GROWTH, POWER AND TIME: DEVELOPING A DEEPER UNDERSTANDING OF ANTHROPOGENIC DRIVERS OF CARBON DIOXIDE EMISSIONS FROM 1960-2015

by

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This dissertation uses data from the World Bank and hierarchical linear modeling approaches in order to further develop our understanding of the relationships between ecological rationality, international inequality, and carbon dioxide emissions in the global economy from 1960 to 2015. In order to do so I draw from sociological theories concerning international inequality and the impact of socio-economic processes on the quality environment. I use measures of world system position and draw from W.E.B. Du Bois and others in using colonial legacies in order to measure international inequality. Doing so, I find that a nations position in the international economy significantly limits or facilitates the ability of that nation the reduce the impact of economic activity of carbon dioxide emissions. Further, by emphasizing the work of W.E.B. Du Bois I theoretically highlight the racialized nature of international inequality in the colonial period, as well as in the contemporary era. Ultimately, my findings suggest that processes of economic accumulation require the existence of both international inequality and environmental degradation, and that such a requirement makes the possibility of a truly sustainable society unlikely absent some notable change to social and economic structures.

This dissertation includes previously published coauthored material.

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CHAPTER I

INTRODUCTION

The problem of the twentieth century is the problem of the color-line- W.E.B. Du Bois (1903)

This chapter contains previously published coauthored material. A version of the paragraphs on the displacement paradox and the green paradox on pages 11-13 appear in an article which has been previously published in *Energy Research and Social Science* with Dr. Richard York and Dr. Julius Alexander McGee (Greiner, York, and McGee 2018).

Though it is, perhaps, the most well-known phrase written by W.E.B Du Bois, it is scarcely known that the above epigraph was penned by Du Bois more than once. While the phrase appeared in both the forethought and the second chapter of *The Souls of Black Folks* (Du Bois 2003), it was only in the second chapter, "Of The Dawn of Freedom", that the full meaning of the phrase was laid bare. "The problem of the twentieth century is the problem of the color-line –the relation of the darker to the lighter races of men in Asia and Africa, in America and the islands of the sea" (Du Bois 2003 p. 16). The often-ignored version of the famous quote belies an important truth. The color-line was deeply tied to matters of international inequality and colonial exploitation. It was as a result of this truth that, in much of his thought and work, Du Bois emphasized the critical role of colonial and imperial relations in the establishment of the international capitalist empires of Twentieth century Europe (Du Bois 1920; Morris 2015; Morris 2017). Thus, it should be noted that when Du Bois discusses the color-line as "the problem of the twentieth century", it is not simply in reference to the internal race relations of the United States or any other nation. Rather, it is in reference to a complex of relations of international inequality which find their roots in colonization and the establishment of an international hierarchy of nation-states which, to a large degree, remains in place today. Indeed, Du Bois reminds us that, not just race, but also the ongoing legacies of colonization, imperialism, and international exploitation that were predicated upon it were established because:

> "It pays. Rubber, ivory and palm-oil; tea, coffee, and cocoa; bananas, oranges, and other fruit; cotton gold and copper –they, and a hundred other things which dark and sweating bodies hand up to the white world from their pits of slime, pay and pay well, but of all that the world gets the black world get only the pittance that the white world throws it disdainfully… Colonies, we call them, these places where "niggers" are cheap and the earth is rich…They belt the earth these places, but they cluster in the tropics, with its darkened peoples: in Hong Kong and Anam, in Borneo and Rhodesia, in Sierra Leone and Nigeria, in Panama and Havana –these are the El Dorados toward which the world powers stretch itching palms" (Du Bois 1920, pp.22-23).

In the Twenty-First century the problem of the color line and international inequality has not subsided, despite popular notions to the contrary. In fact, the recognition of another key problem in the Twenty-First century, environmental degradation, has only exacerbated these issues and highlighted the urgent need to understand how it is that international inequality and the ever-quickening pace at which the environment is being destroyed are linked together. Interrogating these links raises important questions, the answers to which, in many ways, offer a challenge to conventional understandings of both moral and technological progress that is thought to accompany development of the international economy. Questions such as: what is the relationship between economic development and environmental impact? Has this relationship been improving over time, as we all hoped it would? How does inequality play into this relationship? How can we best understand inequality between nations? What is the relationship between colonization and environmental impact? And is it possible for us to foster economic growth in all nations while also reducing the impact that humans have on the environment?

The essays that follow provide a sociological meditation on such questions. Throughout the course of this meditation I argue that, contrary to popular beliefs about environmental sustainability, global economic development –as it is currently conceived –is incompatible with the mitigation of environmental impacts, even when technological advances are considered, and even as awareness of the problem of environmental change spreads. Further, I argue that this incompatibility is ineradicably rooted in historical relations of international inequality. Relations which in many ways trace their origins to colonial and imperial patterns of domination. In order to demonstrate this, I empirically explore the relationship between economic development, political and technological change, and environmental impacts in nations occupying various positions of power in the international economic system. Prior to presenting these analyses, however, I believe it would be of use to provide a brief description of the connections between environmental protections, inequality, and economic development. To begin, I turn to a discussion of the sustainable development concept.

The Sustainable Development Concept

Broadly speaking, concerns with environmental mitigation and understandings of sustainability have been deeply tied to issues of equality, at least tangentially. For example, the first and most commonly employed definition of sustainable development was established at the World Commission on Environment and Development, which has come to be known as the Brundtland Commission (UN 1987). The document created during the commission, *Our Common Future*, or *The Brundtland Report* (UN 1987), identified sustainable development, quite simply, as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. In this definition, equality appears as the operating principle, where no given generation’s needs are favored over any others, with development being mentioned only insofar as it is considered the means by which those means are met.

The broad outline for sustainable development laid forth in the *Brundtland Report* was given greater structure during the United Nations Conference on the Environment, or the Rio Earth Summit. In the resulting document (UN 1992) it was stated that governments should promote sustainable development policies at the national and international level that aim:

> “a. To promote an open, non-discriminatory and equitable multi-lateral trading system that will enable all countries – in particular, the developing countries – to improve their economic structures and improve the standard of living of their populations through sustained economic development;
>
> b. To improve access to markets for exports of developing countries;
>
> c. To improve the functioning of commodity markets and achieve sound compatible and consistent commodity policies at national and international levels with a view to optimizing the contribution of the commodity sector to sustainable development, taking into account environmental considerations;
>
> d. To promote and support policies, domestic and international, that make economic growth and environmental protection mutually supportive” (UN 1992, p 5.)

Examination of these objectives reveals three primary priorities. Those of reducing inequality (and in particular economic inequality) between nations, the creation of an open international system of trade that promotes economic development on a global scale, and the protection of the environment. These three priorities, which together compose what I refer to as the sustainable development concept, are rarely in harmony, and when examined critically reveal tensions that are inherent to the project of sustainable development itself. For example, in contrast to the suggestion that economic growth and the liberalization of trade can be a tool for reducing inequality, previous research has shown that economic growth, globalization, and trade liberalization lead to increases in inequality by reducing the cost of wage labor for capital (Harrison 2002; Kristal 2010; Piketty and Saez 2014). Further, it has been well established that reductions in wages, as well as the orientation of economies toward exports, is associated with the establishment of unequal exchange between nations (Emmanuel 1972a; Amin 1974). Specifically, trade liberalization and the establishment of export economies prevents the establishment of viable internal economic development within poorer nations (Emmanuel 1972a) and places deflationary pressures upon wages and currencies (SAPRIN 2004), putting nations that take such actions on a path of 'underdevelopment' (Frank 1967) relative to their wealthier counterparts in the global North.

In practice, even in the simpler understanding of sustainable development (UN 1987), the phrase "development that meets the needs of the present" is often interpreted by policy makers and neoclassical economists as development which does not impede or slow the accumulation of capital. As a result, understandings of international environmental sustainability are focused on amalgamating the mitigation of global environmental change and spurring the pace economic development. Such a view of sustainable development has led many approaches to intervening in anthropogenic climate change, such as emissions stabilization to the levels of the year 1990, to be dismissed as being too costly in terms of economic growth (Nordhaus 1992). Despite the privileged position that economic development occupies in sustainable development discourse, increasing, or even maintaining, the present pace of economic development is widely recognized as being at odds with mitigating environmental harm (York et. al 2003a; Jorgenson and Clark 2012), as economic activity is known to be one of the primary drivers of carbon dioxide emissions (IPCC 2014). In order to understand why it is that economic activity tends to be a driver of environmental devastation, it is worth turning to the treadmill of production theory.

Treadmill of Production theory was introduced in order to account for the massive environmental degradation that followed the end of World War II (Gould, Pellow, & Schnaiberg, 2004). Drawing from Marxian theories concerning economic accumulation, Schnaiberg (1980) argued that as more capital was made available to be invested into newer and more efficient technologies, production processes would become more and more reliant on these technologies, eventually using them to replace significant portions of the workforce. The replacement of human labor with new technologies would have two effects. First, as new technologies penetrated deeper into the production processes of society, expanded extraction of natural resources would be required in order to provide these new machines with the materials they require to operate properly. The second effect of the growth in capital's application of the new technologies would be that political elites, under pressure from industry to support expansion, and from workers to provide a growing job market, would enact policies that would enable businesses to easily expand into new markets and sectors. This expansion, in turn, would grow consumption levels, as the employment rate stayed relatively stable, and the market for new technologies steadily increased. The end result would be a cycle, or ‘treadmill’, that required ever-greater quantities of ecological resources, and produced ever-greater quantities of pollutants (Gould et al., 2004; Schnaiberg, 1980; Schnaiberg & Gould, 2000).

Understanding these relations, particularly with respect to withdrawals and additions, sheds light onto the difficulty of reducing environmental impact globally, as well as how it is that much of international pollution occurs in the global South. All social production processes rely on varying amounts of inputs that must be derived from the surrounding ecosystem in order to be carried out. Such production processes also require that environmental inputs be transformed in some way through various physical or chemical procedures. Once the transformation of inputs has been achieved, waste from all aspects of the production process must be done away with. Despite the physical requirement of environmental additions and withdrawals in the production process that have been noted by neo-Marxian theorists, in the late Twentieth century several environmental economists noted that the observed relationship between national level income and a variety of atmospheric pollutants was weakened as income levels rose (Grossman and Krueger 1995; Panayatou 1997). Extrapolating from these observations, many began to argue that increasing national wealth was accompanied by investments in more ecologically efficient technologies (Samuelson and Nordhaus 1992), and the implementation of political policies that were aimed at protecting environmental resources. The crux of this argument, which would come to be called the Environmental Kuznets Curve hypothesis, was that as wealth was developed populations could “afford” to be concerned with protecting the environment. Put differently, a safe and healthy environment should be considered a luxury item (York et al. 2003a).

It should be noted that the belief in a dematerialized economy, where growth can take place without impacting the environment, (Mol 2000) largely ignores that all material goods require environmental additions and withdrawals, as well as the global nature of economic activity. Indeed, proceeding in theoretical and empirical analyses as though every nation's environmental resource and sink use is contained within its borders, known as the Netherlands fallacy (Ehrlich and Holdren 1971a), disregards the international division of labor (Fröbel, Heinrichs, & Kreye 1981) and the fact that legacies of colonization and economic underdevelopment have rendered poorer nations more likely to be the sight of resource extraction (Bunker 1984) and environmentally intensive/inefficient production (Jorgenson 2003; Roberts, Grimes, & Manale 2003). Thus it is that, while economic development might lead to a "decoupling" of environmental impact and economic activity in the global North, it typically tightens the coupling of these factors in the global South, increasing both international inequity and environmental impact in one fell swoop.

Resolution Through Technology

Recognition of the inherent tensions between economic development and environmental protection, and economic development and international equity, that rest at the heart of the sustainable development concept has led green technology to be widely viewed as a mechanism through which capital accumulation can continue unabated, while allowing environmental sinks and resources to be conserved indefinitely (Lomborg 2012). For example, the most recent report of the United Nations Environment Program begins by arguing that while in the past "tackling pollution was equated to imposing costs on industry and economic growth…global trends are demonstrating this is no longer the case… investing in green technologies is a strategy for long term profitability and prosperity for all" (UNEP 2017, p. 1). Such a contention implies that the environmental crisis is, at root, a technical issue, one which is devoid of social or historical relevance and the attendant issues of power and inequality that accompanies it.

That technology should not be viewed as an asocial deity through which the crises of international inequality, a la the color-line, and environmental devastation, a la global climate change, can be resolved independently of social discretion is perhaps best expressed by Mészáros:

> "To say that 'science and technology *can* solve all our problems in the long run' is much worse than believing in witchcraft; for it tendentiously ignores the devastating social embeddedness of present day science and technology. In this respect, too, the issue is not whether we use science and technology for solving our problems –for obviously we must– but whether we *succeed* in radically *changing* their *direction*, which is at present narrowly determined and circumscribed by the self-perpetuating needs of profit maximization" (Mészáros 2015, p. 29).

Understanding how it is that science and technology are circumscribed by the social, economic and political dictates of the accumulation of capital is critical to grasping why it is that the problems of international inequality and environmental change are not, solely– or even primarily– technical problems.

There are, broadly speaking, two reasons that technology is unlikely to increase the ecological impact of social and economic processes and, thereby, reduce the rate or scale of anthropogenic climate change. As suggested by Mészáros (2015), both reasons are tied to the role of technology as a tool of accumulation in the socio-metabolic formation of capital. The first of these reasons has to do with the adoption of new technologies in the production process, while the second concerns the use of new technologies once they have been adopted.

Commonly, it is assumed that new technologies will be adopted by firms in order to increase the efficiency of their operation, thereby allowing them to increase the rate of production and, in doing so, both reduce the variable component of capital (e.g. the cost of wage labor) while maintaining or growing the rate at which each commodity unit is produced. According to this logic, by taking such action firms are given a marketplace advantage, one which other firms seek to emulate. Those who are successful in this emulation proceed to reformulate the composition of the constant (e.g. fixed) component of their capital investments, while those who are not successful are absorbed. This is what Schumpeter (1950) terms the “creative destruction” of capitalism. Critically, this view of capitalism ignores the increasingly centralized nature of capital in the contemporary economy. Put differently, this ignores that over the course of the twentieth century giant firms, rather than small business and corporations, became the primary economic actors both nationally and internationally (Baran and Sweezy 1966). In this new form of monopoly capital– and to an even greater degree in the subsequent stage of monopoly finance (Foster 2010), or abstract (Amin 2013), capital– “innovations are typically introduced (or soon taken over) by giant corporations which act not under competitive pressure but with careful calculations of the profit maximizing course” (Baran and Sweezy 1966, p. 93). As a result of this shift in competitive logic, new innovations in methods of production will only be introduced in particular circumstances. Those circumstances being that the new mode of production provides large enough gains in efficiency that the losses of abandoning the capital invested into the previous mode of production are entirely recovered, or that there is an opportunity for market expansion and new productive facilities are required at any rate. In either case, firms will not adopt new technologies simply for their benefit to the environment or because other firms have done so (Baran and Sweezy 1966).

In the instance that new technologies are adopted in order to expand markets, another barrier to the use of such technologies for reductions in ecological impacts is imposed. Specifically, the use of technologies in order to expand the reach of a firm into new consumer markets does not result in the displacement of previously existing, less environmentally efficient technologies, but rather adds the impacts of the new technology to those of the older ones. This phenomenon, which has been termed the displacement paradox (York 2012; McGee 2015; McGee 2017), focuses on the power of corporations in market economies to drive growth so as to increase profits (York 2016; York 2017; York and McGee 2016). Displacement paradox theory highlights that companies typically will work to 1) ensure that their products have markets, and to 2) expand consumption of all such products within those markets (McGee 2015). As a result, we should not necessarily expect a new technology, resource, or product, to simply replace another one, because in most arenas of economic enterprise the goal of the typical firm is to produce more products and increase the frequency with which all its products are consumed (York and McGee 2016; York 2017). With respect to "green" technologies, this dynamic often has the consequence of preventing resources and technologies that are less environmentally harmful from *replacing* those that are more so. If, as it is often implicitly assumed is the case, demand for products was more or less constant, then producing commodities using new technologies would inevitably lead to a reduction in both the use of older technologies and the consumption of resources. However, the realities of sunk costs and geographic limitations can prevent new technologies and more efficient resources from replacing those that are extracted and distributed through well-developed infrastructures, and in some instances can even spur the use of established resources and technologies (Sinn 2009).

In addition to theory on the displacement paradox, another complimentary socio-ecological approach, the green paradox (Sinn 2012), presents reasons why supply-side forces generate demand. The green paradox and displacement paradox together highlight how broader political and economic context may influence the extent to which one resource is able (or not) to effectively displace another. The displacement paradox emphasizes that new products, technologies, and resources often serve to expand consumer markets, rather than replacing resources previously used in such markets. Complimenting this view, the green paradox offers insight into how regulation and market mechanisms intended to curb the use of a particular resource might unintentionally lead to an intensification of its use. The green paradox theorization starts with the observation that businesses typically seek to avoid regulations and work to prevent loss of profits from the devaluation of their own capital assets, such as control of fossil fuel reserves. Resource-owning firms anticipate the introduction of regulations that may reduce the value of their assets – such as new environmental laws that could increase the costs of extracting, and/or lower the profit margins for selling, fossil fuels. For instance, policy implementation and government subsidization aimed at encouraging the production of wind power are likely to have the intended effect of driving down the market price of wind power, but this will also suppress the price of other energy sources in a competitive market. This brings about the unintended consequence of motivating firms to anticipate future government actions in order to extract and sell as much of the capital invested in old technologies and established resources as quickly as possible, *before* new regulations or subsidies are implemented that drive down prices or prevent the firms from accessing or selling such resources. Thus, the paradox is that the anticipation of new environmental laws aimed at suppressing the use of fossil fuels, or at reducing the use of less efficient technologies, drives growth in the rate of their use (Sinn 2009; 2012). The green paradox fits with the displacement paradox in that it shows how supply-side logics drive production and can prevent new technologies and resources from suppressing the use of established ones[1].

Finally, it is important to note that even if more efficient resources or technologies are able to replace previously existing ones, there is yet another barrier to this replacement resulting in the reduction of environmental impact. The Jevon's paradox is the term used to describe occasions where increases in the efficiency with which resources used in the processes of production are associated with increases in the overall levels of consumption of that resource (Foster, Clark, and York 2010; York and McGee 2015). York and McGee (2015) cite two primary reasons that this pattern is regularly observed. First, it is possible that reductions in the cost of commodity production associated with more efficient resource use leads to increasing consumption. That is, as a product becomes cheaper it is more likely to be consumed. Second, it could be the case that the supply and demand side savings from the improvements in efficiency spur

[1] A version of the paragraphs on the displacement paradox and the green paradox appear in an which has been previously published in *Energy Research and Social Science* with Dr. Richard York and Dr. Julius Alexander McGee.

spending elsewhere, and thereby lead to an increase in the total consumption of the resource.

In a fashion similar to the claim that technological innovation can, on its own, lead to a reduction of environmental impacts, the proposition that technology can be relied upon to reduce national or international level inequality ignores the role that technologies often play in processes of accumulation. As a result of its critical role in processes of war, finance, and production, technology serves as a means of domination in the global economic system (Chase-Dunn and Hall 1997; Pomerantz 2000; Amin 2013). Interestingly, while within the formation of capital environmental resources and sinks are often seen as free gifts, technologies are not. For example, even in the course of the transition from the feudal system of social relations to those of capital the control of technological resources was critical to maintaining conditions favorable to accumulation. For this reason, accounts of English landlords smashing, burning, and otherwise destroying the hand-mills of the peasant and laboring populations in order to force the use of the landlord's centralized mill in processes of production can be found from the Twelfth to the Sixteenth century (Merchant 1990). The control of technology has only intensified with the passage of time, with governments using violence and political apparatus to ensure that the ownership of technology by firms in the global North is not infringed upon in the course of global production processes (Pomerantz 2000; Screpanti 2014)

As a result of the strict control of the flow of technological goods in the global economy, multinational corporations within the wealthy nations of the global north often rely upon a combination of intellectual property rights and trade liberalization in order to retain control over the global distribution of technologies (Chase-Dunn and Hall 1997). The results of this are twofold. Technologies employed in the global South increase the average labor productivity of the production process, thereby minimizing the cost of wages to firms operating within those nations, even as they raise the typical rate of investment in fixed capital (Pomerantz 2000). In the global North the control of technological resources grants firms an exchange advantage in the international marketplace that enables the transfer of wealth from labor in the South to capital in the North (Screpanti 2014), while also exerting a deflationary pressure on the wages of laborers in the North by reducing the cost of goods and, thereby, the cost of living (Foster, McChesney, and Jonna 2011).

Primitive Accumulation, Exploitation, And the Necessity of Inequality in Capital

Quite apart from the limitations of technologies employed within the circuits of capital to bolster global equity, there is another reason that international inequality is unlikely to be alleviated under the sustainable development paradigm. In the most straight forward sense, the elimination of international inequality is at odds with the accumulation of capital, and, thus, circumscribed by the pursuit of economic growth. This insight is at least as old as Marx's (1976) critique of political economy itself. According to this critique, the establishment of inequality is a necessary precursor to the accumulation of surplus value through the exploitation of wage labor. Specifically, before capital can draw surplus from a labor force it must create a labor force. This requires of course that a population be separated from the means of subsistence it had traditionally relied upon. This 'primary', or 'primitive' moment in the establishment of the social relations that constitute capital "operates two transformations, whereby the social means of subsistence are turned into capital, and the immediate producers are turned into wage-labourers. So-called primitive accumulation, therefore, is nothing else than the historical process of divorcing the producer from the means of production" (Marx, 1867, pp. 874-875). As the general process of accumulation requires that surplus be exploited from the wage laborer in the course of the working day, the establishment of a situation wherein some minority of the population maintains control over the resources necessary to the processes of production at the expense of the majority (i.e. the inequitable distribution of resources) is fundamental to the proper function of the system as a whole.

Though it is often viewed as a precondition for the realization of capital, the expansion of capital necessitates the growth of the laboring population which is available to it in order to allow for the continuation of accumulation and economic growth. As a result, the processes of accumulation, and the expropriation of labor must be international in scope.

> Capitalism in its full maturity also depends in all respects on non-capitalist strata and social organizations existing side by side with it…capital needs the means of production and the labour power of the whole globe for untrammeled accumulation; it cannot manage without the natural resources and labour power of all territories. (Luxemburg, 2004, pp. 345-346)

This insight raises an important question. How is it that the expropriation of labor and the accumulation of resources, and subsequently capital, in territories beyond the borders of an economy's origin takes place? Du Bois provides us with the answer to this question in the form of the color-line, colonialism, and the establishment of a hierarchical world system.

As evidenced above, Du Bois was well aware of the necessity of expropriation of both labor and natural resources to the survival of the social formation of capital. Failure to provide an opportunity for such expropriation has the potential to create a situation wherein "the requirements of accumulating capital… exceed the growth in labor-power or in the number of workers," and, as a result, labor gains an advantage relative to capital that can be mobilized in order to increase wages and improve conditions (Marx, 1867, p. 763). The exhaustion of available resources and, in particular, the lack of a suitable reserve army of labor, which "during periods of stagnation and average prosperity weighs down the active army of workers; [and] during the periods of overproduction and feverish activity… puts a curb on their pretensions" (Marx, 1867, p. 792), in much of Europe thus led to the establishment of various social services and the beginnings of a reduction in inequality. It was for this reason Du Bois exclaimed that the:

> "Breath of life, thought to be so indispensable to a great European nation… is expansion overseas; it is colonial aggrandizement which explains, and alone adequately explains, the [first] World War. How many of us today fully realize the current theory of colonial expansion, of the relation of Europe which is white, to the world which is black brown and yellow? Bluntly put, the theory is this: It is the duty of white Europe to divide up the darker world and administer it for Europe's good. This Europe has largely done" (Du Bois 1920, p. 20-21).

Du Bois made the importance of the expropriation of laborers of color around the globe to the success of capital abundantly clear in his analysis of the reconstruction era following the Civil War in the United States. In particular, he argued that the establishment of the racialized hierarchy that shouldered the development of one of the most dominant capitalist economies in the modern world system was not a tragic occurrence unique to that nation, but rather represented a microcosm of the conditions under which the capitalist world system was able to develop, expand, and thrive (Du Bois 2007). In other words, it is the expropriation of not just environmental resources, but also of physical labor power, that is necessary of the ongoing expansion of the accumulation complex (Robinson 2000).

Building upon Du Bois' recognition of the importance of the color-line and international inequality to the ongoing expropriation of resources and labor, and, thus, the accumulation of capital, more recent work has demonstrated that the modus operandi of capitalism has always been to magnify cultural and physical difference in order to create racialized others. Thus, it was the Slavs who become the first slave caste under capitalism, and the Irish who became the first colonized population (Robinson 2000). This racialization was not only fundamental to the establishment of capitalist accumulation (Du Bois 2017; Dawson 2016; Fraser 2016), but has served as the mechanism through which historical and ongoing forms of expropriation were established and justified, including "territorial conquest, land annexation, enslavement, coerced labor, child labor, child abduction, rape… prison labor, transnational sex trafficking, corporate land grabs, foreclosures on predatory debt… and… contemporary imperialism" (Fraser 2016, p. 167). In this way, racialized expropriation still plays an important role in the accumulation of capital, particularly with regards to the ongoing imperialism that is constituted through relations of unequal exchange that rest on the historical foundations of colonial empires, as well as the implementation of financial exploitation through the accumulation of odius debt and the application of structural adjustment policies (Stiglitz 2007; Amin 2013; Screpanti 2014). Considering the origins of accumulation in inequality and racialization, it seems dubious, to say the least, that a sustainable development which prioritizes the continuation of economic growth can also accommodate the reduction of inequality in the international economy.

In light of the literature discussed above, in the subsequent chapters I will perform a series of analyses in order to demonstrate the importance of understanding and addressing international inequality in order to move the global economy in a more sustainable direction. In chapter 2 I interrogate the contention that the development of ecological rationality can lead to a global reduction in environmental impact. In order to do so I examine the relationship between theoretically relevant factors captured by the passage of time, such as technological change, the implementation of political regimes aware of the environmental crisis, and the increased social awareness of– and concern with– global climate change. I condition the relationship between such factors and carbon dioxide emissions on the position that a nation holds in the world system to capture the effect that geopolitical inequality has on these relationships. In chapter 3 I compliment the analysis performed in chapter 2 by considering the effect of international power relations, in terms of a country's placement in the world system, on individual nation's ability to use wealth to mitigate negative environmental impacts. Further, I argue that understanding historical inequalities between nations is critical to furthering our knowledge of the social and economic drivers that underlie climate change. In performing this analysis, I explore the argument that global economic development can provide a route to sustainable socio-economic relations, regardless of consideration of historical international inequality. A version of chapter 3 has been previously published in the journal Socius with my coauthor, Julius Alexander McGee (Greiner and McGee 2018. My Co-author helped to frame the argument, helped to develop the modeling approach, and wrote the section on the Environmental Kuznets Curve, as well as parts of the conclusion. In chapter 4 I build on this argument further by exploring these relationships in the context of the historical legacies of colonization. In doing so I am able to indirectly take into account, not just inequality, but also the racialized nature of international exploitation in capital. Further, in combination with the analysis in chapter 3, chapter 4 facilitates a discussion of how we should best understand international inequality in our attempts to explain the drivers of CO_2 emissions.

CHAPTER II

ECOLOGICAL RATIONALITY AND ENVIRONMENTAL IMPACT- HAS TIME REDUCED OUR IMPACT ON THE ENVIRONMENT?

It is often taken for granted by national governments and international organizations that, over time, there is a linear progression in both technological efficiency and ecological awareness among populations, producers, and policy makers that leads to a general decline in negative anthropogenic environmental impact (IPPC, 2014; UNEP, 2012). In many ways, the environmental social sciences have been developed through the findings, debates, and contentions that surround the relationship between year to year changes in social, economic and political factors, and such impacts– and are meant to examine whether such trends do indeed exist. The nuances of the relationship between carbon dioxide emissions and a host of other social indicators, such as economic growth, population structures, and technological change have been the motivating force behind many theoretical and methodological innovations, though such developments have often taken place with the aim of refuting or qualifying the validity of preceding contributions to method or theory. For example, in the field of structural human ecology (SHE) York, Rosa and Dietz (2003a) employed cross-national STIRPAT analyses to demonstrate the presence of a significant and positive association between economic growth and increases in a nation's environmental footprint. Such findings were built upon and complicated by Liddle (2014) whose work demonstrated the importance of accounting for the demographic age structure of populations in such studies. These contributions continue to be built upon further still, as is well exemplified by recent work that incorporated spatial regression analysis into the traditional STIRPAT formulation in order to illustrate the need to conceptualize the effect of urbanization as a phenomenon that brings about environmental impact in both technological (e.g. spatial) and demographic capacities (McGee, Clement & Besek, 2015).

Interestingly, while the question of how the relationship between human induced CO_2 emissions and social factors– such as those mentioned above– might vary over time has been central to many of the theoretical debates and developments within the diverse field that constitutes the environmental social sciences, few studies to date have chosen to deal with the effect that the passage of time (and more particularly the changes in cultural, technological, and political/ institutional factors that are captured by the passage of time) has on the relationship between environmental impact and human activities directly (Jorgenson & Clark, 2012; Jorgenson, 2014; Jorgenson & Givens, 2015). Here, I hope to contribute to the field by using a relatively novel method to address the effect of factors captured by year to year changes in time, such as technological change, on per capita CO_2 emissions, while also accounting for the modifying effect that geopolitical context has on this relationship.

In order to effectively explore the role that temporal developments play in the achievement of a greater or lesser degree of emissions, I use a hierarchical linear growth curve modeling approach to better understand how the passage of a year of time affects CO_2 emissions per capita on average, while also controlling for the effect that a host of other theoretically relevant factors have on this important outcome. Further, considering the findings of research performed in the unequal ecological exchange and environmental world systems literatures (Bunker, 1984; Roberts & Grimes, 1997; Roberts, Grimes, &

Manale, 2003; Grimes & Kentor, 2003; York, Rosa & Dietz, 2003b; Jorgenson, 2006), I interact the temporal variable with the world systems strata of core, periphery and semi-periphery in order to understand how this relationship varies within the developmental strictures typically placed upon nations belonging to such categories as a result of the contemporary structure of the geopolitical field.

I contextualize the findings of the present research by drawing upon several theoretical traditions within environmental sociology. Specifically, key theories used to understand study findings and to orient the research project are neomarxian theories such as treadmill of production (ToP), SHE, environmental world systems, and EM frameworks. Building upon such scholarship, I employ the methods used here to and add greater nuance to the tensions between neomarxian understandings of environmental crises and Ecological Modernization (EM) perspectives. In doing so I note that, in many ways, this debate acts as a proxy for the larger debate among policy makers, activists and academic experts surrounding the ability of technological progress and potentially growing ecological rationalization to mitigate anthropogenic environmental impact on its own (e.g. absent meaningful structural and policy reform).

Literature review

While scientific knowledge concerning the potentially devastating effects of climate change– and key anthropogenic drivers behind such changes– has grown immensely, several assumptions that are foundational to modernization hypotheses still seem to limit the incorporation of such knowledge into global mitigation strategies in a number of ways. The influence of the modernization school in this respect is perhaps most readily visible in international policy organizations' emphasis on elaborating mitigation strategies that reduce environmental impact while still maximizing economic growth, despite the fact that economic activity is recognized as a key contributor to climate change by the very same institutions (IPPC, 2014). Such strategies reflect an approach to achieving sustainability that still understands and measures international development in terms of various stages of growth (Rostow, 1959), and that seems to suppose that the most salient route to sustainability is likely through the introduction of a technical and consumption based solution that will "consistently produce such a countervailing effect that [it] neutralizes scale effects" (Rosa & Dietz, 2012, p. 4) of growth in economic activity and population size.

Importantly, the inability to conceptualize a route to global sustainability that incorporates economic stability, as opposed to economic growth, has led to an adoption of mitigation strategies that primarily rely on the ecological rationalization that is outlined by Ecological Modernization (EM) theorists, such as improvements in technological efficiency, the establishment of environmentally conscious political regimes and policies, and a turn towards more environmentally friendly consumption and production patterns (Sonnenfeld, 2000; York & Rosa, 2003; Mol, 2010; Longo, Clark, Schriver & Clausen, 2016). Considering this, it is of the utmost importance that environmental social science research contribute to the development of a more robust understanding of the effectiveness of modernization strategies with respect to reducing environmental impact. To a large extent, much of macro-structural environmental sociology research has been performed with this goal in mind. A point to which I now turn.

EM theorists developed the EM framework in the last decade of the twentieth century in order to provide a counterpoint to the neomarxian approaches to environmental sociology that understand environmental crises as an inevitable outcome of modernization processes under capitalism. To that end, EM has focused on developing an understanding of emergent processes of institutional environmental reform (Mol, Spaargaren & Sonnenfeld, 2014). In particular, EM proponents have focused much of their attention on demonstrating that as socio-economic processes and institutions develop, or modernize, renewed and intensified environmental concerns, and improved efficiency and technology can lead to the decoupling of the economy and environmental impact (Mol, 1997; York & Rosa 2003; York, Rosa, & Dietz, 2010). Thus, given sufficient time and economic growth, the introduction of environmentally protective political policies, and popular social movements, as well as more environmentally aware choices among consumers– and subsequently producers– within the market place should lead to a relative dematerialization of economic processes and allow for economic growth and environmental mitigation to be compatible (Jorgenson & Clark, 2012; Mol, 2002; Spaargaren & Cohen, 2009).

The process of 'ecological rationalization' has been the center point of EM research, which has often relied upon case studies of ecologically reflexive institutions to demonstrate that, even if ecological modernization has not spread through our cultural and economic systems wholesale, there are still instances that illustrate the potential, and presence, of such a transition (Mol, Spaargaren & Sonnenfeld, 2014; Mol & Spaargaren, 2000; York et al., 2010). Or, as Mol et al. note, "structural human ecology/ neo-Malthusian perspectives diverge significantly from ecological modernization theory in that the former are highly abstract, rather than richly particular" (Mol et al. 2014 p.25). Following the logic of modernization theory, EM proposes that the process of ecological rationalization is fundamental to development, and that, though more developed nations will experience such a rationalization first, all nations will ecologically rationalize as a consequence of the economic growth they may experience, as well as through gaining access to global flows of environmental information and goods (Jorgenson & Clark 2012; Mol 2010; Spaargaren & Mol, 2008). A central assumption of this approach is that, on the whole, progress under modernization is linear and fairly continuous and will lead to reductions in environmental impact (York, 2004). Yet, despite the centrality of time to the assumption of progress, EM research does not generally deal with, or account for, the potential effects of technological, cultural, or institutional factors associated with time on improvements in ecological outcomes empirically.

Neomarxian and SHE perspectives have taken opposing theoretical and methodological approaches to EM in understanding the capacity of institutions and policy makers to address the environmental crisis through the modernity processes of capitalism. For example, ToP, which was developed by Schnaiberg (1980) to facilitate an understanding of the uptick in pollution and resource extraction following World War II, posits that due to the Iron Laws of Competition (Marx, 1976) economic processes under capitalism, which also entail economic expansion, will lead to ever increasing rates of environmental impact. Specifically, theorists in this perspective argue that as more capital is made available to be invested into newer and more efficient technologies, production processes become more and more dependent on these technologies, and capital eventually uses them to replace significant portions of the workforce. The replacement of human labor with new technologies in leading firms has two effects, according to this perspective. First, as new technologies penetrate deeper into the production processes of society, expanded extraction of natural resources would be required in order to provide these new machines with the materials they require to operate properly. The second effect of the growing use of new technology would be that political elites, under pressure from industry to support expansion of production, and from workers to provide a growing job market, enact policies that enable businesses to easily expand into new markets and increase firm's access to natural resources. This expansion, in turn, grows consumption levels, and, as a result, the market for new technologies steadily increases. The end result is a cycle, or 'treadmill', that requires ever-greater quantities of ecological resources, and produces ever-greater quantities of polluting byproducts (Gould, Pellow & Schnaiberg, 2004; Schnaiberg, 1980; Schnaiberg & Gould, 2000). In a fashion similar to EM approaches, ToP has temporal processes at the center of its most foundational hypothesis. However, contrary to EM theories, ToP would suggest that with the passage of time there would be ever greater rates of financial accumulation and industrial expansion, which would result in more pressure being placed on environmental sinks and resources and, thus, ever greater environmental impacts. Critics of such theories often point to their apparent economic and technological determinism as weaknesses, arguing that they leave no space for the possibility of reform and rationalization that EM examines (Mol et al., 2014).

In addition to differing from the EM perspective in how it conceptualizes the role of temporality in socio-ecological processes, neomarxian approaches such as ToP understand the role that global power relations play in conditioning such processes in a manner that directly challenges the logic of the modernization theory that EM builds upon. Importantly, EM theorists have taken great care to address concerns of eurocentrism within the framework (Mol et al., 2014). Thus, a greater number of EM studies have begun looking at processes of environmental reform, including the presence of environmental Kuznets curves, in countries throughout the Global North (Roach, 2013; Shahbaz et al., 2013), Asia (Baek and Kim, 2014), and several other nations throughout the Global South (Tiwari et al., 2013; Chandran et al., 2013; Ahmed and Long 2013). Other critiques of EM have claimed that the perspective ignores the global context of many economic and environmental processes, and have resulted in the development of a new international understanding of EM, which is well represented by the environmental flows approach Mol and others have developed (Mol & Spaargaren, 2005). However, while EM proponents relying on this approach often posit that global flows of resources, technology and information will likely lead to a reduction of impacts from social and economic processes across all nations, environmental world systems and unequal ecological exchange theorists who draw from– and contribute to– ToP and other neomarxian traditions argue that global power dynamics, which enable the domination of trade networks and conditions by a few countries, result in less powerful nations being forced into a position where they bear the brunt of the international community's environmental burden (Roberts & Grimes, 1997; Roberts et al., 2003; Grimes & Kentor, 2003; York et al., 2003a; Jorgenson, 2006; Jorgenson & Clark, 2009; York & Ergas, 2011; Ergas & York, 2012; Prell & Sun, 2015). As a result of such a power dynamic, a number of neomarxian theorists argue that even if economic growth were to proceed in all nations, many nations would continue to pollute because, in such countries, economic growth is dependent on the establishment and expansion of environmentally intensive economic activities.

As has been noted above, the field of SHE has been deeply involved in the question of how human activities– including the introduction of new technologies, political policies, and cultural changes– impact the environment. One of the most influential strains of scholarship to deal with such questions in this tradition has been STIRPAT (stochastic impacts by regression on population affluence and technology). Contemporary STIRPAT literature, and the SHE methodologies and analyses that draw from it, traces its origins to the IPAT (Impacts = Population * Affluence * Technology) formulation (Ehrlich & Holdren, 1972; Commoner, 1972). The development of IPAT– which is at its heart an accounting equation whereby one can determine the value of any particular term so long as the other three are known– centered to a significant degree around debates over the role of technology in how humans impact their environment. Particularly, IPAT developed through a debate between Barry Commoner, who argued that environmental degradation was most appropriately attributed to changes in technology and economic growth (Commoner, 1971), and Paul Ehrlich and John Holdren, who believed that environmental harm was primarily driven by unrestrained population growth (Ehrlich & Holdren, 1971). For Dietz and Rosa (1994; 1997) the debate between Commoner, and Ehrlich and Holdren highlighted that, due to its multiplicative nature, IPAT could not be used in order to identify singular causes of anthropogenic impact or to test hypotheses concerned with such matters (Dietz, 2013; Jorgenson, 2013). These realizations led to the elaboration of the IPAT equation into STIRPAT, a tool with which the multiplicative logic of IPAT could be subjected to hypotheses testing in regression analyses. In practice, the difficulty of measuring factors of anthropogenic impact represented by T in the STIRPAT formulation has led to technology being calculated as the exponentiation of the residual in STIRPAT models after accounting for population and affluence (York et al., 2003b). However, a powerful tool in models within, and influenced by, the STRIPAT tradition has been the decomposition of STIRPAT components in order to more closely approximate the effect of technology. As Dietz notes, "it was always clear that unpacking technology would capture a variety of structural effects that vary across contexts" (Dietz, 2013, p 199), a fact which is well represented by the development of literatures which find their methodological impetus in the STIRPAT tradition.

Despite the importance of the behavior of measures of pollution and sustainability over time to our understanding of the relationship between human activity and environmental impact, and what can be assumed to be a relatively strong relationship between time and changes in factors intended to be captured by the T of models influenced by STIRPAT, few works in this area have considered the relationship between time and impact in an immediate manner (Jorgenson & Clark, 2012; Jorgenson, 2014; Jorgenson & Givens, 2015). To this end, Jorgenson and Clark (2012) examined the effect of economic growth on CO_2 emissions conditioned by time by interacting GDP per capita with time in five year increments. They also take global power relations into account by performing the analyses within the context of less developed and developed countries. While their findings indicated a minor decoupling of economic growth and CO_2 emissions per capita in developed countries, no such trend was found in less developed countries. These findings lend support to the notion that more powerful nations reduce their environmental impact by exporting environmentally harmful activities to less powerful countries, or the ‘pollution-haven’ hypothesis (Pearson, 1987). Jorgenson (2014) then built upon the previous work by examining the relationship between the carbon intensity of well-being (CIWB) and GDP per capita conditional upon time period. Here, time was again integrated into the study by interacting every fifth year with GDP per capita in five different continents, and findings demonstrated that in all continents except Africa economic development increased CIWB. Recently, this work has been furthered still, as researchers have performed a similar analysis on consumption based CIWB by interacting GDP per capita and time for every year from 1990 to 2008 in the context of both OECD and non-OECD nations (Jorgenson & Givens, 2015). Jorgenson and Givens (2015) suggest that economic growth was associated with declines in sustainability across all countries, with the effect being particularly notable in OECD nations– once again demonstrating that the relationship between economic development and impact must be understood in both a temporal and geopolitical context.

The present study attempts to contribute to this tradition by examining the effect of difficult to measure factors that change through time on the CO_2 emissions per capita, while also accounting for the position nations hold in the world system, using a hierarchical linear growth curve modeling approach. In performing such an analysis the present study makes two important contributions to the literature. First, I argue that by examining the association between time and CO_2 per capita– while also accounting for power, age structure, economic development, levels of urbanization, geographic advantage, and contemporaneous factors– one is able to gain insight into the effect of difficult to measure variables that are also associated with time, such as ecological awareness of a population, policy changes, and technological improvements that might affect how social processes relate to environmental impact. Using such a technique allows us to approach the issue of time in the context of sustainable development in a new way, and enables us to think about the debate over the role of technology in environmental mitigation from a different angle. Second, here I argue that, though interacting years with economic activity is a good way to understand how particular years modify the effect that growth has on impact, treating time as a continuous variable allows for the development of a more general understanding of how CO_2 per capita has been impacted by those factors most directly captured by changes in time when all other theoretically relevant drivers of impact are accounted for. In this way, this research grants us insight into how the combined factors of technological change, environmental policy reform, and the development of ecological concern amongst consumers and producers effect CO_2 emissions per capita in the core, semi-periphery, and periphery of the world system.

Data and methods

With the exception of world system position (WSP) all variables were drawn from the World Bank (2013) for the years 1960 to 2011. The dependent variable, CO_2 emissions per capita, measures CO_2 emissions from liquid, gas, and solid fuel consumption– as well as emissions from gas flaring– in kilograms, divided by the total population within a given nation at a given time. It is important to note that the use of per-capita emissions makes the emphasis of the analysis less focused on the effect of population itself, and more concerned with the extent to which environmental resources, and CO_2 emissions per capita in particular, are affected by the social activities of that population. Using such a measure allows us to avoid focusing on the biological aspects of environmental impacts to too great a degree and ensures that the effect of social processes carried out by populations is highlighted. Of course, this entails a trade-off, where the direct effect of population is left unexplored. Additionally, it should be noted that use of territorial, or production-based emissions, rather than consumption based/embodied emissions makes the focus of the analysis on that is concerned with the general location of environmentally intensive processes, as opposed to identifying the true source or cause of such processes. This, is important, as the use of different measures of emissions will change the results of the analysis drastically. Here the theoretical focus is on which nations are most able to benefit from ecological rationality as opposed to which nations are most at fault for the destruction of the environment. However, drawing from theories of unequal ecological exchange and environmental world systems theory I highlight that where ecological rationality occurs cannot be disentangled from relations of power and exploitation. Such a consideration serves to remind us that the social cause of pollution, and its location, are two very different things.

The independent variable of interest in the present study is time, which is a continuous variable measured in years from 1960-2011. Here, I follow previous work in the SHE tradition, and attempt to capture the effect of technology, which is traditionally viewed as being captured in the residual term of models by disaggregating a model component that encompasses many other relevant factors (Dietz, 2013; Jorgenson, 2013; McGee et al., 2015). However, while many researchers have attempted to capture the impact of technology by disaggregating variables that are known to be fundamental drivers of environmental impact–e.g. population (Liddle, 2014; Roberts, 2011), or affluence (Shi, 2003; Wang et. al., 2013)– here I follow McGee et al. (2015) and attempt to capture technology by bringing a new component into such analyses. Yet, the present study also differs significantly from McGee et al. (2015) in that, where they attempt to capture technology by incorporating a measure of impervious surface development in a nation, I capture the effect of technology and ecological rationales among populations and policy makers by disaggregating technology using the temporal variable. Thus, I argue that time is of interest because, when all time varying covariates that are theoretically important to understanding the relationship between social activity and emissions are accounted for, what time then represents are those theoretically relevant drivers of impact which we are unable to measure, such as technological progress– including those technologies associated with the spread and intensification of impervious surfaces–, political regime change, and ecological awareness, albeit in an imperfect manner. To that end, the controls included in the models presented below account for a number of factors that are known to have an effect on CO_2 emissions per capita and to vary significantly over time. Specifically, urbanization, age structure of the population, and GDP per capita are included in the models in order to control for factors relevant to CO_2 emissions per capita that are easily measurable and highly time-variant.

I account for power in geopolitical relations by relying upon the WSP measures created by Clark and Beckfield (2009). In order to test for robustness in findings, alternative analyses to those presented here were performed using the more traditional, Snyder and Kick (1979), WSP indicator. The findings reported below were robust across both measures of power. There are 91 nations for which information on environmental indicators and WSP are available that are included in the present study.

Though I use both Snyder and Kick (1979) and Clark and Beckfield's (2009) measure of world system position in this study, I focus my analysis on those models using Clark and Beckfield's measure because it provides a greater level of parsimony. Specifically, while both measures of WSP are created using network block modeling techniques, the Snyder and Kick (1979) measure performs its block calculations using an index variable that consists of trade flows, treaty participation, occurrence of military intervention, and the presence of diplomatic relations. The Clark and Beckfield (2009) measure only relies on trade network centrality. The result of this is that, though the Snyder and Kick measure acts as an effective gauge of placement in the World System, the Clark and Beckfield measure is a more easily interpretable measure of power for the purposes of the present study.

Importantly, the models used in this study assume that world system position is relatively fixed in the 51-year period being examined. While the degree of mobility of nations within the world system is an unsettled issue, there is a precedent of treating the position of nations as fixed over periods of time that may be considered brief relative to the 550-year time span that the modern world system has developed within (Snyder & Kick, 1979; Clark & Beckfield, 2009). Understanding this, I contend that the position of power held by a nation in the international economy during the early years of the postwar era was one of many key factors that contributed to the adoption of political, social, and economic policy programs that were determinative with regards to the ways the nation interacted with the environment over the period of time observed in this study. In order to test this assumption, an alternative model was explored where world system position was enabled to be slightly dynamic by allowing for a change in world system position following the year 1989. To do so, change in national WSP was coded according to Clark's (2012) updated WSP indicator. Findings did not differ substantially from those presented below, and, as a result, I focus on the more parsimonious (fixed WSP) model.

With the exception of WSP and time, all variables in the study were natural log transformed, making the coefficients of such variables presented in the models below elasticities. The result of this is that all coefficients below represent the percent change in CO_2 per capita associated with a 1 unit change in the independent variable (York et al., 2003b).

Table 1.1 World System Position Descriptive Statistics

Variable	All Nations	Core	Semi-periphery	Periphery
Mean GDP Per Capita	11241.67	18105.05	7507.357	3572.61
Maximum GDP Per Capita	81947.24	67804.55	81947.24	61662.50
Minimum GDP Per Capita	113.8766	150.55	408.72	113.87
Mean CO_2 Per Capita	1.83e-06	2.63e-06	1.73e-06	7.45e-07
Maximum CO_2 Per Capita	1.97e-05	1.18e-05	1.97e-05	1.1e-05
Minimum CO_2 Per Capita	1.28e-10	3.49e-08	9.40e-09	1.28e-10
Groups (Countries)	91	34	18	39

I use a hierarchical linear growth curve model, with years nested within nations, to perform the analyses presented below. Such an approach is beneficial, as hierarchical linear models entail a precise weighting operation that prevent the biasing of coefficients or standard errors by unusual observations or panel sizes. Additionally, the clustering of years within nations serves to control for both contemporaneous and extemporaneous effects. Controlling for these two factors serves to limit the influence of omitted variable bias substantially. Further accounting for contemporaneous factors, or the clustering of years, allows for the effect of changes from one year to another, such as changes in technology, culture, policies, and institutions to be captured within the time variable. Thus, the effect of a 1-year change in time corresponds to the average effect of within nation changes of such factors. The general structure of the hierarchical linear growth curve model used here is as follows:

$$CO2PC_{it} = \beta_{0i} + \beta_1(GDPPC_{it}) + \beta_2(GDPPC_{it}^2) + \beta_3(Urban_{it}) + \beta_4(Urban_{it}^2) + \beta_5(Productive\ Age_{it}) + \beta_{6i}(time_{it}) + e_{oit}$$

$$\beta_{0i} = \beta_0 + \beta_7(Core_i) + \beta_8(Semi_i) + \beta_9(Peri_i) + \mu_{0i}$$
$$\beta_{6i} = \beta_0 + \beta_{10}(Core_i) + \beta_{11}(Semi_i) + \beta_{12}(Peri_i) + \mu_{1i}$$

level 2: $\begin{bmatrix} \mu oi \\ \mu 1i \end{bmatrix} \sim N\left(0, \begin{bmatrix} \sigma_{u0}^2 & \\ & \sigma_{u1}^2 \end{bmatrix}\right.$

Level 1: $e_{0it} \sim N(0, \sigma^2_{e0})$

Where $CO2PC_{it}$ represents the log of per capita carbon dioxide emissions of the *i*th nation in year *t*; $GDPPC_{it}$ is the logged value of nation *i's* GDP per capita in time period *t*; $GDPPC_{it}^2$ is the log of the quadratic term for country *i* in year *t*; $urban_{it}$ is the log of the percent of the population living in urban areas in nation *i* during year *t*. $urban_{it}^2$ is the quadratic term for the log of urban population percentage; $time_{it}$ is the value of the variable time in country *i* during year *t*; $peri_i$ is the binary measurement of the periphery status of nation *i*; $semi_i$ is the binary measurement of the semi-periphery status of nation *i*; $core_i$ is the binary measurement of the core status of nation *i*; e_{0it} is the residual difference in CO_2 emissions per capita for the *i*th country in year *t*; μ_{0i} is the residual differential CO_2 emissions per capita value for country *i* when all predictor variables are held at 0; μ_{1i} is the residual difference in CO_2 emissions per capita change for nation *i* for every additional 1 unit increase in time. σ^2_{u0} represents the between nation variance in CO_2 emissions per capita; σ^2_{u1} is the between nation variance in CO_2 emissions per capita change for every 1 unit increase in time.

Results and discussion

The results of the hierarchical linear growth curve model analyses are presented in table 2 below. Model A demonstrates the effect of time on CO_2 emissions per capita absent of any theoretically relevant time variant controls. The results indicate that every year of temporal change, on average, results in a .025 percent increase in CO_2 emissions per capita.

Model B examines the effect that time has on CO_2 emissions per capita while holding constant theoretically relevant variables, without taking global power structure into consideration. Findings suggest that, outside the effect of changes in population, economic development, and urbanization –which are controlled for in both model B and model C– time has no effect on CO_2 emissions per capita when context is not considered.

Model C controls for all theoretically relevant time variant variables and also examines variation in the effect of time in nations belonging the core, semi-periphery and the periphery. Findings suggest that in the core, a one year increase in the temporal variable– or, put differently, a one year change in technologies, ecological awareness/concern, political regimes, and environmental policies– is associated with an increase of .01 percent in CO_2 emissions per capita. The effect of time variant factors on CO_2 emissions decreases by .009 percent in semi-periphery nations, resulting in an increase of .001 percent in kilograms of CO_2 emissions per capita being associated with a change of 1 year. Interestingly, periphery nations are found to have an even greater decrease in the effect that time has on CO_2 emissions per capita, .0159, suggesting that in such nations the passage of a year of time is associated with a slight decrease of .0059 percent in CO_2 emissions per capita on average. The graphic representation of these relationships can be seen in figure 1. With the exception of the working age ratio variable, all regression coefficients reported in model C were found to be statistically significant at the .001 alpha level with a two tailed test. Considering the importance of questions around the impact that economic growth has on environment health, it is important to note that model C indicates that there is an attenuation in the relationship between GDP per capita and CO_2 emissions per capita, such that as GDP per capita reaches very high levels its effect on emissions decreases substantially. Importantly, this research does not examine if, or how, this relationship is modified by power differentials in the global economy, which is an important consideration in such discussions. Additionally, I note that the relationship between GDP per capita and emissions remains positive throughout the range of observed values. Thus, the model indicates that even when nations achieve what might be seen as unusually high levels of GDP per capita ($81,947.24) economic growth is still found to result in increases in emissions.

Likelihood ratio tests between model B and C suggest that model C provides the best fit to the data, as a result I focus the discussion on this model.

Overall, the findings presented here suggest that factors captured by the passage of time that, as of yet, are not able to be directly measured and controlled for on the international scale– such as technological change, changes in policy approaches and political regimes at the national and international level, and changes in the level of ecological concern among producers and consumers– do have a significant effect on CO_2 emissions per capita. While the association of time and CO_2 is modest in all world systems categories, it is also found to be highly significant, and, importantly, significantly different in every world system strata.

The findings of the present research complicate our understanding of the role that social factors that change over time have on CO_2 emissions in interesting ways. For example, the fact that all three world systems categories have relationships that are significantly different from one another provides support for the supposition of environmental world systems scholars that, due to the nature of power relations in the international economy, nations holding different positions in the world system will have notably different social and economic structures, which will ultimately lead to notable differences in the impact that such nations have on the environment. Thus, as figure 1 demonstrates, time is associated with increases in CO_2 emissions per capita to a greater degree in core nations than it is in the semi-periphery, and is associated with decreases in CO_2 emissions per capita in the periphery. However, the specific relationship between time variant factors of interest and CO_2 emissions per capita do not necessarily support a world systems understanding of how such a relationship should play out in each world system category. For example, if this relationship is viewed through the environmental world systems lens, then it might be considered surprising that all nations in the analysis except for those belonging to the periphery express a positive association between time and emissions. In particular, this finding seems to challenge the well-established ‘pollution-haven’ hypothesis (Pearson, 1987), where core nations improve socio-ecological relations by exporting environmentally harmful production processes to nations in the semi-periphery and periphery. Despite this apparent contradiction, if viewed with an eye towards consumption, then these findings do seem to offer support to environmental world systems hypotheses, which note that labor forces in such nations, “being poorly paid, cannot constitute an important consumer market” (Roberts, Grimes, & Manale, 2003). This insight, when taken in conjunction with insights of from the ‘displacement paradox’– which notes that new technologies are often used in addition to, as opposed to in place of, older technologies, and the ‘Jevon’s paradox’, which argues that increases in technological efficiency often lead to the technology being used by consumers at greater rates (York, 2006; York & McGee, 2016)– literatures provides a plausible explanation of these initially surprising findings. Considering these theoretical contributions, we should not necessarily be surprised to see factors such as technological change, policy change, and increasing ecological concern associated with increases in emissions in the core, as it is possible that 1) new technologies, particularly in the energy sector, are being used in order to expand markets in the core, rather than replacing older technologies (York, 2012), and 2) increases in efficiency are leading to increases in consumption, as has recently been found to be the case in the United States with alternative fuel vehicles (McGee, 2017).

The existence of a positive relationship between time variant factors and emissions in the semi-periphery indicates that these nations might be experiencing increases in emissions as a result of taking on environmentally harmful production processes in order to provide consumer goods for nations in the core. Thus, this finding offers support for environmental world system's 'pollution-haven' hypothesis (Pearson, 1987; Roberts, Grimes, & Manale, 2003).

The negative relationship between the temporal variable and emissions in nations in the periphery offers support to both environmental world systems theory and to Mol's theory of environmental flows. Specifically, we should expect periphery nations to release fewer production and consumption related emissions (Smith & White, 1992; Van Rossem, 1996; Roberts, Grimes, & Manale, 2003) than those belonging to the semi-periphery and core due to the fact that such nations often rely on niche economies (such as tourism) or human and non-human animal labor to grow their GDP, but such nations often still have access to some of the benefits of technological change that EM, and environmental flows theory in particular, notes is fundamental to ecological rationalization.

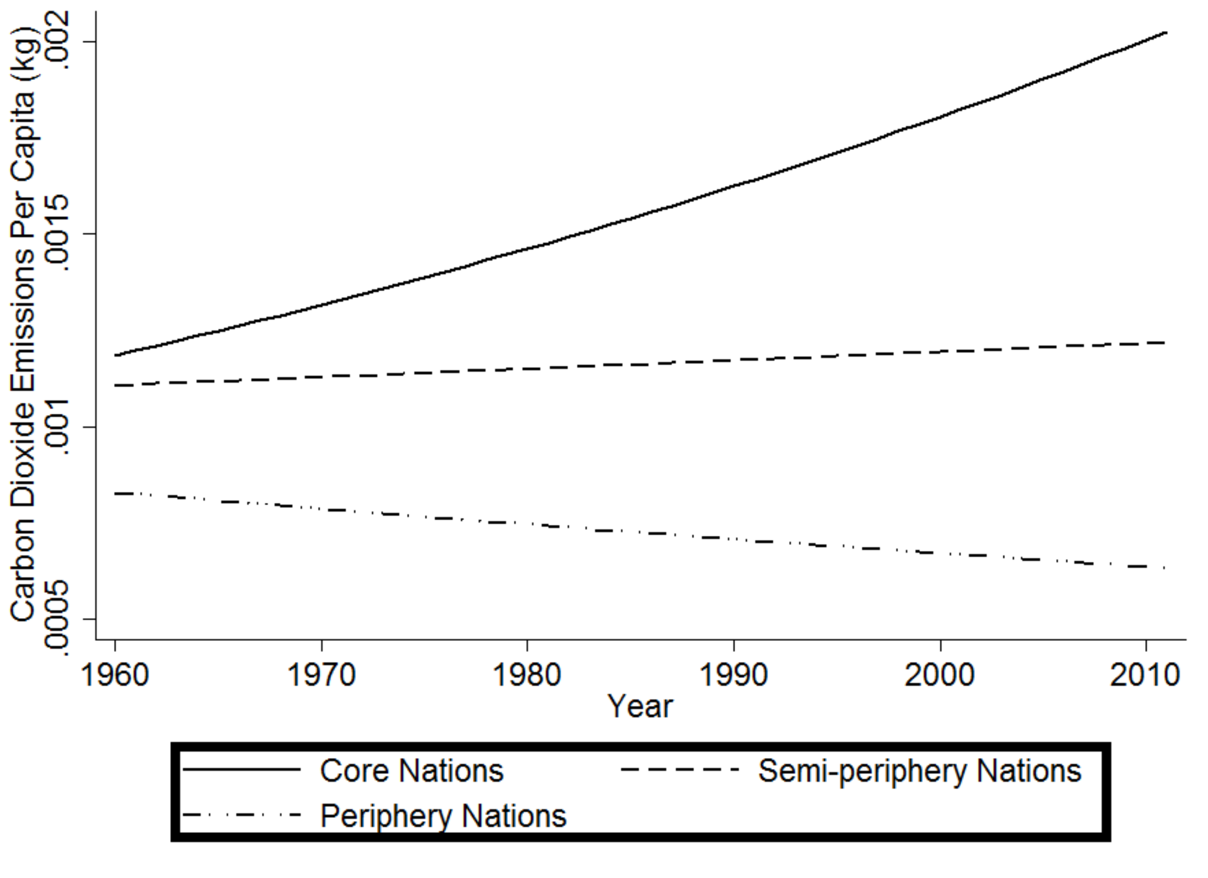
While these findings offer support to the notion that flows of environmental goods and information will benefit less powerful countries in the global economy, they also challenge the hypothesis of EM that all nations will improve in their relationship to the environment, given enough time, as a result of a global process of ecological rationalization. Rather, the findings presented here suggest that, in the majority of nations, time dependent factors are associated with increases in CO_2 emissions per capita. It is important to note that, as indicated above, the majority of emissions have historically come from nations belonging to the core and the semi-periphery (as can be seen in table 1), as a result, we should expect that– supposing the trends observed here continue– CO_2 emissions per capita will continue to increase globally.

Table 1.2. Hierarchical Linear Growth Curve Model of the Effect of Time on CO_2 Emissions Per Capita.

Variable	Model A	Model B	Model C
Level 1 Variables			
GDP Per Capita	–	2.346*** (.176)	2.539*** (.178)
GDP Per Capita^2	–	-0.091*** (.010)	-0.112*** (.011)
Urbanization	–	-5.572*** (.370)	-5.331*** (.365)
Urbanization^2	–	0.901*** (.053)	0.890*** (.052)
Ratio of Working Age Population	–	-0.012 (.047)	-0.019 (.046)
Time	0.025*** (.001)	0.002 (.001)	0.011*** (.002)
Level 2 Variables			
Periphery	–	–	30.676*** (3.340)
Semi-Periphery	–	–	16.848*** (3.881)
Core (reference)	–	–	–
Cross Level Interactions			
Year*Periphery	–	–	-.0158*** (.002)
Year*Semi-Periphery	–	–	-.009*** (.002)
Year*Core (reference)	–	–	–
Constant	-50.873	-10.346	-27.347
Variance Terms			
σ^2_{eo} (Year level)	0.293	0.225	0.219
σ^2_{uo} (Country level)	4.393	1.606	0.278
σ^2_{u1}	–	–	$3.03e^{-7}$

Notes: All models include 91 nations and 3556 nation-years. p<.001***; standard errors in parentheses.

*Figure 1.1***.** Estimated effects of time variant factors on CO_2 emissions per capita



Conclusion

This chapter draws from structural human ecology, neomarxian environmental theory, environmental world systems theory, EM literature, and uses a hierarchical linear growth curve modeling approach in order to examine the association between social factors associated with environmental impact that change over time, and CO_2 emissions per capita in the world system. Using such an approach, I examine the debate between EM theorists and environmental world systems proponents in a novel way. By using time in order to disaggregate technology, I gain insight into the contentious issue of the extent to which the aggregate of changes in technological efficiency, policy approaches, and the ecological awareness of producers and consumers affect emissions at the national level.

Building on work that has found that changes in time modify the relationship between economic activity and emissions, I find that the relationship between time and CO_2 emissions per capita is statistically significant, as well as statistically different across world systems strata. In particular, the findings here suggest that in all nations except for those belonging to the periphery time is positively associated with CO_2 emissions per capita, with the strongest association being in the core of the world system. This finding suggests that, outside of the periphery, the process of ecological rationalization is not working to reduce the rate of emissions over time, and supports the argument of SHE and environmental world systems scholars that broader structural changes will likely need to be made to the global economy if we hope to reduce the environmental impact of social processes.

In a broader sense, the findings presented in this study suggest that assumptions that temporal progress in technological change, ecological awareness, and environmentally friendly policies and political regimes lead to a gradual decline in the environmental impact of social processes are not necessarily valid, at least insofar as greenhouse gas emissions are concerned. What's more, the findings presented here indicate that the modernist assumption of global economic processes leading to increasing similarities in the way that nations relate to the environment is a questionable one, and that, in fact, nation's that belong to different world systems positions– or have notably different levels of control over their trade network and, thus, their role in the international economy and production chain– have trajectories of growth in CO_2 emissions per capita that are decidedly different from one another. The implication of these findings is that international policy makers must account for such difference as they attempt to outline pathways to sustainability for all nations. Further, the findings presented above suggest that– at both the national and the international level– policy makers must take a more active role in ensuring that social structures and processes become more environmentally benign, rather than assuming that socio-ecologically sustainable societies will roll in on the wheels of inevitability. To that end, the findings of this study point in two broad research directions. First, as data becomes more readily available, efforts must be made to track the effect of those factors that were captured by time in this study on carbon dioxide emissions per capita more precisely. Second, it is important that comparative and qualitative work be done in order to better understand what causes the relationship between time and CO_2 emissions to differ across world system positions, as well as what interventions might successfully limit these differences.

In the chapter that follows, I will explore how the relationship between economic growth and emissions differs in varying strata of the world system. Further, I will examine how much of the variation in emissions is explained by a nations position in the world system, allowing for the exploration of how deeply global inequality among nation states effects environmental impact.

CHAPTER III

DIVERGENT PATHWAYS: THE IMPACT THAT A HIERARCHICAL WORLD SYSTEM HAS ON THE ENVIRONMENT

A version of this chapter was published in *Socius* with Julius Alexander McGee (Greiner and McGee 2018). My Co-author helped to frame the argument, helped to develop the modeling approach, and wrote the section on the Environmental Kuznets Curve, as well as parts of the conclusion.

It is now accepted by climate scientists that the environmental conditions which allowed for the initial growth and establishment of human civilizations is in a period of rapid transition. Further, it is now known that one of the primary causes of the rapid shift in the ecological conditions that house human activities are human technologies and social organizations (Rockström et al., 2009). As a result of this knowledge, it has been one of the primary aims of environmental sociology, and other environmental social sciences, to identify the key social drivers of the current environmental change. In several instances, this concern has taken the form of examinations of the relationship between economic growth at the national level and environmental degradation (See Jorgenson and Clark 2012; York et al. 2003a; 2003b York and Rosa 2012).

Despite a shared concern for environmental outcomes among the researchers who interrogate such matters, there has been a general split in the understanding of the environmental impacts of economic growth among social science researchers. Generally speaking, this divide can be drawn between environmental economists from the neoclassical school- as well as a number of environmental sociologists- who believe that, ultimately, economic growth can work to decrease environmental impacts of social activity and benefit the environment, and structural human ecologists (SHE) and world systems theorists who argue that economic growth has a continuously negative effect on environmental health. While acknowledging that economic development has historically had a negative effect on the environment as a whole, many environmental economists and sociologists (see Shahbaz, Mutascu, & Azim, 2013; Ehrhardt-Martinez, Crenshaw & Craig Jenkins 2002) argue that regulations on business and trade eventually reverse this relationship, leading to a correlation between environmental impacts and economic growth that resembles an inverted U shaped curve. This relationship is commonly referred to as an Environmental Kuznets Curve (EKC) (Grossman and Krueger 1991; Dinda 2004). Contrary to this, researchers in the field of human ecology and world systems have noted that the conceptual framework of the EKC fails to take into account the global nature of contemporary economies, (York, Rosa, & Dietz 2003a, 2003b; Dietz, Rosa &York 2007; Rice 2007) pointing out that in many instances wealthy and powerful nations are able to decrease their impacts only by exporting their environmentally harmful activities and industries to less powerful nations that are in search of ways to grow their economy.

In the field of environmental sociology, the tension between those who claim to find an EKC and those who argue that economic growth is deeply, if not inherently, tied to the degradation of ecological resources has played out in the debate between the proponents of Ecological Modernization theory (Mol & Spaargaren 2000) and those of Treadmill of Production theory (Schnaiberg 1980). Within this debate, Ecological Modernization theory has traditionally attempted to demonstrate the ‘ecological rationalization’ of social and economic processes, and thus support the EKC hypothesis, by performing case studies of ecologically reflexive institutions, noting that even if ecological modernization has not spread through our cultural and economic systems wholesale, there are still instances that illustrate the potential, and possible presence, of such a transition (Mol & Spaargaren 2000; York et al. 2010).

Contrary to Ecological Modernization Theory, Treadmill of Production has typically attempted to demonstrate the ties between economic growth and environmental degradation globally by performing macro-level cross-national analyses (Gould et al. 2004; Liddle 2013; Rudel & Horowitz 1993; York et al. 2003a), recognizing that both capitalist processes of accumulation and the environmental impact that might come of them are now global in their scope (Grimes & Kentor 2003). As a result of this global focus, and the recognition that economically and ecologically exploitative relationships between the global North and the global South are inherent to the functioning of capitalism and, thus, to understanding the Treadmill of Production, a non-trivial body of literature has merged the Treadmill of Production theory into a World Systems framework, using the logic of STIRPAT modeling approaches, in order to refute the contention of EKC proponents that, given adequate growth and time, all nations will experience a decline in emission levels (Ergas & York 2012; Ewing 2017; Jorgenson 2006, 2007, 2012; Jorgenson & Clark 2009; Liddle 2013; Rudel & Horowitz 1993; York & Rosa 2003; York et al. 2003a).

Here, we take a novel approach to examining the tensions in the debate surrounding the EKC and utilize a random coefficients model to examine how a nation's placement in the world system modifies its relationship between economic growth and environmental impacts, measured as CO_2 emissions per capita. The random coefficients approach allows us to analyze the development of this relationship over time (a common way of assessing the effect of economic growth on CO_2 emissions), and also examine whether the majority of variation in CO_2 emissions is more appropriately understood as attributable to time invariant nation state characteristics or to attributes that vary from year to year. In other words, we are able to assess whether most variation in CO_2 emissions per capita is attributable to across, or within unit differences. In the present study we have specified time as the first level of analysis, which we use to examine the effect of theoretically relevant time variant predictors. We have specified countries as the second level– to which we have associated the relatively stable/ time invariant predictor of world system position. Though we recognize that world system position is a time variant characteristic, here we argue that a nation's world system position in the years following the establishment of the Bretton Woods institutions is an important predictor of the role it would play in the global economy throughout our range of observations. As a result, we treat world system position at the beginning of the 1960s as a time invariant characteristic. By examining the strength and direction of the association between growth and impact, and the amount of variation that is attributable to time dependent predictors relative to geopolitical structure predictors, we are able to speak to the EKC/SHE debate in a new way. Namely, such an approach enables us to examine the extent to which we can expect time dependent variables, such as GDP and urban population size, to alleviate environmental impact relative to variables associated with the structure of the modern world system.

If common interpretations of the Environmental Kuznets Curve hypothesis are correct, then we should expect to find that most nations have a relationship between GDP per capita and CO_2 emissions per capita that resembles an inverted U, and that the majority of variation is attributable to level 1 (time dependent) variables. However, the logic of structural human ecology and world systems theory would suggest that the Environmental Kuznets curve will be specific to those nations that wield the most power in the world system (i.e. the core). While the less powerful countries of the semi-periphery and the periphery will have a relationship between GDP and CO_2 emissions that greatly limits their ability to use economic growth as a tool to prevent negative environmental impacts. Further, according to such theories we should expect to find that the majority of variation in CO_2 emissions is attributable to level 2 (country level/time stable) variables, as opposed to level 1 (time variant) variables.

The Environmental Kuznets Curve Hypothesis

The Environmental Kuznets Curve was first presented empirically in an NBER working paper by Grossman and Krueger (1991), who identified an inverted U-shaped relationship between SO_2 emissions and smoke, and income per capita. The authors noted that while initially environmental pollution increased alongside income per capita, there was a point in which income per capita became associated with declines in environmental pollution. Grossman and Krueger used the name “Kuznet” to describe the phenomenon due to its resemblance to Simon Kuznet’s famous Kuznets Curve hypothesis (1955), which found an inverted U-shaped curve between income inequality and economic growth. The term Environmental Kuznets Curve was later coined by Panayotou (1992) to describe a similar pattern identified between deforestation and air pollution, and per capita income. Since the 1990s, the EKC has been applied as a hypothesis to numerous forms of environmental degradation and processes of modernization, which are not limited to measurements of economic development. For example, Ehrhardt-Martinez et al. (2002) and Choumert et al. (2013) demonstrated that an inverted U-shaped relationship existed between urbanization and deforestation.

Since our analysis focuses on the EKC with regard to CO_2 emissions, here we place particular emphasis on research examining the relationship between CO_2 emissions and economic growth. Numerous studies have found evidence of an inverted U-shaped relationship between CO_2 emissions and economic development within specific nations -- Shahbaz et al. (2013; Romania), Tiwari et al. (2013; India), Chandran et al. (2013; India), Ahmed and Long (2013; Pakistan), Roach (2013; across US states), and Baek and Kim (2014; Korea). In these analyses, emphasis is often placed on the effects of environmental policy. For instance, Chandran et al. suggests that the existence of an EKC in India (or what they call a bi-directional relationship) and not in China is due to environmental degradation affecting economic growth in India and not in China. They conclude that China is capable of reducing CO_2 emissions from coal without reducing economic growth through increased efficiency and renewable energy production. While there is obvious merit to nation-specific analyses, the policy recommendations in these analyses often ignore the transnational residual effect of policies aimed at reducing CO_2 emissions. Sinn (2012) argues that laws aimed at reducing CO_2 emissions in specific nations often influence transnational corporations to increase fossil fuel production elsewhere. Thus assessing the cross-national pattern of CO_2 emissions' connection to economic growth is necessary to understand the extent to which environmental policy leads to an EKC.

Chow and Li (2014) and Ibrahim and Law (2014) have recently each found evidence of an EKC between CO_2 emissions and economic growth cross-nationally using panel data. While each of these analyses, which are only the most recent studies of EKC and CO_2 emissions, find evidence for an EKC in both developing and developed countries, there is no discussion of the theoretical implications of the EKC (in fact this is explicitly stated by Chow and Li) or of power and the relationship between nations. As Dinda (2004) points out in a review of EKC research, empirically, the EKC describes a dynamic process of change, where the relationship between economic growth and environmental degradation is expected to change at different levels of economic development. Thus, empirically the EKC is simply a description of relative changes in the relationship between environmental output and economic development. However, the lack of theoretical insight in cross sectional analyses of EKC and CO_2 emissions and the limited discussion of the transnational implications of national policies can produce numerous empirical problems that we intend address in this study.

In a Marxist critique of the EKC, Lynch (2016) acknowledges numerous inconsistencies across EKC analyses, noting that there is no consistent methodology or unit of analysis particular to EKC research. The author contends that traditional interpretations of the EKC as an empirical phenomenon are too optimistic and fail to understand the broader economic context in which anthropogenic environmental pollution is produced. Lynch (2016) interprets the existence of an EKC through a Marxist perspective, arguing that the EKC is merely a pattern that fits the traditional Marxist critique of capitalism nationally and globally. Within nations, Lynch contends that the existence of an EKC is an inadvertent consequence of "profit-making" driving technological change or changes in input use. Globally, the author argues that the existence of an EKC in “core” nations is a product of patterns inherent to global capitalism, where production is shifted from developed to developing nations.

In contrast to Lynch’s perspective, proponents of EKC argue that the attenuating relationship between economic development and environmental degradation is mostly a result of policies, regulations, and individual actions prompted by a general increase in awareness of environmental conditions, as well as a shift away from industrial production to service based economies (Dinda 2004). As noted above, in environmental sociology Ecological Modernization Theory (see Mol 2000; Mol. et al. 2009) presents prevailing discourses pertaining to environmental policy and strategic industrial techniques based on the assumption that an EKC is a common outcome of economic development (Buttel 1987). Under this school of thought, scholars contend that the trajectory of economic development is linear, noting that the existence of an EKC in developed countries is a pattern that will soon be followed in developing countries. While recent cross-sectional analyses argue that the EKC is now visible in both developed in developing nations, we contend that this is due to theoretical oversights in overtly empirical assessments of the EKC.

Building on the Lynch’s (2016) critique of the EKC, we contend that the lack of theoretical depth in EKC analyses, specifically those that explore the relationship between CO_2 emissions and economic development, as well as the lack of consistency across empirical studies, generates problems in the empirical assessment of the EKC and CO_2 emissions. Specifically, we argue that, currently, empirical analyses of the EKC and CO_2 emissions on a global scale, fail to acknowledge the variation in nations’ relationships with each other and their internal relationships to economic growth. Similar to Lynch, we argue that the existence of an EKC should be understood through a more critical lens, which acknowledges that the EKC is a product of unequal relationships between nation-states that the current structure of the global economy is predicated on. To this end, cross-national empirical assessments of the EKC and CO_2 emissions should attempt to acknowledge the power dynamics that exist between nations in their analyses. While we acknowledge that no empirical analysis can fully incorporate the variation in relationships between nations, we believe methodologies exists that, at the very least, address a variety of broad theoretical concerns. What follows is a brief overview of the insights developed in World Systems theory and research on Unequal Ecological Exchange that we use to craft a more appropriate assessment of the EKC and CO_2 emissions.

World Systems Analysis and Unequal Ecological Exchange

In the past several decades, environmental scholars have begun to incorporate world systems theory as an analytical tool to examine how global political economic structure influences environmental impacts (Bunker 1984; Burns, Davis & Kick 1997; Chew 2001; Ergas & York 2012; Grimes & Kentor 2003; Hornborg 2009; Jorgenson 2003; Jorgenson 2007; Jorgenson & Clark 2009; Roberts & Grimes 1997; Roberts, Grimes, & Manale 2003; York et al. 2003a). World systems theory was developed in the early 1970s to facilitate the application of neo-Marxist strains of political economic thought to the function of the global economy within the historical context of the capitalist economic system (Chase-Dunn & Grimes 1995; Wallerstein 1974, 1979, 2004). Traditionally, world systems theory focused on the structured hierarchy of the global economy and the developmental constraints faced by some nations while attempting to grow their economies as a result of this hierarchy. World systems theorists argue that developmental pathways and economic factors, such as trade partners, labor policies, and environmental regulations, shape the products that nations might choose to produce and dictate how businesses operate in such nations, which in turn affects the ways in which a nation's population is environmentally and economically exploited (Bunker 1984; Chase-Dunn & Grimes 1995; Roberts et al. 2003; Jorgenson 2003). To this end, Jorgenson (2003) demonstrated that of a variety of social structural factors– such as urbanization, literacy rates, and domestic inequality– it was world system position which acted as the strongest positive predictor of a nation's ecological footprint.

The work of world systems researchers has typically centered on the domination of the global economy by core nations– which are economically, militarily, and politically preeminent– at the expense of nations in the periphery and, to a lesser degree, semi-periphery, which have historically been economically and politically disadvantaged as a result of the legacy of colonial operations within their country. Within this schema it is argued that core nations exploit all other nations through geopolitical relations and the control of economic trade networks, while semi-periphery nations occupy a position of domination over those nations that belong to the periphery, and thus are unique in their propensity to both exploit and be exploited (Clark & Beckfield 2009; Snyder & Kick 1979; Wallerstein 1974). Wallerstein (1974, 1979, 2004) has noted that it is the presence of such an intermediate category of nations, which simultaneously benefit from the hierarchical structure of the world system and are exploited by it, that lends stability to the structure, and prevents exploited nations from attempting to restructure the political and economic relations that characterize the capitalist global economy.

Drawing from orthodox world systems traditions (Wallerstein 1974), as well as from dependency theory (Frank 1967), subsequent work focused on the extraction and progressive underdevelopment of the global periphery (Bunker 1984), as well as the development of a new international division of labor wherein industrial sectors that are relatively environmentally benign (e.g. the service industry) began to be concentrated in core nations. Meanwhile, hazardous activities increasingly began to take place within nations belonging to the periphery and semi-periphery (Fröbel, Heinrichs, & Kreye 1981; Roberts & Grimes 1997; Roberts et al. 2003; Schoenberger 1988).

Burns et al. (1997), in one of the earliest empirical analyses of the effect of world systems position on the environment, found that core nations were associated with the highest levels of CO_2 emissions. The authors also find that semi-core and semi-periphery nations had the highest levels of methane emissions due at least impart to the movement of agribusiness from core nations to these regions. In an additional analysis, Burns et al. (2003) note that between 1990 and 2000 deforestation occurred with the greatest intensity in the periphery, followed closely by the semi-periphery, while increasing affluence was found to slow deforestation globally.

Though we do not directly test such theories in the analyses presented here, the theoretical reliance of the present work on developments within the field of unequal ecological exchange renders a discussion of this theory beneficial. Contemporary work in the field of unequal ecological exchange has demonstrated how politically and economically privileged countries belonging to the global core have exported the environmental costs of their economic activities to poorer nations within the global economy (Grimes & Kentor 2003; Jorgenson 2006; Jorgenson & Clark 2009; Prell & Sun

2015). Highlighting the importance of the export of ecological goods from poorer nations to wealthy– militarily powerful– nations, unequal ecological exchange studies have used trade measures as continuous variables in order to examine the effect of exports and imports between nations on ecological outcomes (Jorgenson 2006; Jorgenson & Clark 2009; Prell & Sun 2015). Such an approach has illuminated how trade relations are exploited within the world system in ways that allow for core nations to maintain the health of their ecological resources, even as their economic activities continue to drive environmental degradation elsewhere. For example, recent research has demonstrated that nations occupying peripheral positions within the global economy tend to have increased levels of environmental degradation as their levels of exports to other countries grow (Jorgenson & Clark 2009; Jorgenson & Clark 2011; Rice 2007). Similarly, previous research in this field has suggested that, while there may be a relative decoupling of economic growth and environmental impact in the more geopolitically advantaged nations of the global core, the same relationship does not hold for nations that do not belong to the upper quartile of the World Bank's income classification of nations (Jorgenson & Clark 2012). The present study attempts to build upon these traditions by using a relatively novel modeling approach to examine if there is a meaningful difference in the relationship between environmental impact and economic growth among nations holding different world systems positions.

Hypotheses

Keeping in mind the work in the fields of environmental world systems, unequal ecological exchange, dependency theory, and the EKC, we argue that the environmentally destructive trade relations that these fields illuminate are borne out of advantages held by core nations that are inherent to their status as core countries in the world system. Considering this, we hold that, due to qualitative differences in their economic structures, nations belonging to different groupings in the world system at the beginning of our observed time period will have a significantly different relationship between economic growth and atmospheric pollution as measured by CO_2 emissions per capita. Specifically, we follow the work of previous environmental world systems scholars (Roberts & Grimes 1997; Burns, Davis & Kick 1997; Roberts et al. 2003) in arguing that nations in the core will likely have a relationship between economic growth and environmental pollution that resembles an environmental Kuznets curve as a result of their ability to export a number of their environmentally harmful activities to nations belonging to the semi-periphery, which falls in line with research concerning other indicators of environmental impact as well (Burns et al. 2003). Considering this, we hypothesize that nations belonging to the semi-periphery will likely have a relationship that is monotonically positive or increases geometrically, as such nations have often grown their economies by employing low standards of labor regulation and environmental protection, while simultaneously growing their industrial capabilities in order to act as manufacturers for multi-national corporations whose markets are often centered in core nations (Roberts et al. 2003). Additionally, we suspect that periphery nations will likely have a relationship that appears to be relatively flat and stable– though on average such nations should have notably lower CO_2 emissions– as these nations often grow their economies via the extraction of raw environmental resources through the use of human or non-human animal energy (Smith & White 1992; Van Rossem 1996), or by participating in specialized industries such as tourism and banking– none of which have a particularly notable effect of CO_2 emissions (Roberts et al. 2003).

As noted above, much of the debate surrounding the EKC is deeply tied to the question of whether or not the majority of variation in CO_2 emissions is attributable to differences within or across nations. Put differently, one could argue that the EKC debate, in no insignificant way, is tied to the question of whether or not changes in factors that are highly responsive to temporal variation– such as GDP or urban population size– can potentially account for, and thus be used to mitigate, CO_2 emissions or if factors that are insensitive to the passage of time– those such as colonial legacies, resource presence and absence, and world system position at a critical point in world history– are also important factors in understanding and addressing climate change. Understanding this aspect of the EKC and the theoretical discussions that surround it, here we hypothesize that the analysis of variance that is permitted by the random coefficients model used in the present study will yield a variance partition coefficient (VPC) that indicates that the majority of variation in CO_2 emissions per capita is attributable to factors associated with the nation, such as its place in the global economic structure in the years following the establishment of supranational institutions, rather than those factors that express year to year within nation changes.

Data

With the exception of the world system placement variable, the dependent variable, as well as all independent variables, used for this study were gathered from the World Bank's 'world development indicators' database (2015). The world development indicators database provides information on a wide range of topics for 214 nations from the year 1960-2015. In the present study data is included for 91 countries for the years 1960-2011. Descriptive statistics of these variables are reported in table 1.

The dependent variable of interest in the present study is *carbon dioxide emissions per capita*. In order to construct this variable, we divided the World development indicator's carbon dioxide emission variable, which measures CO_2 emissions from liquid, gas and solid fuel consumption, as well as emissions from gas flaring, in kilotons, by the total population within a given nation at a given time.

Seven independent variables are included in the analysis. The primary independent variables of interest are *Gross Domestic Product (GDP) per capita* and *world system position*. GDP per capita is measured in constant 2005 U.S. dollars and is generated by the World Bank by dividing a nation's gross domestic product by its mid-year population size. The World Bank measures GDP as the sum of gross product that is added by producers that are residents of the nation being examined plus the difference of product taxes and subsidies that are not included in the final calculation of a product's value. GDP per capita does not include depreciations for either environmental degradation or fabricated assets.

World system position consists of three categorical, binary coded, variables that are intended to measure power in the global economy and geopolitical environment. We follow the traditional literature in world systems analysis and allow each country to belong to one, and only one, of the three world systems classifications. Thus, nations can belong to the core, the periphery, or the semi-periphery. We utilize Clark and Beckfield's (2009) world system classification in order to determine which nation belongs to which of the three world system categories. As a result, the analyses presented below rely on the nation-state classifications presented by Clark and Beckfield (2009). Clark and Beckfield (2009) use the International Monetary Fund's database (2004), 'Direction of Trade Statistics', in order to create a trichotomous world system indicator that is based on trade flow centrality. All nations with $1 million dollars or more in imports were included in their construction of a trichotomous world system structure. They then assigned each included nation a proportional measure of 'coreness', which is derived from each nation's international trade connection density in the world system, using UNICET 6. Finally, they organize the nations into a three-block structure where 'coreness' is made to resemble theoretical expectations of world systems analysis as much as possible. Thus, core nations are those which maximize the intra-block density of the core category, bringing it as close to one as possible and signifying that these countries share near perfectly complete trade connections with one another. Semi-periphery nations are those which bring the intra-category block density as close as possible to the global median of trade network density. Periphery nations are those that bring the intra-block density as close as possible to 0, signifying that there are no trade connections between the nations that compose this category. Clark and Beckfield's (2009) analysis includes 116 nations in its analysis that are also present in Snyder and Kick's (1979) world system position classification. Of these 116 nations there are 91 for which data for the dependent variable is available through the world development indicators database. Thus, our models are limited to the yearly observations that exist within these 91 nations[2]. Descriptive statistics

[2] In an alternate model Snyder and Kick's (1979) trade based trichotomous world system position measure was used in order to identify core, periphery and semi-periphery nations. Findings from the alternative model varied from, but were supportive of, those reported here. Notably, the alternative model suggested that both periphery and semi-periphery nation's had a relationship between CO^2 emissions per capita and growth in

concerning Clark and Beckfield's world system position measure can be found in table 2. A list of all nations included in analyses using the Clark and Beckfield (2009), or the Snyder and Kick (1979) measure of world system position can be found in table 3

We acknowledge that the models presented here rest on the assumption that the global world system is relatively stable/ time invariant within the time period examined in the present study. Here, we highlight that our argument is not that world system position is time invariant, but rather that world system position in the years immediately following the establishment of the Bretton Woods institutions plays an important role in determining how a nation's economic activity will affect carbon dioxide emissions per capita in the period being examined. Despite this, we also include several alternative analyses in order to demonstrate that temporal variance of world system position within the period examined is not biasing our results. Thus, we include an alternative model, wherein we limit our analysis to years preceding the collapse of the Soviet Union. We conceptualize this as one appropriate check for the fixity of world system position, as it offers one of the best opportunities to observe a potential 'shake-up' of the global

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GDP per capita that was significantly different than such a relationship in core countries. More importantly for the purposes of the present study, while core nations have a strong attenuation in CO_2 emissions per capita at higher levels of GDP per capita, semi-periphery nations demonstrated a much smaller attenuation of emissions at higher levels of GDP per capita, and continued to increase within the range of observed values. Additionally, Periphery nations display a relationship between CO^2 emissions per capita and growth in GDP per capita that begins to plateau at higher levels of GDP per capita, but also continues to increase within the range of observed values (See figure 3, and model 5 of table 5).

Sensitivity analyses were also performed in order to ensure that the placement of China, United Arab Emirates, or India into particular world system categories did not drastically change the results. Removal of these countries from the dataset did not produce notably different results in any of the models that were run. These models are available upon request.

political economy in the 51-year period examined here. Findings from this model were consistent with findings from similar models that incorporated all available years into the sample, and can be seen in model 6 of table 4. However, we note that this alternative model was only performed using the Snyder and Kick (1979) world system position indicator, as the models using Clark and Beckfield's (2009) measure were unable to converge when using the truncated sample. As an additional check against model sensitivity to nations changing world system position, we run an analysis using Clark's (2012) update of Clark and Beckfield's world system position indicator in order to identify nations which have transitioned from one world system category to another, and exclude them from the analysis. Again, there were no substantial changes from the models presented in table 4. Results of this sensitivity analysis can be seen in model 7 of table 5.

Percent of the population that resides in urban areas is also included in the models in order to account for intensity of land use and rates of consumption that can differ significantly between urban and rural settings. Additionally, previous research has established that urban population size is a significant driver of fossil fuel use and, as a result, CO_2 emissions per capita (Clement 2010; Ehrhardt-Martinez, Crenshaw, & Jenkins 2002). Urban population percentage, as defined by the World Bank, measures the proportion of the total population living in areas that are defined as urban by a country's national statistical offices. The calculation is made using total population estimates from the world development indicators database and the United Nations World Urbanization Prospects' urban ratios statistic.

As previous research has repeatedly found that the relationship between both GDP per capita, and the percent of Urban residents and CO_2 emissions per capita is non-monotonic, we include squared terms for both of these measures in the analysis in order to capture potential nonlinearity.

Following York and colleagues (York, Rosa, & Dietz 2002; York et al. 2003a, 2003b), we log all variables in the analysis in order to reflect the multiplicative and elastic relationship between anthropogenic drivers and carbon dioxide emissions per capita. The result of this is that all findings represent the proportional change in CO_2 emission per capita for every one-percent change in a given predictor variable. In order to make the fit of models comparable by way of likelihood ratio testing, all observations with missing data on any of the independent variables were dropped from the analysis.

Table 2.1. Logged Level 1 (time variant) Variable Descriptive Statistics

Variable Name	Mean	Median	SD	Minimum	Maximum
CO^2 Emissions Per Capita	-14.476	-14.063	2.111448	-22.781	-10.83609
GDP Per Capita	8.385	8.392	1.538	4.735	11.314
Percent Urban Population	3.978	4.151	0.507	1.388	4.588
Level 1 observations: N=3556					

Table 2.2. World System Position Descriptive Statistics

World System Category	Groups (Countries)	Mean GDP Per Capita	Maximum GDP Per Capita	Minimum GDP Per Capita
Periphery	34	3572.61	61662.50	113.87
Semi-Periphery	18	7507.357	81947.24	408.72
Core	39	18105.05	67804.55	150.55
Total	91	11241.67	81947.24	113.8766

Note: The minimum core value of 150.55 is attributable to China in 1971; the maximum periphery value of 61,662.5 is attributable to Iceland in 2007; and the maximum semi-periphery value of 81,947.24 is attributable to the United Arab Emirates in 1980.

Table 2.3. World System Measure Nation Classifications

	Core	Semi-periphery	Periphery
Clark and Beckfield (2009)	Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, India, Iran, Ireland, Italy, Japan, South Korea, Malaysia, Mexico, Morocco, Netherlands, New Zealand, Norway, Pakistan, Poland, Portugal, Russian Federation, Saudi Arabia, Spain, Sweden, Switzerland, Thailand, Turkey, United Kingdom, United States	Chile, Colombia, Cote d'Ivoire, Cyprus, Iraq, Israel, Kenya, Kuwait, Libya, Nigeria, Panama, Peru, Philippines, Sri Lanka, Tunisia, United Arab Emirates, Uruguay, Venezuela	Benin, Bolivia, Cambodia, Cameroon, Congo (Dem. Rep.), Congo (Rep.), Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Ethiopia, Gabon, Ghana, Guatemala, Haiti, Honduras, Iceland, Jamaica, Jordan, Lebanon, Malta, Mongolia, Nepal, Nicaragua, Paraguay, Senegal, South Africa, Sudan, Syrian Arab Republic, Togo, Trinidad and Tobago, Vietnam, Yemen
Snyder and Kick (1979)	Australia, Austria, Belgium, Canada, Denmark, France, Germany, Greece, Italy, Japan, Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, United Kingdom, United States	Argentina, Bulgaria, Cuba, Cyprus, Finland, Hungary, India, Iran, Iraq, Ireland, Israel, Jordan, Kenya, South Korea, Lebanon, Malaysia, Pakistan, Peru, Philippines, Russian Federation, Saudi Arabia, Sri Lanka, Turkey, Uruguay, Venezuela	Benin, Bolivia, Brazil, Cambodia, Cameroon, Chile, China, Colombia, Congo (Dem. Rep.), Congo (Rep.), Costa Rica, Cote d'Ivoire, Czech Republic, Dominican Republic, Ecuador, El Salvador, Ethiopia, Gabon, Ghana, Guatemala, Haiti, Honduras, Iceland, Jamaica, Kuwait, Libya, Malta, Mexico, Mongolia, Morocco, Nepal, New Zealand, Nicaragua, Nigeria, Panama, Paraguay, Poland, Senegal, Sudan, Syrian Arab Republic, Thailand, Togo, Trinidad and Tobago, Tunisia, United Arab Emirates, Vietnam, Yemen

Methods

All models included in the analysis are hierarchical linear models of CO_2 emissions per capita with yearly observations of variables nested within nations. We use a hierarchical linear modeling approach, as opposed to the fixed effects approach that has become more traditional in structural human ecology studies, for two reasons. First, hierarchical linear modeling provides more information concerning the structure of the variation in the outcome of interest than can be provided by fixed effects approaches. This is useful, in this case, because it enables us to determine whether or not the majority of variation in CO_2 emissions per capita is explainable within nations (over time) or between nations. That is to say, by allowing for the calculation of a variance partition coefficient, a multi-level modeling approach allows one to determine whether variation in CO_2 emissions per capita is more likely a function of time variant factors, such as GDP and urbanization, or differences in the relatively time invariant characteristics of nation states, such as world system position. Developing such an understanding is important if we hope to craft policies that are able to successfully mitigate negative environmental effects by reducing CO_2 emissions.

Second, multilevel, random coefficients modeling approaches weight the effect that groups have on global outcomes according to the number of observations that each group has relative to the total sample of observations. Thus, multilevel modeling generates results that are less likely to be skewed by unusual observations, even when working with smaller samples. Though this can be done using a fixed effects modeling approach, such weighting is inherent in the random coefficients model as a result of the way that standard errors are calculated. Consequently, HLM is a more parsimonious way of weighting panels in order to ensure findings are well estimated. Panel weights within random coefficients models are calculated as follows:

$$\beta_{0i} = w_i\beta_{0i}^{*} + (1 - w_i)\beta_0$$

Where β_{0i} is the weighted nation specific mean of CO_2 emissions per capita included in the random coefficients model; w_i is the weight, which is calculated as a ratio of the between nation variance divided by total variance; β_{0i}^{*} is the unweighted nation-specific mean of CO_2 emissions per capita; and β_0 is the grand mean of CO_2 emissions per capita within the model.

The logic of our modeling approach is as follows: the null model is a random intercept model and provides a basic understanding of whether most of the variation in CO_2 emission per capita appears to be explainable by differences in time variant factors (level 1) or relatively time invariant nation state characteristics (level 2). Specifically, the null model allows for a straightforward calculation of the variance partition coefficient. Model 1, similar to the null model, is a random intercept model. However, model 1 also includes level 1 fixed effect predictor variables. Comparison between the null model and model 1 will help to interpret whether or not the inclusion of these common predictors appear to change the level that the majority of the variation in CO_2 emissions per capita is attributable to in any meaningful way. Model 2 complicates model 1 by including the level 2 fixed effects predictors of world system position. Using a likelihood ratio test enables us to conclude whether or not including level two variables is a meaningful improvement in model fit relative to model 1, which only includes level 1 (time variant) variables. Model 3 is a random coefficients model, and serves to test whether or not there is any meaningful interaction between the level 2 variables of world system position, and the level 1 variable GDP per capita, while also holding the covariance of the intercept and slope of GDP per capita relative to CO_2 emissions per capita equal to 0. Further, model 3 allows the relationship between GDP per capita and CO_2 emissions per capita to vary randomly, or, in other words, for the model to account for this relationship within each individual nation, while also continuing to investigate the broader trend at the cross-national level. Finally, model 4 replicates the logic of model 3, however, this model allows covariance to be unstructured. Thus, model 4 serves to test whether or not there is a tendency for nations relationships between GDP per capita and CO_2 per capita to become more or less similar as GDP per capita increases, as well as examining the form and strength of relationships between all other predictors and CO_2 emissions per capita.

The general structure of the random coefficients model with unstructured covariance and all fixed and random effects variables included is as follows:

Micro Model- $CO_{2it} = \beta_{0i}(x_{0it}) + \beta_{1i}(GDPPC_{it}) + \beta_{2i}(GDPPC_{it}^2) + \beta_{12}(urban_{it}) + \beta_{13}(urban_{it}^2) + e_{0it}$

Macro Model-
$$\beta_{0i} = \beta_0 + \beta_3(peri_i) + \beta_4(semi_i) + \beta_5(core_i) + \mu_{0i}$$
$$\beta_{1i} = \beta_1 + \beta_6(peri_i) + \beta_7(semi_i) + \beta_8(core_i) + \mu_{1i}$$
$$\beta_{2i} = \beta_2 + \beta_9(peri_i) + \beta_{10}(semi_i) + \beta_{11}(core_i) + \mu_{2i}$$

level 2: $\begin{bmatrix} \mu oi \\ \mu 1i \\ \mu 2i \end{bmatrix} \sim N\left(0, \begin{bmatrix} \sigma_{u0}^2 & & \\ \sigma_{u0u1}^2 & \sigma_{u1}^2 & \\ \sigma_{u0u2}^2 & \sigma_{u1u2}^2 & \sigma_{u2}^2 \end{bmatrix}\right.$

Level 1: $e_{0it} \sim N(0, \sigma^2_{e0})$

Where CO_{2it} represents the log of per capita carbon dioxide emissions of the *i*th nation in year *t*; $GDPPC_{it}$ is the logged value of nation *i's* GDP per capita in time period *t*; $GDPPC_{it}^2$ is the log of the quadratic term for country *i* in year *t*; $peri_i$ is the binary measurement of the periphery status of nation *i*; $semi_i$ is the binary measurement of the semi-periphery status of nation *i;* $core_i$ is the binary measurement of the core status of nation *i*; $urban_{it}$ is the log of the percent of the population living in urban areas in nation *i* during year *t.* $urban_{it}^2$ is the quadratic term for the log of urban population percentage; e_{0it} is the residual difference in CO_2 emissions per capita for the *i*th country in year *t;* μ_{0i} is the residual differential CO_2 emissions per capita value for country *i* when all predictor variables are held at 0; μ_{1i} is the residual difference in CO_2 emissions per capita change for nation *i* for every additional 1 unit increase in GDP per capita; μ_{2i} is the residual difference in CO_2 emissions per capita change for nation *i* for every additional 1 unit increase in GDP per capita squared; σ_{u0}^2 represents the between nation variance in CO_2 emissions per capita (in models 3 and 4 this is only true at the intercept); σ_{u1}^2 is the between nation variance in CO_2 emissions per capita change for every 1 unit increase in GDP per capita; σ_{u2}^2 is the between nation variance in CO_2 emission per capita for every additional increase in GDP per capita squared; σ_{u0u1}^2 is the country level estimate of the covariance between nation's value of CO_2 emissions per capita at the intercept and their relationship between CO_2 emissions per capita and GDP per capita; and σ_{u0u2}^2 is the country level estimate of the covariance between nation's value of CO_2 emissions per capita at the intercept and their relationship between CO_2 emissions per capita and GDP per capita squared.

Results

Outcomes of random intercept and random coefficient models with structured and unstructured covariance analyses are reported in table 2.

Null model findings suggest that the vast majority of variation between the per capita emissions is explainable by relatively time invariant, national level characteristics, rather than changes within nations across time periods. Specifically, the VPC of the country level in the null model is 0.917 (VPC=$\frac{\sigma_{uo}^2}{\sigma_{uo}^2+\sigma_{eo}^2}$), indicating that 91.7% of variation is explainable at the country level. These findings tentatively indicate that it is proper to conceptualize the drivers of differences in CO_2 emissions as being largely related to time invariant characteristics that are nation specific.

The findings reported in model 1 and model 2 largely support the results found in the null model, demonstrating that the inclusion of time variant predictors and country specific variables still renders roughly 88% of the total variation in CO_2 emissions explainable by level 2, time invariant, nation state factors. Additionally, findings here support previous research which suggests that GDP per capita, and urbanization are all significant drivers of CO_2 emissions per capita. Examination of the decrease in country level variation between model 1 and model 2 indicates that roughly 3.5% of all variation in CO_2 emissions per capita can be accounted for simply by including world system position indicators indicators ($\frac{\sigma_{\mu}^{2^1}-\sigma_{\mu}^{2^2}}{\sigma_{\mu}^{2^1}} = \frac{1.644-1.587}{1.644} = 0.0346$)[3]. We note that this finding suggests that there is a great deal of variation in CO_2 emissions per capita to be accounted for outside of world system position. However, we also note that this is a non-trivial amount of variation in CO_2 emissions per capita, and that such a finding highlights the importance of including factors related to the structure of the global political economy in

[3] In an alternate model we use Snyder and Kick's world system position measure and find that it accounts for roughly 5% of all variation in CO_2 emissions per capita. Despite this, we focus our analysis here on models using Clark and Beckfield's (2009) WSP measure because it is more recent, was generated in a more parsimonious manner, and has been shown to outperform Snyder and Kick's WSP measure as a predictor of economic growth (Clark & Beckfield 2009). Findings from the alternate model are represented in Figure 3.

analyses concerned with the relationship between economic growth and CO_2 emissions per capita.

Both model 1 and 2 suggest that GDP per capita increases CO_2 per capita drastically initially, with a slight attenuation of this increase being introduced at higher rates of GDP per capita. This relationship grants limited support to the notion that if nations increase wealth they might decrease environmental impacts. However, it is important to note that in both models the increase in CO_2 emissions associated with the growth of GDP is so dramatic that the relatively small decline later on would likely not be adequate to significantly mitigate environmental impacts. Likelihood ratio tests suggests that both models 1 and 2 fit the data better than the null model, but neither model 2 or model 1 provide improvements in model fit relative to one another.

Models 3 uses a random coefficients approach in order to compare the effect of GDP per capita on CO_2 emissions within nations of periphery and semi-periphery world systems categories to the effect within core countries. Model 4 serves the same purpose as model 3, however, contrary to previous models, model 4 also allows for covariance to remain unstructured. Considering that likelihood ratio tests suggested that model 4 provided a significant improvement in model fit over all other models, and that allowing for unstructured covariance provides more information, the following interpretation will focus on model 4.

Findings in model 4 suggest that core nations have both an environmental Kuznets curve and significantly lower CO_2 emissions per capita than all other nations in the world system, all other factors held constant. Conversely, model 4 findings also suggest that semi-periphery nations, on average, are associated with a more than 34 percent increase in CO_2 emissions per capita relative to all other nations. Further, unlike in previous models, allowing covariance to be unconstrained demonstrates that in semi-periphery nations there is an inverse Kuznets curve, where the relationship between GDP per capita and CO_2 emissions per capita is strongly negative initially, but as GDP per capita increases this negative effect is attenuated until at higher levels of GDP per capita the relationship between GDP per capita and emissions becomes positive. These findings support our hypotheses above, and are in line with world systems theory and the theory of unequal ecological exchange (Rice 2007), as such research suggests that semi-periphery nations are unable to mitigate negative environmental impacts even as they grow their economy due to the fact that, in many instances, these nations must grow their economy by producing goods for consumption in core nations with production techniques that are environmentally harmful, but affordable enough to make mass consumption of goods possible in the core. According to model 4, periphery nations are not significantly different from core nations in their relationship between GDP per capita and CO2 emissions per capita. This finding, once again, is to be expected, as periphery nations have economies that often rely on the extraction of raw goods for export to producing nations in the core and the semi-periphery of the world system.

Figure 2.1

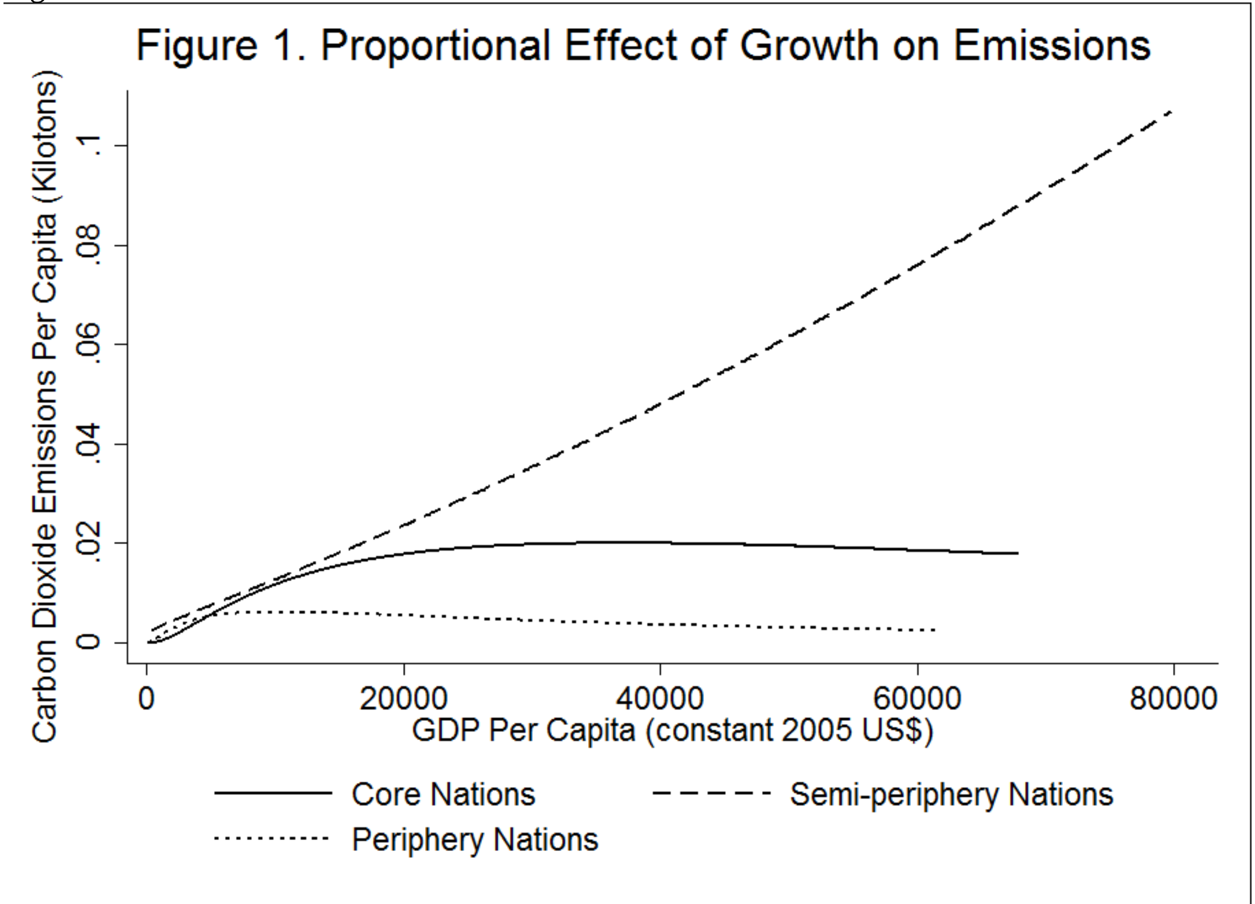


Figure 2.1 Caption: Figure 1 represents findings outlined in model 4. Dashed, solid, and vertical dashed lines represent semi-periphery, core, and periphery nations, respectively. Note that, while semi-periphery and core nations have a similar relationship between GDP per capita and CO_2 emissions per capita initially, they begin to diverge around $15,000 per capita. Beyond that point, semi-periphery nations' emissions accelerate as GDP grows while core nations' level of emissions begins to decrease. Though periphery nations were included for reference, we note that model 4 findings suggest that the relationship is not statistically significant.

It is important to note that the covariance of the relationship between GDP per capita and CO2 emissions per capita is strongly negative, however, we find a small positive value for the covariance in the relationship between GDP per capita squared and CO2 emissions per capita which suggests that as GDP per capita increases nations will have increasingly similar levels of CO_2 emissions per capita until higher values of GDP per capita are achieved, at which point nations begin to have increasingly dissimilar relationships between GDP per capita and CO_2 emissions per capita, as can be seen in Figure 2.

Figure 2.2

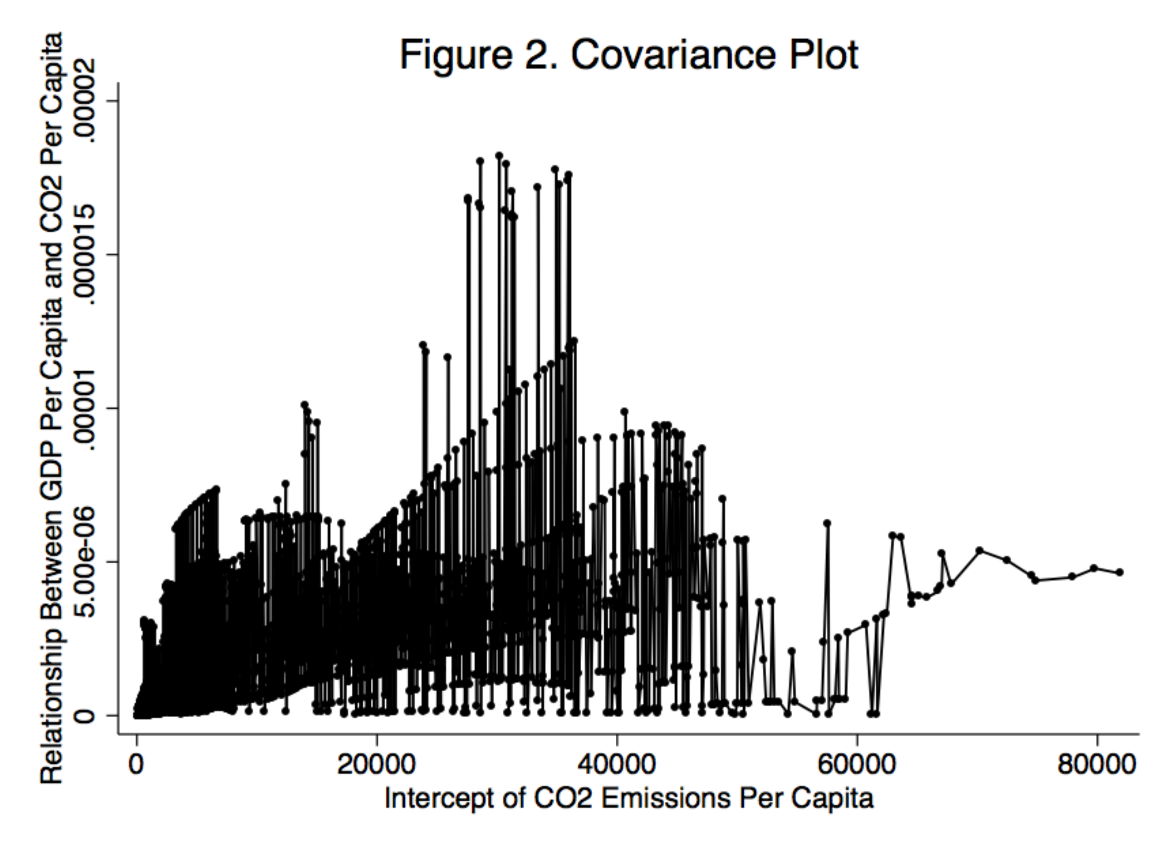


Figure 2.2 Caption: Figure 2 represents model 4 covariance findings. Findings suggest that at low levels of GDP per capita nations have an increasingly similar relationship between GDP per capita and CO_2 emissions per capita, but as GDP per capita increases nations have increasingly different relationships between GDP per capita and CO_2 emissions per capita.

Here we highlight that the finding of the present study, particularly those of an inverse Kuznets curve in the semi-periphery, a high percentage of variation in emissions being attributable to time invariant factors, and a non-trivial percentage of emissions being accounted for by world systems position, offers a great deal of nuance to the current understanding of the EKC hypothesis, and challenges the assertion that *all nations* would see a reduction in CO_2 emissions given a high enough level of economic development. To the contrary, the findings of the present study indicate that the relationship between CO_2 emissions and economic growth within nations is heavily influenced by the developmental pathway that is made available to them within their particular world system position.

Table 2.4. Random Coefficients Models of Drivers of CO_2 Emissions
(All Variables are Logged)

Variable	Null Model	Model 1	Model 2	Model 3	Model 4
Time (Level 1) Variables					
GDPPC	–	2.237*** (.151)	2.226*** (.151)	4.061*** (.578)	6.603*** (1.477)
GDPPC^2	–	-0.083*** (.008)	-0.083*** (.009)	-0.185*** (.034)	-0.314*** (.078)
Urban Population		-5.584*** (.360)	-5.590*** (.360)	-5.906*** (.462)	-6.494*** (.518)
Urban Population^2	–	0.918*** (.051)	0.918*** (.051)	0.958*** (.064)	1.032*** (.071)
Country (Level 2) Variables					
Periphery WSP	–	–	-0.505 (.300)	-4.906 (4.242)	8.820 (9.776)
Semi-Periphery WSP	–	–	-0.118 (.361)	15.495** (5.864)	34.794** (11.927)
Core WSP (Reference)	–	–	–	–	–
Cross-Level Interaction Variables					
Core x GDPPC (Reference)	–	–	–	–	–
Core x GDPPC^2 (Reference)	–	–	–	–	–
Periphery x GDPPC	–	–	–	1.834† (1.044)	-1.254 (2.147)
Periphery x GDPPC^2	–	–	–	-0.157* (.071)	0.025 (.118)
Semi-periphery x GDPPC	–	–	–	-3.176* (1.362)	-7.547** (2.596)
Semi-periphery x GDPPC^2	–	–	–	0.159† (.087)	0.410** (.141)
Constant	-14.537	-19.685	-19.395	-27.191	-38.630
Variance Terms					
σ^2_{eo} (Year level)	0.3922	0.2255	0.2255	0.1394	0.1362
σ^2_{uo} (Country level)	4.372	1.644	1.587	19.577	1067.782
σ^2_{u1}	–	–	–	1.10e-12	49.829
σ^2_{u2}	–	–	–	.0048	.1422
σ^2_{uou1}	–	–	–	0	-228.7363
σ^2_{uou2}	–	–	–	0	12.003

***** p<.001 ** p<.01 * p<.05**

Table 2.4. Random Coefficients Models of Drivers of CO^2 Emissions. Includes 91 nations for the years 1960-2011. All models include 3556 total observations that are separated into the 91 country clusters. The average cluster size is 39.1, the maximum

cluster size id 52 and the minimum cluster size is 1 (Jamaica is only included for a single year due to data limitations).

Conclusion

The results presented in this analysis offer new insights into the long standing debate over the relationship between economic growth and environmental degradation. The EKC is a useful descriptive empirical tool for understanding the dynamic processes of change between economic development and environmental impacts, however the lack of theoretical depth applied to conceptualizations of the EKC produces inaccurate interpretations of socio-environmental processes. There have been numerous insights developed in the field of environmental sociology that help to create a more accurate assessment of the variations in nation-state relations to environmental processes. In this analysis we draw on world systems theory analyses to identify distinct qualitative differences between nations that affect the empirical existence of an EKC cross-nationally over time. We have chosen to rely upon World Systems theory in our study because it is a field that is widely recognized as having developed a sophisticated understanding of differences between nations-states based on a variety of factors related to the structure of the global political economy.

We operationalize the classification of nations' placement in the World System, and assess if these classifications are meaningful distinctions that affect the non-linear relationship between economic growth and environmental impacts. These distinctions are found to be statistically significant and demonstrate that different groups of nations have different non-linear relationships between GDP per capita and CO_2 emissions per capita. Specifically, while the EKC is found to exist in core countries, the opposite relationship exists in countries the semi-periphery category of World System position. We note that, though the models used to assess the variation across world systems stratum treat world system position as temporally invariant, we conceptualize this as demonstrating that a nation's position in the world system in the decades immediately following the institution of Bretton Woods establishment has had a lasting effect on how its economic activity affects the environment. However, to test for model sensitivity to world system position changes we also performed an alternate analysis on years prior to the collapse of the Soviet Union that yielded results that were consistent with those presented here, as well as an analysis in which all nations believed to have changed world system position (Clark 2012) were dropped. In all analyses, our results remained consistent. Finally, we highlight that by using a multilevel random coefficients model we are able to demonstrate that most of the variation in CO_2 emissions is due to time invariant nation state characteristics – in the case of this analysis we focus on one such characteristic, position in the capitalist world system in the period following World War Two. To this end, our model indicates that the effect of economic development on CO_2 emissions is dependent on classifications that are less time variant, and we believe that in the future this approach can be built upon by including other time invariant predictors, such as the colonial history of a nation. In particular, we believe that including aspects of colonial history such as time spent under colonial rule, and the colonization tactics of the relevant regime will be helpful in such analyses.

This finding offers new insights into the general assumptions made in EKC analyses, in that it demonstrates that economic development is not homogenous and the existence of an EKC is more dependent on categories of nations than it is on stages of economic development. While these findings fit the assumptions and previous results of Ecological-Marxists assessments of similar patterns, they also offer a unique empirical conceptualization of the EKC. Our results demonstrate the need for EKC analyses to draw on existing theories when observing processes of environmental change, a practice that we hope future researchers interrogating this relationship will build upon as well.

Having determined that global inequality among nations is indeed a critical aspect of anthropogenic climate change, and that historical, nation specific factors offer the potential to explain a staggering amount of this variation, in the chapter that follows I will explore these relationships from a slightly different perspective. Considering the importance of colonization to the establishment of inequality in the international economy, patterns of unequal exchange and uneven development, and both resource extraction and environmental pollution in the global South, in the next chapter I explore the effect of colonial legacies on the relationship between economic activity and environmental impact.

Figure 2.3

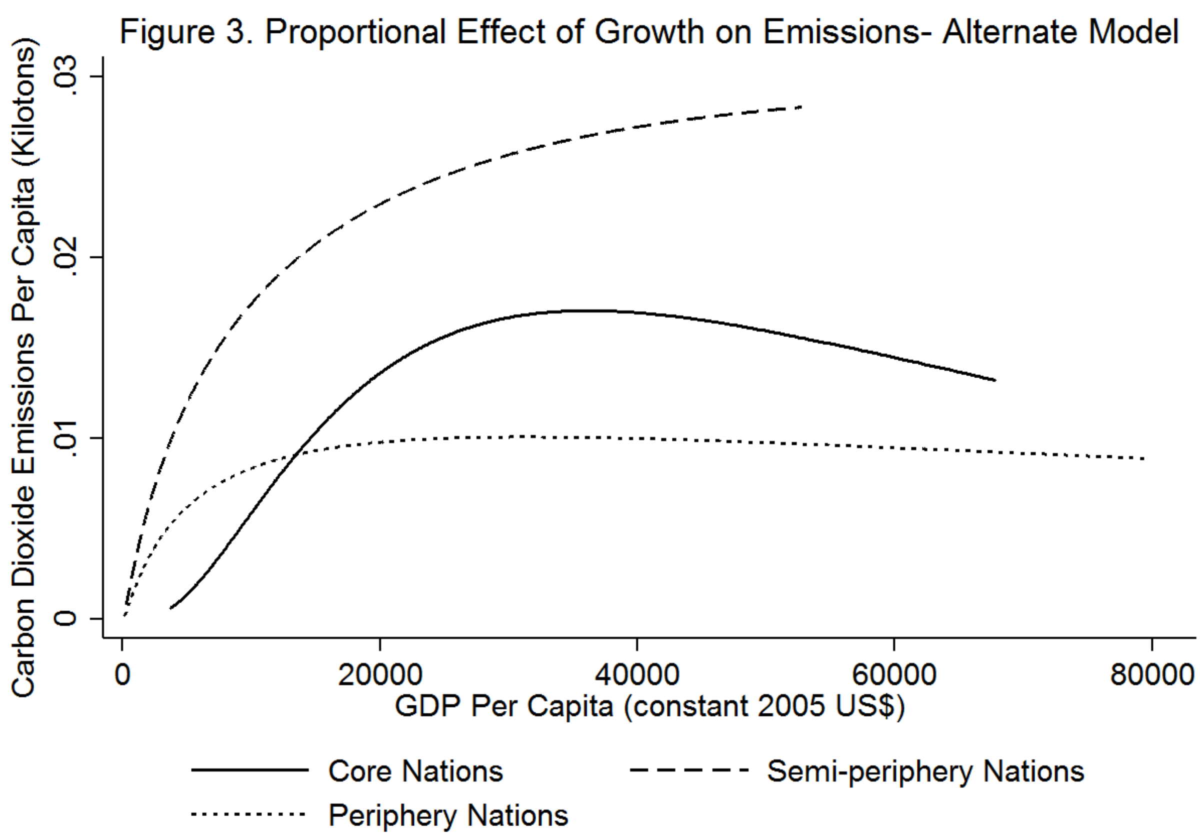


Figure 2.3 Caption: Figure 3 represents findings from alternate model (model 5) based on Snyder and Kick's (1979) world system position indicators. Dashed, dotted, and solid lines represent semi-periphery, periphery and core nations, respectively. Note that, while core nations show a decrease in emissions per capita at high levels of GDP per capita, semi-periphery nations continue to increase and periphery nations remain relatively flat, within the observed range of values.

Table 2.5. Alternate Random Coefficients Models of Drivers of CO_2 Emissions
(All Variables are Logged)

Variable	Model 5	Model 6	Model 7
Time (Level 1) Variables			
GDPPC	13.556*** (2.172)	9.838*** (2.890)	7.708*** (1.594)
$GDPPC^2$	-0.646*** (.114)	-0.449** (.154)	-0.369*** (.082)
Urban Population	-6.482*** (.516)	-5.897*** (.657)	-6.560*** (.522)
Urban $Population^2$	1.034*** (.071)	0.874*** (.093)	1.048*** (.072)
Country (Level 2) Variables			
Periphery WSP	55.051*** (11.378)	40.219** (14.575)	10.189 (11.554)
Semi-Periphery WSP	57.670*** (12.414)	36.609* (15.336)	51.194*** (14.447)
Core WSP (Reference)	–	–	–
Cross-Level Interaction Variables			
Core x GDPPC (Reference)	–	–	–
Core x $GDPPC^2$ (Reference)	–	–	–
Periphery x GDPPC	-10.549*** (2.458)	-7.782* (3.181)	-1.341 (2.479)
Periphery x $GDPPC^2$	0.501*** (.132)	0.369* (.174)	0.008 (.134)
Semi-periphery x GDPPC	-11.097*** (2.701)	-6.795* (3.368)	-11.083*** (3.108)
Semi-periphery x $GDPPC^2$	0.538*** (.146)	0.316 (.185)	0.602*** (.169)
Constant	-75.212	-57.196	-44.064
Variance Terms			
σ^2_{eo} (Year level)	0.118	0.095	0.131
σ^2_{uo} (Country level)	728.349	652.270	1295.487
σ^2_{u1}	38.190	38.043	56.178
σ^2_{u2}	0.115	0.129	0.151
σ^2_{uou1}	-165.757	-156.802	-267.395
σ^2_{uou2}	9.088	9.035	13.579
Nations	91	85	2966
Nation-Years	3556	1730	76

***** p<.001 ** p<.01 * p<.05**

Table 4. Alternate Random Coefficients Models of Drivers of CO^2 Emissions. Model 5 results represent the WSP's effect on the relationship between GDPPC and CO_2

emissions per capita if the classic, Snyder and Kick (1979), measure of WSP is used, rather than Clark and Beckfield’s (2009) measure. Model 6 presents the results when using Snyder and Kick’s WSP measure and the analysis is limited to those years prior to 1991. Model 7 displays results using Clark and Beckfield’s (2009) WSP measure, but leaving out those countries that were found to have changed world system position when Clark (2012) updated this measure.

CHAPTER IV

LEGACIES OF POLLUTION: THE INTRODUCTION OF COLONIAL HISTORIES TO DISCUSSIONS OF EMISSIONS

A research concern of increasing importance is that of the relationship between inequality, economic activity and environmental impact at both the national and international level (Brulle & Dunlap 2015; Jorgenson 2015; Jorgenson, Schor, & Huang 2017). Indeed, recognition of the pace with which anthropogenic climate change is proceeding has been spurred by increasing global temperatures, weather events and natural disasters that are unprecedented in both scale and regularity, and continuously rising sea levels (IPCC 2014). As CO_2 emissions are recognized as one of the most important drivers of such change, special attention has been given by environmental social scientists to the socio-economic and political factors that are associated with such emissions. While such research has long focused on the relationship between economic activity and economic development, particularly as that relationship is modified by a number of relevant social factors (York, Dietz and Rosa 2003; York 2008; York 2012; Jorgenson and Clark 2012; Knight and Schor 2014; York and McGee 2017), recent developments in our understanding of the growing problem of economic and political inequality (Picketty 2014), as well as the recognition that such increases in inequality are often associated with economic growth(Picketty and Saez 2014), has led to inequality becoming one of the primary focuses in discussions of sustainable development (United Nations 2012; IPCC 2014).

As a result of these developments environmental sociology, in particular, has seen a call for an increased understanding of the complex ways in which national and global inequality interact with and modify the relationship between emissions and economic development (Ehrhardt-Martinez, Schor, Abrahamse, Alkon, Axsen, Brown, Shwom, Southerton, and Wilhite 2015; Carmin, Tierney, Chu, Hunter, Roberts, and Shi 2015). While a growing body of literature has taken on the task of understanding the role that inequality plays in impact using increasingly novel methods and data at the national level (Ravallion et al. 2000; Jorgenson et al. 2012; Jorgenson et al. 2015; Jorgenson et al. 2016; Jorgenson et al. 2017; Knight et al. 2017; McGee and Greiner 2018), research concerning the ways in which international inequality modifies such relationships has remained focused on operationalizations of world systems theory (Burns, Davis, and Kick 1997; Roberts, Grimes, & Manale 2003; Prew 2015; Greiner and McGee 2018), or on the use of trade imbalances and foreign direct investment in the international economy (Jorgenson 2007; Rice 2007; Jorgenson 2012; Prell and Sun 2015). The present study contributes to the existing literature on the effect of inequality in the international economy on emissions by exploring the ways in which a nation's colonial history modifies its relationship between economic development and emissions.

Using a random coefficients modeling approach and variance partition analysis, I examine how the time a nation spent under the rule of a colonial power affects the relationship between CO_2 emissions per capita and GDP per capita, as well as how much of the variation in national level emissions per capita is explainable by the time spent under colonial rule. Such an analysis provides a deeper insight into how international inequalities engendered by historical patterns of colonization meaningfully influence the ways that economic activity impacts environmental quality today. Additionally, I argue that determining the proportion of the variation in emissions that is accounted for by the amount of time a nation was colonized further clarifies the extent to which international patterns of unequal ecological exchange are a legacy of colonization that offer ongoing benefits to territories that colonized nations around the world, while hindering nations that were colonized as they attempt to achieve sustainability.

In order to properly understand the findings of the research presented here, I draw upon a number of theoretical traditions in the fields of environmental sociology and political economy. From environmental sociology I rely upon work in the tradition of environmental world systems, structural human ecology, and unequal ecological exchange theory to better understand how it is that international inequality often provides environmental advantages to some nations at the expense of others. Within political economy I draw heavily upon the work of those in the world systems and dependency theory traditions, as well as Marx, and W.E.B Dubois to explore the ways in which colonial relations of the past have been transformed into geopolitical advantages in the present. In doing so I will demonstrate that taking colonial legacies into account can present a relatively powerful and straightforward way to understand differences in the way that economic activity seems to relate to environmental impact in nations of the global South and global North. Finally, by employing a variance partition analysis I will demonstrate that, broadly speaking, mitigating cross-national inequality by providing a redress to the legacies of colonialism offers a path to reducing emissions that is just as critical as addressing economic growth, population size and location, and a population’s demographic structure.

Literature Review

Work concerning the effects of international inequalities and environmental impact has taken a variety of approaches over the last several decades, the most common of which, environmental world systems and unequal ecological exchange, shall be reviewed here. Attempts to develop frameworks which could both further our understanding of anthropogenic drivers of environmental degradation and while still considering the historical development of international inequalities in the global economy drew simultaneously from Impact literatures (Ehrlich & Holdren, 1972; Commoner, 1972), Dependency theory (Frank 1967), Unequal Exchange (Emmanuel 1972a), and World Systems theory (Wallerstein 1974). In doing so, such work paid particular attention to how the underdevelopment of economies within the global South would be oriented to extraction of natural resources and hyper-exploited labor, as well as environmentally intensive production. In what follows, I will briefly review the origins of this work. In doing so I will attempt to highlight the foundations of contemporary international inequality in colonial relations, as well as the import of considering such historical interactions when attempting to understand patterns of environmental impact.

Over the course of the second half of the twentieth century work in the field of political economy and development theory responded to the widely held international economic theory of comparative advantage, which claimed that a nation's role and position in international exchange regimes was, simply put, determined by its ability to produce and export a particular product cheaper than any other nation (Ricardo 1817; Mill 1821; Magee 1980). As a result of this process, according to adherents of this theory, all nations would be able to get all goods for the lowest possible cost, allowing all countries equal opportunity to thrive. It was largely from responses to this theory, ones which attempted to understand how the mechanisms underlying international trade served to transfer wealth, in the form of surplus value, from less powerful nations (typically those within the global South) to more powerful ones (e.g. nations in the global North), that much of the contemporary understanding of inequality in the international economy was derived. In the broadest sense, it can be said that the critiques of development theory and comparative advantage in this period developed into three distinct, yet interrelated traditions: Dependency theory (Frank 1967), Unequal Exchange (Emmanuel 1972a), and World Systems theory (Wallerstein 1974).

Here, I highlight that these three academic traditions attend to the development of a hierarchical international system of exchange, wherein *historical interactions of colonialism and imperialism* have led to a subset of nation-states being placed in an advantageous position in relations of exchange and production in relation to others. For example, unequal exchange theory (Emmanuel 1972a; Chase-Dunn and Grimes 1995; Jorgenson 2009) has noted that wages in the global South have been artificially restrained via the use of military force, and, more recently, political and economic pressures from international bodies such as the World Bank and the International Monetary Fund in the form of Structural Adjustment Policies (Harvey 2003; 2005). Through this wage suppression, nations of the global North are able to extract surplus value from nations of the global South in the international marketplace, as the wages of consumers in the global North allow products to be sold for a much greater price than they could be otherwise, even as the share of variable capital involved in the production process is kept at a minimum (Emmanuel 1972a). Similarly, dependency theory (Frank 1967) argues that the ability of certain nation states to control networks of trade relations through military and political pressure places them in a position of power in negotiations with other nation states. By leveraging this power these nations are able to dictate many of the terms of production in other nations in order to make them more favorable for the multinational corporations whose economic interests are viewed as most closely aligned with their own (Pomerantz 2000). Often, if not always, such relationships hinder the development of the disadvantaged nations, leading them to invest in infrastructures and technologies that make it ever more difficult for them to seek alternative, more beneficial, trade relations (Chase-Dunn 1998). Thus, this form of path dependency has been termed "the development of underdevelopment" (Frank 1967).

Finally, world systems theory, as it was developed by Wallerstein (1974), argued that there was a more or less formal hierarchy of nation-state groups: the core, semi-periphery and periphery. Placement of these nations into their respective groupings determined their ability to exploit other nations in international trade, or, alternatively, the likelihood that they would be exploited. Thus, according to this schema, core nations were able to mobilize political and military advantages in the world system in order to manipulate the development process of nations in the semi-periphery and periphery, thereby rendering such nations vulnerable to exploitation via trade. Here, semi-periphery nations are distinct from nations in the periphery and the core in that, even as they are exploited by the core, they are able to exploit the periphery. Wallerstein notes that it was during the expansion and relative solidification of the modern world system that nations fell into their respective roles of core, semi-periphery, and periphery nations.
Specifically, drawing from Marx (1976), Lenin (1999), and Luxembourg (2004)

Wallerstein (2007) notes that it was the need to incorporate additional sources of labor and resources into the international capitalist economy that led more established capitalist nation states to seek out and colonize other territories. In doing so, colonial powers established colonies, and ensured that “the colonial state was the weakest in the interstate system, with the lowest degree of autonomy, and therefore maximally subject to exploitation by firms and persons from a different country, the so-called metropolitan country” (Wallerstein 2007, p 56).

While work in these literatures were incredibly beneficial to developing a greater understanding of international trade, development, and inequality, such traditions largely ignored how these relations might affect the way that nations development processes impact environmental goods and resources. In particular, while Marx himself was concerned with the socio-environmental relations that international patterns of capital accumulation brought about (Foster 1999; Foster, Clark and York 2010), it was not until the development of the new ecological paradigm (NEP) (Catton and Dunlap 1978a; 1978b) that considerations of the environment began to be taken seriously within sociology and development theory. However, following the identification of human exceptionalism within much of sociology, work concerning the relationship between development, international inequality, and environmental impact began to develop rapidly.

One of the first works in this tradition was Bunker’s (1984) classic piece concerning unequal ecological exchange and modes of extraction. Bunker contended that a critical, and all too often overlooked aspect of development theories was the limitation that the orientation of technologies, infrastructures, and labor toward the extraction of resources and energy by colonial powers placed on the development opportunities of nations in the global South. As Bunker noted, a strict reliance on the labor theory of value (Marx 1976) in order to determine the extent of exploitation that occurred through international exchange was ecologically naïve[1]. In particular, Bunker noted that, while the infrastructure and populations that developed around productive economic activities tended to contribute to later development– assuming of course that outmoded technologies and infrastructures where able to be replaced by newer ones, which they often are not in the periphery and semi-periphery of the capitalist world system (Bond and Downey 2012)– organizing populations, technologies and infrastructures around extractive activities tends to reduce opportunities for future development, as the resource they are in place to extract is diminished with time. Importantly, this implied that it is only with an appreciation for the historical legacy of a nation's economic development that its current patterns of development, and in particular the relationship between its economic development and environmental health, could be properly understood. The introduction of colonial relations to many territories in the global South "established a locally dominant class which created a mode of extraction and so exploited both labor and nature that neither could reproduce itself as rapidly as it was being appropriated… the rates of exchange for the resulting exports were so unequal that the cycles of extraction and trade ultimately impoverished not only the physical and human environments but also the dominant classes that depended on them" (Bunker 1984, p. 1024).

[1] Bunker (2007) later acknowledged that Marx had indeed reckoned with many of these principles in the course of discussing capitalism's rift with the natural metabolic processes of the earth (Foster 1999), and that a failure to incorporated ecological factors into understandings of unequal exchange was not, per se, a failure of the Marxist framework, but rather an under interrogated arena of development theory.

Lenski and Nolan (1984; 1985) sought to explore the importance of historical activities to contemporary patterns of development from an ecological-evolutionary theory perspective. Their analysis explored whether nations of the global South had greater economic success in the contemporary era (e.g. the 1970s and 1980s) if they had adopted plow or hoe/digging stick agricultural traditions. Recognizing critiques of ecological evolutionary theory as technologically determinist and naïve with respect to international power relations, Lenksi and Nolan explored the effect of agricultural technology in light of both world system position and colonial legacies. However, due to data limitations at the time, they were only able to measure such factors indirectly (Ziltener, Kunzler, and Walter 2017). Thus, colonial legacy was incorporated into Lenski & Nolan's analysis by limiting the exploration of the relationship between premodern agricultural tradition and contemporary development to nations that had attained independence from colonial powers following 1940. While such a procedure is reasonable, as the task of Lenski and Nolan was to determine the effectiveness of agricultural tradition as a predictor of developmental success *among* nations that had been colonized, their analysis failed to consider how difference in colonial legacy might *itself* serve as a predictor of contemporary patterns of development.

Further consideration of the effect that historical and contemporary international inequality has on the relationship between economic and social development patterns and environmental impact during this period was derived from developments within the impact literature. The most famous formulation of environmental impact, IPAT (Impact= Population*Affluence*Technology) (Ehrlich & Holdren, 1972; Commoner, 1972) was, itself steeped in controversy regarding the importance of inequality in the formulation.

With Ehrlich (1971) and colleagues taking the stance that the most notable anthropogenic driver of environmental degradation was population, while Commoner (1971) highlighted the fact that population was only truly meaningful in the context of affluence and technology[2]. It was with an eye towards these debates that the subsequently developed STIRPAT (Dietz and Rosa 1997) (stochastic impact by regression on population, affluence, and technology) formulation was created.

From its inception, STIRPAT analysis was enmeshed in the debate over the existence of the Environmental Kuznets Curve (EKC) (Grossman and Krueger 1991; Panayotou 1992). The debate over the EKC can perhaps best be understood as a debate over the role of economic development in the STIRPAT formulation. Namely, proponents of the EKC argue that given sufficient economic development, further economic growth will reduce anthropogenic environmental impact (Dinda 2004). However, scholars within Marxian (Lynch 2016), environmental world systems (Roberts and Grimes 1997; Roberts, Grimes and Manale 2003; Prew 2015; Greiner and McGee 2018) and unequal ecological exchange traditions (Jorgenson 2006; Jorgesnon & Clark 2009) argue that the observation of an EKC is not evidence of nations developing in ways that reduce the relationship between affluence and the environment. Rather it is the result of wealthy, militarily powerful nations becoming more environmentally benign, while nations belonging to the global South tend to worsen with respect to this relationship. For example, Roberts and Grimes (1997) and Greiner and McGee (2018) have demonstrated that belonging to a particular stratum of the world system tends to predict the relationship

[2] Importantly, Ehrlich later came to acknowledge that inequality is a critical factor driving anthropogenic impact: “population growth, along with overconsumption per capita, is driving civilization over the edge: billions of people are now hungry or micronutrient malnourished, and climate disruption is killing people” (Carrington 2018)

between economic development and CO_2 emissions within a nation, and, further, that it is only in nations of the global core that anything resembling an EKC is observed.

Lynch (2016) in an insightful theoretical critique of the EKC notes that many of the patterns of the EKC literature can be explained through a Marxist understanding of the global production chain. Following the logic of Emmanuel (1972), Lynch observes that the globally mobile nature of capital will result in the placement of new production facilities in locations where the costs of labor and environmental resources are lowest. In doing so capital creates a situation where the potential for surplus value creation is greatest and the requirements for investment are lowest, providing an opportunity to minimize both the variable and fixed components of capital. This link between the EKC and the reduction of the forms of capital is important, since, as noted above, to a great degree it is colonial legacies that are responsible for the suppression of wages and the ongoing exploitation of environmental resources in the global South.

Though it is empirically beyond the scope of the analyses presented here, theoretically it is important to note that, to no small degree, Marxist analyses have revealed that consideration of the legacy of colonialism and imperialism is not only foundational to understanding the impact, development, inequality relation, but is fundamental to understanding the function of capital itself. According to Marx,

> "the treatment of the indigenous population was, of course, at its most frightful in plantation colonies set up exclusively for export trade, such as the West Indies, and in rich and populated countries, such as Mexico and India, that were given over to plunder…The colonies provided a market for the budding manufactures, and a vast increase in accumulation which was guaranteed by monopoly of the market… the treasures captured outside Europe by undisguised looting, enslavement and murder flowed back to the mother-country and were turned into capital there" (Marx 1976, p 917-918).

Thus, the foundations for contemporary capitalism rest in primitive accumulation via dispossession, and the establishment of markets for the production and export of inexpensive goods and resources from colonies to imperial centers.

Further, the foundations of the modern global economy, and the socio-environmental relations that define it, in the colonial expansion of marketplaces was not a matter of historical happenstance. Such processes of ongoing expropriation are necessary if processes of accumulation are to proceed. Thus, to theoretically relegate the act of expropriation to a 'primary' moment which predates the development of the modern world system is to ignore the unique access the nations of the global North have had, and continue to have, to international pools of resources and labor in the course of their development (Pomerantz 2000; Fraser 2016).

> "Since capitalist production can only fully develop with complete access to all territories and climes, it can no more confine itself to the natural resources and productive forces of the temperate zone than it can manage with white labour alone. Capital needs other races to exploit territories where the white man cannot work. It must be able to mobilise world labour power without restriction in order to utilise all productive forces of the globe—up to the limits imposed by a system of producing surplus value" (Luxemburg, 2004, pp. 342-343).

Luxembourg's (2004) insight into the necessity of the expansion of capital in the colonial era belies an important truth of capital, that was only fleshed out by Du Bois (1920) some years later. Inequality is not only necessary to the origins, function, and expansion of capital, as others have noted (Emmanuel 1972a; Amin 1974; 2013; Pomerantz 2000), but from the inception of the socio-metabolic formation of capital, inequality– both nationally and internationally– has been operationalized racially. The project of accumulation through colonization, as well as the maintenance of international inequality and environmental exploitation through military power and the use of supranational institutions (Downey 2015), has served to intertwine the progress of capital and the establishment of a racial hierarchy on a global scale. The project of imperialism created an ongoing opportunity for "exploitation on an immense scale for inordinate profit, not just to the very rich, but to the middle class and to the laborers. This chance lies in the exploitation of darker peoples…in these dark lands 'industrial development' may repeat in exaggerated form every horror of the industrial history of Europe, from slavery and rape to disease and maiming, with only one test of success- dividends!" (Du Bois 1920, p 55).

Indeed, racial capitalism (Robinson 2000), takes as its central argument the Du Boisian notion that racism was one of the foundational logics underlying the establishment and expansion of capital (Dawson 2016; Fraser 2016). What's more racial capitalism calls on theoretical and empirical work to reckon with the implications of applying a logic of historical materialism to modern inequalities, noting that much of the contemporary phenomena that we hope to understand can only be grappled with by applying "greater attention to the processes that shaped the modern world, such as colonization, primitive accumulation, slavery, and imperialism" (Pulido 2017, pp. 3-4).

Hypotheses

Understanding the importance of colonial legacies to outcomes of environmental impact and national development, here I put forth a number of hypotheses. First, I hypothesize that the time a nation spent under colonial rule will be a significant predictor of the relationship between GDP per capita and CO_2 emissions per capita. Specifically, I argue nations that were colonized for longer periods of time will have been subjected to greater levels of underdevelopment, resulting in the establishment of labor practices, environmental resource extraction and protection practices, and infrastructural development patterns that result in an increasingly positive relationship between economic development and emissions. Second, following Greiner and McGee, I hypothesize that the majority of the variation in CO_2 emissions per capita will be explainable by across unit (e.g. country level) factors.

Data

Data for the present study was gather from a number of sources. As with the studies presented in the previous chapters data for year level variables on nation-state factors such as GDP per capita, CO_2 emissions per capita, urbanization, and the age structure of the population were gathered from the World Bank's (2015), World Development Indicators database. Data concerning the length of time that a nation was colonized for were drawn from The University of Zurich's Colonial Transformation Dataset (Ziltener, Kunzler, and Walter 2017) as well as Wimmer and Min's (2006) dataset concerning a territory's political and economic development, both before and after gaining independence.

The dependent variable in the current study is CO_2 emissions per capita from the burning of fossil fuels and the production of cement, measured in metric tons. The primary independent variables of interest are GDP per capita and the length of time spent under the rule of a colonial power. GDP per capita is measured in 2010 constant U.S. dollars, in order to account for well-established nonlinearity in the relationship between GDP per capita and CO_2 emissions per capita GDP per capita^2 is also included in every model except the Null Model. In addition to GDP per capita, all models except the Null Model include controls for the percent of the population living in Urban settlements, including a square term allowing urbanization to effect emissions non-linearly, and the proportion of the population that is of economically productive age (15-64 years old). Each of these variables has been found to be an important driver of CO_2 emissions in structural human ecology analyses (York et. al 2003; Liddle 2014). Descriptive statistics for level 1 variables can be viewed in Table 1.

Data regarding the length of time that a nation was colonized for were gathered from Colonial Transformation Dataset (Ziltener, Kunzler, and Walter 2017) and Wimmer and Min's (2006) dataset concerning the territory's political and economic development. The University of Zurich's Colonial Transformation Dataset provides information on the "impact of colonialism with 15 indicators" for the nations of Africa and Asia. Thus, the Colonial Transformation Dataset (Ziltener, Kunzler, and Walter 2017) was used to determine the length of time that a nation was colonized for in the continents of Asia and Africa, while Wimmer and Min's (2006) dataset was used to determine the length of time involved with colonial powers for nations outside of these continents. Importantly, while the data provided by Wimmer and Min (2006) provides information on a broad number of territories. Using Wimmer and Min's variable on the number of years that a nation was under the rule of an imperial power ("implag") I was able to code the time of colonization for a substantially larger number of nations. I have chosen to end observation for the length of colonization variable in the year 1960 in order to accommodate the assumption of this study that *historical* legacies of colonialism influence variables of interest in the contemporary era. Thus, ending the length of colonization variable in the year 1960 allows me to explore how the colonial legacy of a nation prior to 1960 moderates the relationship between GDP per capita and CO_2 emissions per capita in the years 1960 to 2013. It is important to note that, as this study is meant to capture the effect of a nation being subject to the rule of a foreign power, here I do not consider nations that seceded from others via civil war, or otherwise, to have been under the rule of colonial powers. Thus, for example, Germany is not considered to have been colonized by Austria, and– though in many ways they undoubtedly share the characteristics of colonized states– nations of the former USSR are not considered to have been colonized either. Additionally, following the work of Emmanuel (1972b), I do not consider settler colonial states, such as the United States, Australia, and Canada, to have been colonized, as the unique circumstances of these nations typically led them to benefit from colonial processes, rather than being hindered by them[3]. Such a decision is also in line with work concerning colonization and racial capitalism (Robinson 2000), where it is noted that colonization can best be understood as a process through which an international racialized hierarchy was established that allowed for the ongoing accumulation of capital in nations of the global North.

In the interest of making the results presented here easily comparable with other work done in the world systems and environmental world systems traditions (Clark and Beckfield 2009; Clark 2012; Greiner and McGee 2018), the length of colonization

[3] In some instances, nations which were classified as colonized might be considered problematic. For example, China and Japan were never colonized, per se, but were exposed to unequal treaty agreements by colonial powers. Additionally, South Africa, though fitting the criteria of a settler colonial state in many ways, is included as a colonized nation due to the fact that for much of its history its political apparatus was controlled by an ethnic minority. In order to ensure that the inclusion of such nations was not skewing the results presented here, alternative models were run, where such cases were excluded. As there were no notable differences in the results those models are not presented here, though they are available upon request.

variable is constructed as a trichotomous indicator variable. Where nations have been placed into the categories of *never colonized, colonized between 1 and 75 years, and colonized 76 years or more*, where years is the 75th percentile of time spent under colonial rule, and 1 year is the 50th percentile. Descriptive statistics for GDP per capita and CO_2 emissions per capita conditioned upon the length of time that a nation was colonized for can be seen in Table 2. The list of nation's that fall within each length of colonization category can be found in Table 3, while Figure 1 displays a map depicting which nations belong to which length of colonization categories.

As is common with quantitative analyses in the STRIPAT and structural human ecology tradition, all variables in the study except for indicator variables were natural log transformed, making the coefficients presented in the models below elasticities. The result of this is that all coefficients below represent the percent change in CO_2 per capita associated with a 1 unit change in the independent variable (York et al., 2003b).

Table 3.1. Level 1 (time variant) Variable Descriptive Statistics

Variable Name	Mean	Median	SD	Minimum	Maximum
CO^2 Emissions Per Capita	4.115	1.538	6.262	0.008	67.452
GDP Per Capita	9,741	3,146	14,825	115	115,003
Percent Urban Population	3.735	3.870	0.648	0.767	4.605
Age Dependency	0.368	0.312	0.297	-0.190	1.812
Level 1 observations: N=7408					

Table 3.2. Length of Colonization Descriptive Statistics

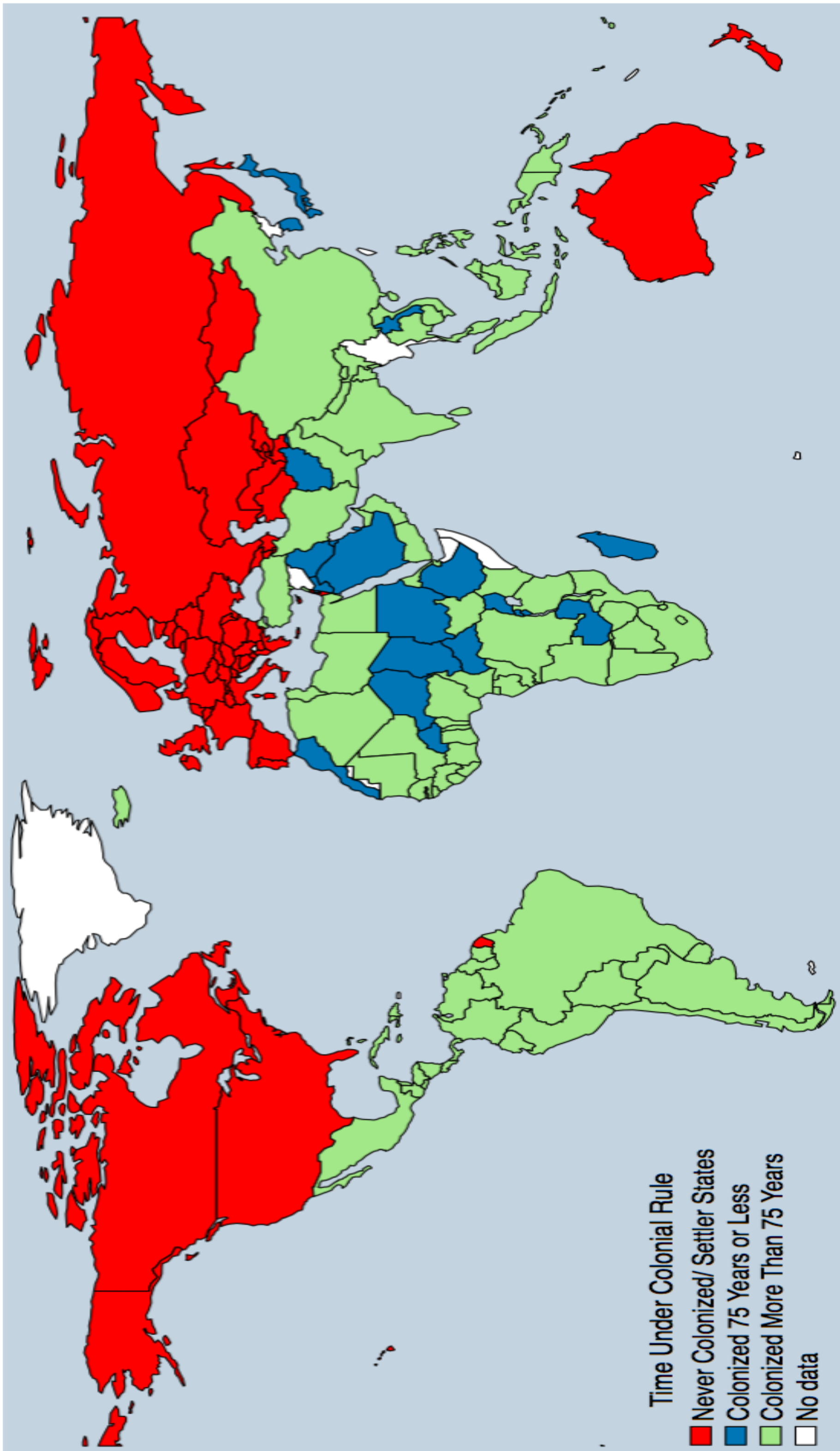
Descriptive Statistics	Never Colonized	Colonized 1 to 75 Years	Colonized 76 Years or More
Mean GDP Per Capita	23,041	5,722	5,236
Maximum GDP Per Capita	110,001	74,449	115,003
Minimum GDP Per Capita	365	105	115
Mean CO_2 Per Capita(t)	8.145	3.230	2.679
Maximum CO_2 Per Capita(t)	40.590	67.452	63.743
Minimum CO_2 Per Capita(t)	0.294	0.009	0.008
Groups (Countries)	54	24	105

Note: The maximum GDP value for nations colonized 76 years or more is attributable to the United Arab Emirates in the year 1980. The maximum GDP value for nations colonized 1 to 75 years is attributable to Qatar in the year 2011. The minimum GDP value for never colonized nations is attributable to Tajikistan in the year 1996.

Table 3.3 Length of Colonization Categories

Never Colonized/Settler State	Colonized up to 75 Years	Colonized 76 Years or More
Albania, Armenia, Australia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Canada, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Ireland, Israel, Italy, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Luxembourg, Macao SAR-China, Macedonia- FYR, Moldova, Mongolia, Montenegro, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Tajikistan, Tonga, Turkmenistan, Ukraine, United Kingdom, United States, Uzbekistan	Afghanistan, Burkina Faso, Burundi, Central African Republic, Chad, Ethiopia, Iraq, Japan, Jordan, Korea- Rep., Kuwait, Lao PDR, Madagascar, Maldives, Morocco, Niger, Qatar, Rwanda, Samoa, Saudi Arabia, Sudan, Uganda, West Bank and Gaza, Zambia	Algeria, Angola, Antigua and Barbuda, Argentina, Aruba, The Bahamas, Bahrain, Bangladesh, Barbados, Belize, Benin, Bhutan, Bolivia, Botswana, Brazil, Brunei Darussalam, Cabo Verde, Cambodia, Cameroon, Chile, China, Colombia, Comoros, Democratic Republic of Congo, Republic of Congo, Costa Rica, Cote d'Ivoire, Cuba, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Fiji, Gabon, Gambia, Ghana, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong SAR-China, Iceland, India, Indonesia, Iran, Jamaica, Kenya, Kiribati, Lebanon, Lesotho, Liberia, Libya, Malawi, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Micronesia, Mozambique, Namibia, Nepal, Nicaragua, Nigeria, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Singapore, Solomon Islands, South Africa, South Sudan, Sri Lanka, St. Lucia, St. Vincent and the Grenadines, Suriname, Swaziland, Tanzania, Thailand, Timor-Leste, Togo, Trinidad and Tobago, Tunisia, Turkey, United Arab Emirates, Uruguay, Vanuatu, Venezuela, Vietnam, Yemen, Zimbabwe

Figure 3.1. Length of Time Under Colonial Rule Groupings



Methods

As was the case in the previous chapters, all models included in the present analysis are hierarchical linear models. The models presented below are structured such that years are nested within nation-state groupings. While there are various other alternatives to modeling the present analyses that could have been employed, such as panel regressions with fixed effects estimators for both country and year, employing a hierarchical linear model allows for country and year specific factors to be controlled for, but also provides the opportunity to perform a variance partition analysis. With respect to the present research, developing a better understanding of the variance partition is critical, as it allows for one to determine the importance of various factors in the model to understanding changes in CO_2 emissions. Thus, by performing a random coefficients model I am able to explore the extent to which historical colonization plays a role in the current relationship between emissions per capita and GDP per capita.

The models presented below have been designed in order to examine the effects of drivers of CO_2 emissions per capita that are understood to be of theoretical and empirical import, while also accounting for the effect of historical legacies of colonialism on the relationship between GDP per capita, perhaps the most well studied of all drivers of anthropogenic emissions, and CO_2 emissions per capita. Considering this, the null model is included as a means to interrogate the distribution of the variance in CO_2 emissions per capita between level 1, or those factors which vary year to year, and level 2, those factors which vary across nations and are more historical in nature. Model 1 includes variables which are commonly understood to be drivers of CO_2 emissions per capita in structural human ecology, such as GDP per capita, urbanization, and the age structure of a population. In doing so, model 1 allows us to explore the proportion of the total variation in emissions that is explainable by such factors. Model 2 builds upon model 1 by including the indicator variables for the length of time that a nation spent under the rule of a colonial power. As with Model 1, including the length of colonization variables in model 2 allows for the proportion of variance that is explainable by such factors to be discovered while also controlling for all other measurable and theoretically relevant variables. The Null Model, and Models 1 and 2 are random intercepts models with structured covariance, which is necessary in order to be able to meaningfully explore variance partition coefficients. Unlike the Null Model, Model 1, and Model 2,

Model 3 is intended to explore the moderating effect that the length of time a nation was colonized for has on the relationship between GDP per capita and CO_2 emissions per capita. Exploring the moderating effect that the length of time spent under the rule of a colonial power has on this relationship requires an interaction between a level two variable, length of time under colonial rule, and a level one variable, GDP per capita. Such an interaction necessitates that the variance covariance matrix be unstructured. While unstructured covariance greatly increases the complexity of the model, and thus also increases the difficulty involved in interpreting the model, it provides another opportunity for additional analysis as well. In particular, the use of an unstructured covariance matrix allows for exploration into whether or not there is a tendency for nations' relationships between GDP per capita and CO_2 per capita to become more, or less, similar as GDP per capita increases. Such an analysis is greatly important to the study at hand, as it allows for an empirical investigation of the validity of the modernization development hypotheses that many contemporary sustainable development goals and plans rest upon. Namely, it allows for a test of the validity of the claim that as nation's grow their economies they will become more, and not less, alike in their ability and desire to protect the environment from anthropogenic degradation. Finally, it is important to note that the nature of the processes that underlie GDP per capita and CO_2 emissions per capita is such that the value of these variables in each year is typically highly correlated to years immediately following and preceding them. This implicit correlation can potentially bias standard errors, leading to overconfidence in estimates and the erroneous appearance of statistical significance. In order to address this issue, model 3 corrects for autoregressive 1 disturbances, correcting for heteroskedastic and contemporaneously correlated residuals (Beck and Katz 1995).

The general structure of the random coefficients model with unstructured covariance and all fixed and random effects variables included is as follows:

Micro Model- $CO_{2it} = \beta_{0i}(x_{0it}) + \beta_{1i}(GDPPC_{it}) + \beta_{2i}(GDPPC_{it}^2) + \beta_{12}(urban_{it}) + \beta_{13}(urban_{it}^2) + \beta_{14}(dependency_{it}) + e_{0it}$

Macro Model- $\beta_{0i} = \beta_0 + \beta_3(Col1To75years_i) + \beta_4(Col > 75years_i) + \beta_5(NoCol_i) + \mu_{0i}$

$\beta_{1i} = \beta_1 + \beta_6(Col1To75years_i) + \beta_7(Col > 75years_i) + \beta_8(NoCol_i) + \mu_{1i}$

$\beta_{2i} = \beta_2 + \beta_9(Col1To75years_i) + \beta_{10}(Col > 75years_i) + \beta_{11}(NoCol_i) + \mu_{2i}$

level 2: $\begin{bmatrix} \mu_{oi} \\ \mu_{1i} \\ \mu_{2i} \end{bmatrix} \sim N\left(0, \begin{bmatrix} \sigma_{u0}^2 & & \\ \sigma_{u0u1}^2 & \sigma_{u1}^2 & \\ \sigma_{u0u2}^2 & \sigma_{u1u2}^2 & \sigma_{u2}^2 \end{bmatrix}\right.$

Level 1: $e_{0it} \sim N(0, \sigma^2_{e0})$

Where CO_{2it} represents the log of per capita carbon dioxide emissions of the *i*th nation in year *t*; $GDPPC_{it}$ is the logged value of nation *i's* GDP per capita in time period *t*;

$GDPPC_{it}^2$ is the log of the quadratic term for country *i* in year *t*; $Col > 75years_i$ is the binary measurement of being colonized for more than 75 years for nation *i*; $Col1To75years_i$ is the binary measurement of having been colonized between 1 and 75 years for nation *i; $NoCol_i$* is the binary measurement of the of never colonized nation *i*; $urban_{it}$ is the log of the percent of the population living in urban areas in nation *i* during year *t*. $urban_{it}^2$ is the quadratic term for the log of urban population percentage; $dependency_{it}$ is the value of the age dependency ratio for nation *i* in year *t*; e_{0it} is the residual difference in CO_2 emissions per capita for the *i*th country in year *t; μ_{0i}* is the residual differential CO_2 emissions per capita value for country *i* when all predictor variables are held at 0; μ_{1i} is the residual difference in CO_2 emissions per capita change for nation *i* for every additional 1 unit increase in GDP per capita; μ_{2i} is the residual difference in CO_2 emissions per capita change for nation *i* for every additional 1 unit increase in GDP per capita squared; σ_{u0}^2 represents the between nation variance in CO_2 emissions per capita (in models 3 and 4 this is only true at the intercept); σ_{u1}^2 is the between nation variance in CO_2 emissions per capita change for every 1 unit increase in GDP per capita; σ_{u2}^2 is the between nation variance in CO_2 emission per capita for every additional increase in GDP per capita squared; σ_{u0u1}^2 is the country level estimate of the covariance between nation's value of CO_2 emissions per capita at the intercept and their relationship between CO_2 emissions per capita and GDP per capita; and σ_{u0u2}^2 is the country level estimate of the covariance between nation's value of CO_2 emissions per capita at the intercept and their relationship between CO_2 emissions per capita and GDP per capita squared

Results

Results from the Null Model and Models 1-3 are presented below in Table 4. Investigation of the variance partition coefficients reported in the Null Model roughly indicates the proportion of variance that is explainable across units (e.g. at the country level), or within units (e.g. at the year level), when no variables of theoretical interest are considered. Results from the Null Model suggest that 89% of the variation in CO_2 emissions per capita is explainable at the cross-unit level (VPC=$\frac{\sigma_{uo}^2}{\sigma_{uo}^2+\sigma_{eo}^2}$). Model 1 incorporates within-unit factors that are commonly included in SHE analyses, in doing so it allows for an opportunity to explore the partition of variance when factors that are broadly understood to be important drivers of CO_2 emissions per capita are included. Model 1 indicates that there is a non-monotonic relationship between GDP per capita and CO_2 emissions per capita, where, as suggested by the EKC hypothesis the effect of GDP per capita is attenuated at higher levels of GDP per capita. Model 1 also indicates that urbanization is a positive of emissions. Variance partition analysis of Model 1 indicates that when level 1 variables of interest are included, 80% of variation on emissions per capita is explainable at the across-unit level (level 2).

Model 2 includes all variables of interest, including indicator variables for the time a nation spent under colonial rule. As with Model 1, Model 2 results are suggestive of a pattern in the relationship between economic activity and emissions that approaches an EKC, and points to the importance of urbanization as a driver of CO_2 emissions per capita. As is the case with the Null model and Model 1, Model 2 indicates that the majority of the variation in CO_2 emissions per capita is explainable at the country level (78%). Comparison of Model 1 and Model 2 allows for an exploration of the amount of variation that appears to be explainable by the inclusion of the colonial history variables.

Such an analysis demonstrates that roughly 12% of the level 2 variation in Model 1 is accounted for by the inclusion of variables for the time a nation spent under the rule of a colonial power in model 2 ($\frac{\sigma_{\mu}^{2^1} - \sigma_{\mu}^{2^2}}{\sigma_{\mu}^{2^1}} = \frac{0.453 - 0.399}{0.453} = 0.119$).

Model 4 uses cross-level interaction terms in order to allow for an examination of the moderating effect that the time a nation spent under the rule of a colonial power has on the relationship between GDP per capita and CO_2 emissions per capita. Results from Model 4 are displayed graphically in Figure 2. According to Model 4 findings, nations that have never been colonized do display a relationship between emissions and growth that attenuates at higher levels of economic development. However, this relationship does not hold for any nation that has been colonized. According to Model 4, nations colonized between 1 and 75 years have the most environmentally intensive relationship between GDP per capita and CO_2 emissions per capita. As can be seen in Figure 2, nations colonized between 1 and 75 years display a relationship between emissions and growth that is geometric, becoming increasingly positive as GDP per capita increases. Nations colonized for more than 75 years display a continuously positive relationship between GDP per capita and CO_2 emissions per capita. It is important to note that the difference between nations that have been colonized for more than 75 years, and nations that were colonized between 1 and 75 years is, substantively, rather small.

Taken together, these findings provide clear support for the hypothesis that the majority of the variation in CO_2 emissions per capita is explainable by across unit, historical factors. The findings provide limited support for the hypothesis that the longer a nation is colonized the greater it's relationship between emissions and economic development will be. While it is clear the being having been colonized is associated with an increase in this relationship, nations colonized between 1 and 75 years display a more environmentally intensive relationship than those colonized for more than 75 years. This could suggest that other factors related to colonial legacies, such as the extractive logic of the colonizing nation, or the level of violence experienced within the colonies, themselves act as important predictors of this relationship (Ziltener, Kunzler, and Walter 2017). Perhaps the greatest insight that can be gained from the results presented in Table 4 and Figure 2 is that having been colonized appears to be associated with having a continuously positive relationship between GDP per capita and CO_2 emissions per capita, while having never been colonized tends to be associated with a relationship between growth and emissions that attenuates as GDP per capita increases. Further, the colonial history variables account for 9.2% of all variation in CO_2 emissions per capita, suggesting that colonial histories are an important aspect of contemporary CO_2 emissions, and are an important consideration in analyses concerned with these issues.

Table 3.4. Random Coefficients Models of Drivers of CO_2 Emissions
(All Variables are Logged)

Variable	Null Model	Model 1	Model 2	Model 3
Time (Level 1) Variables				
GDPPC	–	1.704*** (.067)	1.703*** (.067)	1.766*** (.540)
$GDPPC^2$	–	-0.060 *** (.004)	-0.060*** (.004)	-0.077* (.031)
Urban Population	–	0.491*** (.083)	0.495*** (.083)	1.160*** (.286)
Urban $Population^2$	–	0.021 (.014)	0.020 (.014)	-0.075 (.045)
Age Dependency Ratio	–	0.051 (.033)	0.054 (.033)	0.144 (.097)
Country (Level 2) Variables				
Colonized 75 Years or Less	–	–	-0.646*** (.157)	4.867 (3.271)
Colonized 76 Years or More	–	–	-0.471*** (.107)	3.127 (2.752)
Never Colonized (Reference)	–	–	–	–
Cross-Level Interaction Variables				
Never Colonized x GDPPC (Reference)	–	–	–	–
Never Colonized x $GDPPC^2$ (Reference)	–	–	–	–
Colonized 75 Years or Less x GDPPC	–	–	–	-1.809* (.786)
Colonized 75 Years or Less x $GDPPC^2$	–	–	–	0.132** (.047)
Colonized 76 Years or More x GDPPC	–	–	–	-1.252 (.643)
Colonized 76 Years or More x $GDPPC^2$	–	–	–	0.094* (.038)
Constant	0.370	-11.564	-11.179	-11.537
Variance Terms				
σ^2_{eo} (Year level)	0.343	0.114	0.114	0.238
σ^2_{uo} (Country level)	2.794	0.453	0.399	49.379
σ^2_{u1}	–	–	–	3.135
σ^2_{u2}	–	–	–	0.012
σ^2_{uou1}	–	–	–	-12.275
σ^2_{uou2}	–	–	–	0.724
Nations	202	183	183	183
Nation-Years	9431	7408	7408	7408

***** p<.001 ** p<.01 * p<.001**

Figure 3.2

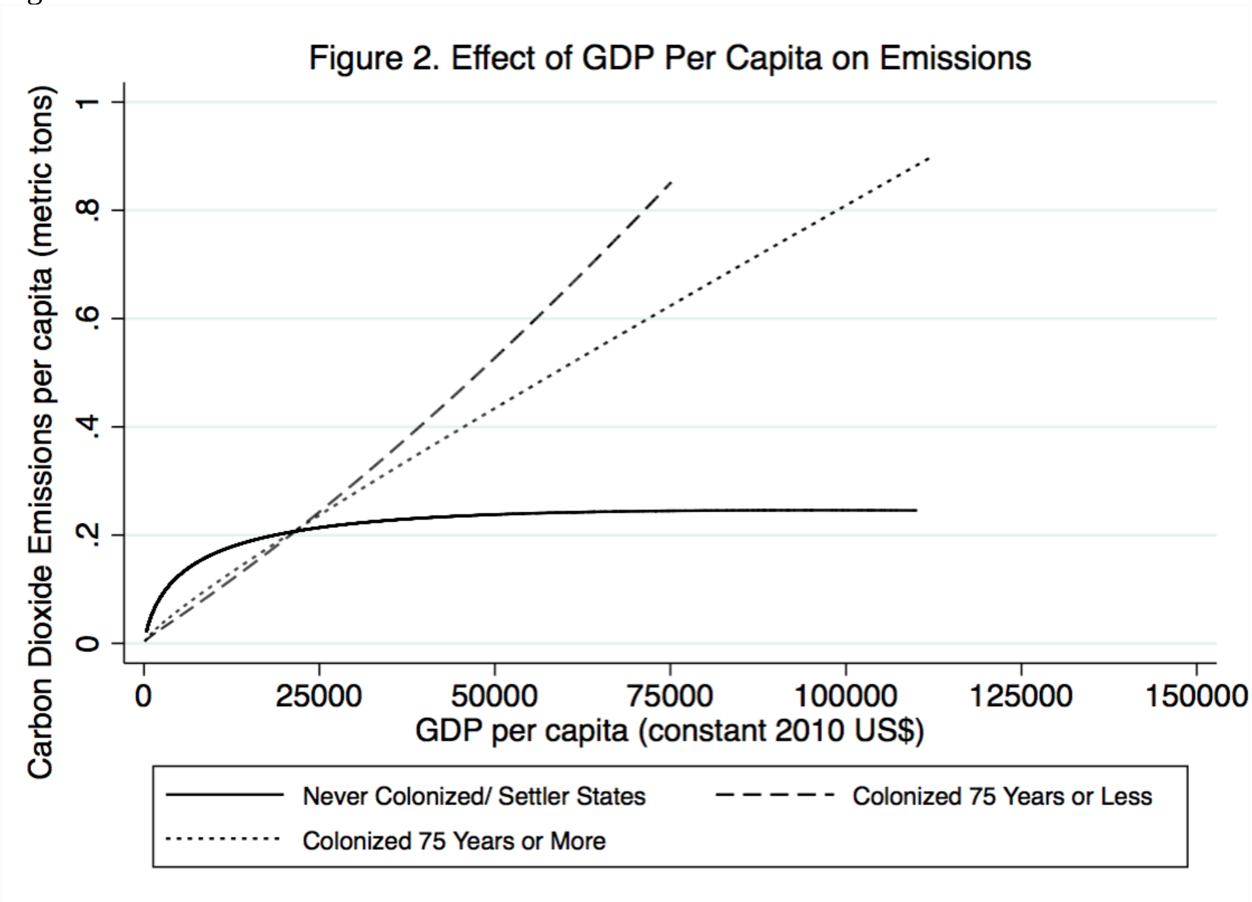


Figure 2. Effect of GDP Per Capita on Emissions
Carbon Dioxide Emissions per capita (metric tons)
0
.2
.4
.6
.8
1
0
25000
50000
75000
100000
125000
150000
GDP per capita (constant 2010 US$)
Never Colonized/ Settler States
Colonized 75 Years or Less
Colonized 75 Years or More

Discussion

Drawing from Marxian theory, unequal ecological exchange, and environmental world systems theory, the analysis presented above demonstrates the importance of colonial legacies to socio-environmental outcomes. The findings here support previous work (Roberts and Grimes 1997; Roberts, Grimes and Manale 2003; Greiner and McGee 2018) which has focused on understanding the relationship between international inequality and socio-environmental outcomes by arguing that there are developmental path dependencies in the relationship between environmental impact and economic development that are indelibly linked to the place that a nation has held within the international hierarchy of the global capitalist economy. By drawing attention to the underlying importance of colonization to understandings of contemporary inequality in the fields of unequal exchange, world systems theory, and their environmental counterparts, I have attempted to highlight the usefulness of considering colonial histories directly when attempting to understand links between international inequality and socio-environmental relations.

Empirically, the results presented above demonstrate the usefulness of using colonial history to operationalizing international inequality in several ways. First, the time a nation spent under colonial rule explains a sizable proportion of the variance in CO_2 emissions per capita. While GDP per capita, urbanization, and the percent of the population that is of working age combined account for roughly 23% of the variation in emissions, inclusion of categorical variables for the length of time a nation was colonized accounts for 9% of such variation. This suggests that the time a nation spent under colonial rule is at least as important to understanding what social factors drive anthropogenic emissions as variables that are widely accepted as being integral to such outcomes (IPCC 2014). Second, while there have been a number of operationalizations of inequality in the international economy, chapter 2 demonstrated that two of the most popular world systems measures of inequality, those of Clark and Beckfield (2009) and Snyder and Kick (1979), explain roughly 3%, and 5% of variation in emissions per capita, respectively. Relative to such findings, the length of time a nation was colonized for seems to more effectively capture differences in environmental impact, at least when impact is operationalized as CO_2 emissions per capita. It should, however, be noted that since the models presented here and those presented in chapter 2 (Greiner and McGee 2018) do not include the same nation-years they cannot be formally compared. Finally, use of the colonization variables has allowed for a much broader set of nations and years to be incorporated into this analysis than were able to be included in chapter 2 (Greiner and McGee 2018), or in similar analyses of the past (Roberts and Grimes 1997; Roberts, Grimes and Manale 2003).

Theoretically, these results are supportive of the notion that colonial legacies established ongoing relationships of production, extraction, and exchange that disadvantaged nations of the global South (Bunker 1984; Barbosa 1993), making it difficult for them to grow their economies while simultaneously protecting their environment, yet facilitating such a phenomenon for nations of the global North. Further in demonstrating the importance of colonial legacies to environmental outcomes, the findings presented here support the claim that colonization and imperial relations were not just projects to control economic resources and international labor (Frank 1967, Emmauel 1972, Amin 1974), but were also the foundations for an ongoing ecological imperialism (Foster, Clark and York 2010). Specifically, the findings presented above support the claim that the legacy of colonization allowed more powerful nations to maintain control over the exchange and production of economic goods in ways which are "central to the forces of competition and accumulation of capital and… [that generate] social and environmental inequalities within and between nations" (Foster, Clark and York 2010, p.346).

Thus, centuries ago the global project of colonization "drew the conquerors down upon the conquered, because the conquered had the fertile lands, the needed materials, the arts of processing goods for human needs" (Du Bois 1995, p. 677). In many ways this project has been ongoing even as it has been continuously metamorphosed (Screpanti 2014). For while the project of colonization gave imperial powers initial control over international systems of monetary and financial exchange, technologies, natural resources, and labor, it was the very ability to control these factors of international exchange and production that enabled such nations to maintain relations of unequal exchange and exploitation in the contemporary era (Amin 2013; Foster Clark and York 2010).

As mentioned above, work concerning racial capital has argued that colonization was a project which was both necessary to the expansion of capital and racialized in nature (Du Bois 1920; Robinson 2000). Thus, colonization not only established an international hierarchy of nation-states but relied upon racial logics to do so. If such an proposition is taken seriously, as I argue it should be, it suggests that the establishment and continuation of unequal ecological exchange has served to benefit both the environment and the economies of historically white nations at the expense of the environment and economies in nations that people of color trace their ancestry to. Differences in cultural understandings of race make it problematic to explore the extent to which international legacies of colonization present an instance of environmental racism in an empirical sense. However, given the links between racial capitalism, colonization, and socio-environmental outcomes I encourage future research in this area to grapple with the notion of international environmental racism theoretically and historically.

Finally, I wish to note that, while this study has demonstrated the importance of considering whether or not a nation was colonized when attempting to understand the relationship between GDP per capita and CO_2 emissions per capita, it has also raised an important question. Namely, the lack of support for the hypothesis that nations colonized for a longer period of time would have a more strongly positive association with emissions indicates that other aspects of colonization might better explain the relationship between growth of GDP per capita and emissions per capita. Future research should aim to explore this possibility, interrogating how factors such as the colonizing nation and the extractive logic it employed impact the subsequent socio-environmental relations in the colonized state.

CHAPTER V.

CONCLUSION

A Dissertation in Review

At the start of this inquiry I highlighted a number of questions that are raised when one considers the complex relationship between economic development, international inequality, and environmental impact. It is my hope that through the course of the analyses presented above the answers have become clearer. In particular, through the examination of the relationship between the development of ecological rationality and environmental impact, as well as the inequality-environmental impact-international inequality complex, I have argued that the sustainable development concept, as it was put forth by the *Brundtland Commission* (UN 1987) and is expressed by supranational institutions today (World Bank 2012; UNEP 2017), contains a number of tensions that make it unlikely to be a successful model for the mitigation of anthropogenic climate change and the reduction of global inequality.

In order to elaborate on these tensions, in the introductory chapter I draw from a number of neo-Marxian theories of environmental impact and international inequality. Drawing from the dependency theory tradition I outline the difficulties inherent in achieving an inclusive sustainability, while simultaneously achieving an economically profitable sustainability. In doing so I highlight the fundamental importance of establishing a downward pressure on wages through trade liberalization and the implementation of structural adjustment policies to the continuation of profit accumulation, as well as how such pressures result in international inequality by way of unequal exchange (Emmanuel 1972a) and the stratification of income at the national level

(Kristal 2010; Picketty 2014). I then explore the compatibility of the goal of mitigating environmental impact with that of maintaining or expanding the rate of economic development through the lens of environmental sociology theories– such as the treadmill of production (Schnaiberg 1980), environmental world systems (Roberts and Grimes 1997), unequal ecological exchange (Bunker 1984), and impact literatures (York et al 2003a). Through this lens I draw attention to the inescapable necessity of environmental additions and withdrawals in systems of production, as well the tendency for the environmental and social costs of such processes to be disproportionately shouldered by populations within the global South. From this theoretical viewpoint, it becomes clear, I argue, that a sustainable development framework which prioritizes the continued accumulation of capital cannot also successfully conserve environmental resources or protect environmental sinks.

Ultimately, I note that despite the hopes that these tensions might be resolved through technology, when employed as a tool of accumulation technology is not able to successfully mitigate environmental change or reduce inequality. This is, in a broad sense, because technologies are used in order to expand the profit generating capabilities of the production process (Baran and Sweezy 1966), not to preserve environmental resources. As a result, increases in efficiency are often used in order to increase consumption to such a degree that the potential environmental benefit of the new technology is wiped out, as in the case of Jevons paradox (York and McGee 2015), or they are used in order to expand market penetration by using the new technologies in conjunction with–rather than in place of– older ones (York 2006; 2012). It is this same embeddedness in the logic of accumulation that prevents improvements in technological efficiency from reducing inequality, as these improvements are seen as opportunities to minimize the costs of labor, resulting in global wage stagnation (Foster, McChesney, and Jonna 2011).

In the end, I argue that it is misguided to believe that accumulation can be reconciled with environmental sustainability and the alleviation of global inequality, for the expropriation of resources on an ongoing and international scale by a minority of the world's population, and hence the generation of inequality, is necessary to both the establishment of capital and the expansion of its reach (Marx 1976; Rosa 2004; Pomerantz 2000). Further, I consider the work of DuBois (1920; 2007) and others in the racial capital tradition (Robinson 2000) in recognizing that, in order to fulfill the requirement of expropriation and inequality, capitalism has racialized various populations and in doing so contributed to the creation a social hierarchy that operated on a national and international level. Internationally, this racialized hierarchy has justified the expropriation of natural resources, but also of human labor in the form of enslavement, colonization, and unequal exchange (Dawson 2016; Fraser 2016). Understanding this, it becomes clear that accumulation is incompatible with the elimination of inequality within, but especially between, nations. What's more, such an understanding of the function of capital clarifies the need to consider the international hierarchy of the world system when attempting to elucidate the ability of economic growth to lead to the mitigation of climate change on a global scale, as well as the fact that– to a large degree– the roots of the contemporary international hierarchy of nations find their origin in colonization and imperialism. Thus, the colonial history of a nation offers a useful way to understand international inequality. It is with an eye towards these issues that I perform the analyses in chapters 3 and 4.

In chapter 2 I use data from the World Bank (2013) and studies previously performed by Snyder and Kick (1979), Clark and Beckfield (2009), and Clark (2012) to perform a growth curve analysis examining the effect that the temporal aspects of ecological rationality have on levels of CO_2 emissions per capita, while also accounting for geopolitical power. Put differently, I ask the question, are nations becoming more ecologically benign over time or less so, and is the relationship between time and pollution becoming more similar or diverging across nations as time progresses? In asking such questions I critically assess the validity of the claims of the ecological modernization school that difficult to measure social changes– such as the march of technology, the development of ecological concern among the population, and the establishment of environmental protection policies– will lead to an alleviation of the impact that social and economic processes have on the environment, even as economic growth continues unabated (Mol 1997; Mol 2002). I argue that, based on much of the logic laid forth in chapter 1, we should expect the less privileged nation-states that belong to the periphery and semi-periphery to both, 1) have less access to newer technologies (Amin 2013; Fröbel, Heinrichs, & Kreye 1981; Roberts & Grimes 1997; Roberts et al. 2003; Schoenberger 1988), and 2) be required to use such technologies in ways that are environmentally harmful in order to grow their economy, leading such nations to become less environmentally friendly over time.

The findings of chapter 2 suggest that, despite the belief that ecological rationality will– given time– lead to a reduction of the impact that socio-economic processes have on the environment, most nations in the world system do not see such a reduction in impact. Surprisingly, those that do see such reductions typically belong to the global periphery, challenging the notion that the least powerful nations will also be the least able to mobilize the temporal factors of ecological rationality in order to mitigate their impacts. Equally surprising, I find that it is the most powerful nations that see the greatest increase in environmental impact over time. In order to understand these results, I turn to the ecological paradoxes presented in chapter 1, arguing that, in the wealthier nations of the core, technological advancement and growth in ecological rationality are accompanied by expansions of consumption and production, leading to an overall increase in the impact of these nations. Contrariwise, in the poorer nations of the global South the introduction of new technologies by global capital increases the efficiency of the production of products within the internal marketplace, and growth in ecological concern reduces consumption and waste overall. Ultimately, I argue that these results demonstrate that ecological rationality cannot, on its own, lead to the mitigation of global climate change, and– absent any other meaningful change– will likely continue to increase the pace of environmental harm induced through social and economic processes. Finally, these results point to a clear divergence in the way that nations relate to the environment as time passes, suggesting that the global movement towards environmentally weightless societies is not occurring. Ultimately, these results reveal that a nation's position in the international economic hierarchy that constitutes the modern world system plays a large role in how it relates to the environment, suggesting that other aspects of socio-ecological relations should be explored in this context, a problem to which I turn in chapter 3.

In chapter 3, I turn my analysis towards the ability of a nation to employ gains in economic development in order to 'purchase' a more environmentally sustainable economy. Drawing from the environmental world systems theory, this exploration provides a critique of the EKC hypothesis as naïve with respect to issues of power in the international economy. Further, relying on the dependency tradition and unequal ecological exchange, I argue that, though a great deal of attention has been paid to temporally flexible drivers of climate change– such as the size of a nation's economy, or the location of its population– much of a nation's relationship between economic activity and impact can be explained by historical factors that vary across the globe. Of these historical factors, I argue that a nation's position in the world system in the past is of key importance in understanding its socio-ecological relations in the future. Using the data from chapter 2 I find that a nation's position in the world system at the time of the establishment of contemporary supranational institutions does significantly affect the relationship between CO_2 emissions per capita and economic development that a nation displays. Contrary to the logic put forth by the EKC hypothesis, the findings displayed here suggest that it is only the most powerful nations in the global economy that are able to reduce their environmental impact as their economies grow. Conversely, nations belonging to the semi-periphery see an increase in environmental impact as the size of their economies increase.

When these findings are considered in conjunction with the theory of unequal ecological exchange, it seems likely that, rather than using economic growth in order to invest in greater environmental efficiency, the global core uses economic gains and political power in order to export the environmental harm associated with the processes of accumulation to the semi-periphery. In this case, the EKC hypothesis is not just incorrect with respect to its assertion that economic growth provides the ability of a nation to invest in environmental goods regardless of that nation's power in the international economic system. The proposition of the EKC that *any* nation is able to mobilize economic expansion in order to 'purchase' environmental protection is incorrect as well. What is observed in empirical analyses that find and EKC pattern is not investment in the protection of environmental goods. Rather, what is being observed is investment in the expropriation and exploitation of the environmental goods of *other less powerful* nations. Beyond demonstrating the theoretical underdevelopment of the EKC, in chapter 3 I find that the vast majority of variation in CO_2 emissions per capita is attributable to factors such as the history of a nation-state, and not per se, in the size of its economy or the location and organization of its population. To be sure, factors such as economic growth impact emissions to a great degree, but the way in which they do so is predicated upon the historical development of a nation's economy, and in particular the role that its economy plays within the international division of labor, as Frank (1967), Emmanuel (1972a), and Bunker (1984) argued decades ago. I argue that this has important implications with respect to the sustainable development concept and the design and implementation of the policy based upon it, as it suggests that– to a notable degree– the focus of sustainable development policy on growing economies and changing population structures would be better aimed at correcting international legacies of inequality that have led to unequal ecological exchange and international exploitation in the contemporary era.

Interestingly, while the analysis presented in chapter 3 overwhelmingly confirms the notion that much of the current patterns in socio-ecological outcomes can be attributed to variation in the historical development of a nation state, it also indicates that a relatively small amount of these relations are accounted for by a nation's position in the world system following the establishment of the Bretton Woods institutions. This, to my mind, suggests that there could be other operationalizations of the historical legacy of inequality in the international economy that are more readily able to account for contemporary socio-ecological relations. Turning to Du Bois' (1920) discussions of the importance of colonization and imperialism to the establishment and maintenance of the capitalist world system, as well as the coupled insights of the racialized foundations of these global institutions and the necessity of ongoing expropriation by way of racialization that were developed in the racial capital tradition (Du Bois 2007; Robinson 2000; Pulido 2017), in chapter 4 I employ the length of time a nation was colonized for to measure inequality in the international system.

The analysis performed in chapter 4 relies on new data in order to explore the relationship between the extent to which international inequality patterns the relationship between economic growth and environmental impact. In order to measure the amount of time a nation was exposed to the rule of a colonial power I drew from the Colonial Transformation Dataset (Ziltener, Kunzler and Walter 2017) and data on the occurrence of war in the contemporary world (Wimmer and Min 2006). I argued that in many instances, the international inequality that is referred to in the theoretical traditions of unequal exchange and world systems is the result of the legacy of colonial relations in the past. As a result, expressly measuring aspects of colonization might better capture the effects of inequality in the current economy than attempting to develop an abstracted measure in order to capture the legacy of these relations indirectly, as operationalizations of world systems theory often do. Further, in chapter 4 I argue that, as work in the field of racial capital suggests, in order to properly understand contemporary patterns of inequity we must consider the establishment of a racialized global order in capital through the lens of historical materialism. Considering the inherent links between inequality, colonization, and racialization, measuring inequality via colonial legacies of the past offers an appropriate, albeit indirect, way to begin to incorporate considerations of racial capital into analyses of unequal ecological exchange.

The findings presented in chapter 4 demonstrate two important developments in this line of reasoning. First, the indicator 'time spent under colonial rule' does a better job of explaining socio-ecological outcomes than the two, well-known, measures of world system position used in chapter 3. This suggests, in a broad sense, that the ways that the systems of international inequality established in the colonial era advantage and disadvantage nations are more numerous and complex than what is captured by accounting for the amount of control a nation is able to leverage over its own trade networks, or the number of international treaty agreements it is party to. This, put simply, is likely to be unsurprising to most, as the function of the international economy is far more complex than can be adequately accounted for through the use of a handful of variables. Contrary to what one might expect, however, the use of additional variables to measure inequality in the international economy is not necessarily likely to improve the accuracy with which inequality is captured. In large part, this is due to the additional complexity of determining the extent to which each additional variable included in calculation of the world system, or global inequality, index contributes to the development of advantages and disadvantages in the international marketplace. For this reason I argue that parsimony is key, and while colonial legacies are also far from adequate when attempting to accurately portray the workings of international inequality, the origins of most aspects of inequality in these legacies makes it a rather good proxy for understanding where a nation stands.

Second, the findings in chapter 4 demonstrate that, while differences in the length of time a nation was colonized did not change the relationship between GDP per capita and CO_2 emissions per capita in a substantially meaningful way, whether or not a nation was colonized explains nearly 10% of the differences observed in emissions per capita between nations. This suggests that the historical fact of colonization is as important to understanding social drivers of climate change as any other factor that we have been able to observe save for, perhaps, advantages of geography. Further, in so far as colonization can be understood as a racialized project of international expropriation, this finding suggests that it is important to understand processes of unequal ecological exchange as an instance of environmental racism. Ultimately, I note that, while variation in cultural understandings of race make it difficult to examine this claim empirically, future work should consider these implications and strive to understand how it is that race, and other forms of inequality which contribute to the ongoing accumulation of capital internationally– such as gender inequality (Waring 1999; Norgaard & York 2005; Ergas and York 2012; Gaard 2015; Pellow 2014)– might be incorporated into discussions of international socio-ecological outcomes.

Lesson Learned and Parting Thoughts

At the beginning of this dissertation I noted that the analyses within were a sociological meditation on questions raised in the course of considering the environmental impact-economic growth-international inequality nexus. In the course of this meditation I believe that I have developed several insights which could be of use to the field of environmental sociology, as well as to policy makers and activists who are truly interested in mitigating the potentially devastating effects of climate change by curbing the CO_2 emissions of social and economic activity. First, in this dissertation I have highlighted the importance of understanding international inequality when exploring drivers of CO_2 emissions and, more broadly, environmental impact. Those familiar with theoretical traditions in environmental sociology will not be surprised by this insight. However, I have, in a variety of ways, demonstrated this importance empirically as well as theoretically. Specifically, the analyses in chapters 2, 3, and 4 have shown that, outside the context of international power relations, attempting to understand the ties between economic growth and environmental impact can be highly misleading, if not wholly incorrect.

Second, despite our wildest hopes to the contrary, we cannot expect incremental changes in social attitudes and technologies to resolve the problems of environmental depredation and international inequality. In the labor of creating a sustainable global society we can conceptualize the twin concerns of climate change and inequality as the heads of Orthus, each representing one dangerous face which exists in order to sustain the accumulation of capital, but in this analogy ecological rationality is no Hercules. Our hero must be bolder and dig deeper. Whatever form our Hercules ultimately takes, it must reckon with the fact that in order to eliminate the dangers presented by Orthus' heads, it must also allow Orthus' body to perish. Thus, though there are no social laws which dictate what is possible and what is not, as we might find in the realms of physics or chemistry, it seems incredibly unlikely that we will create an equitable and environmentally sustainable social system without also radically transforming the social and economic relations that currently structure the function of our globalized society.

Third, contemporary international inequality cannot be disentangled from the legacies of colonization and imperialism that the modern world system was constructed upon. The patterns of domination, expropriation, and exploitation that were established in the colonial era are inextricably linked to unequal exchange in the present day, as well as the environmental devastation that accompanies such trade imbalances. When we allow ourselves to consider these links, it becomes clear that the problem of the twentieth century– the color-line– (Du Bois 2003) is the problem of the twenty-first century as well, as it is impossible to fully understand the environmental crisis and the development of international inequality without it. Importantly, this suggests that the remediation of climate change and runaway inequality should begin with a consideration of the massive amounts of debt, pollution, and resource extraction that has been concentrated in the nations of the global South as a result of colonization, as well as potential ways to remedy these historical injustices.

Finally, the sustainable development concept is, put bluntly, unattainable as it is currently conceived. The tensions within this important idea are simply too great to be resolved. So long as development is understood as economic growth, its incorporation in sustainable development policy approaches will prevent the achievement of environmental sustainability and international equity. Considering this, I argue that we should not be concerned with sustainable development, so much as with the social development of sustainability. When we focus on the development of sustainability, as opposed to the achievement of sustainable development, it allows us to deprioritize accumulation, and in doing so to reconsider the relation of nation-states to one another and their environments. It is only by doing this, that global social sustainability can be developed.

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