 3

Albania, Algeria, Angola, Argentina, Armenia, Azerbaijan, Bangladesh, Belarus, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cameroon, Central African Republic, Chad, China, Colombia, Comoros, Congo Dem. Rep., Costa Rica, Cote d'Ivoire, Djibouti, Dominican Republic, Ecuador, El Salvador, Equatorial Guinea, Eritrea, Ethiopia, Fiji, Gabon, The Gambia, Georgia, Ghana, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, India, Indonesia, Iran, Iraq, Jamaica, Jordan, Kazakhstan, Kenya, Kyrgyz Republic, Lao PDR, Lebanon, Lesotho, Liberia, Libya, Madagascar, Malawi, Malaysia, Mali, Marshall Islands, Mauritania, Moldova, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Papua New Guinea, Paraguay, Peru, Philippines, Rwanda, Senegal, Serbia, Sierra Leone, Solomon Islands, South Africa, Sri Lanka, Sudan, Suriname, Tajikistan, Tanzania, Thailand, Timor-Leste, Togo, Tonga, Tunisia, Turkmenistan, Uganda, Ukraine, Uzbekistan, Vanuatu, Venezuela RB, Vietnam, Zambia, Zimbabwe.