Examining a Sustainable Approach to Global Climate Change Policy

by

Susan Spierre Clark

A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Approved April 2013 by the
Graduate Supervisory Committee:

Thomas Seager, Chair
Sonja Klinsky
Braden Allenby

ARIZONA STATE UNIVERSITY

May 2013

ABSTRACT

The United Nation's Framework Convention on Climate Change (UNFCCC) recognizes *development* as a priority for carbon dioxide (CO_2) allocation, under its principle of "common but differentiated responsibilities". This was codified in the Kyoto Protocol, which exempt developing nations from binding emission reduction targets. Additionally, they could be the recipients of financed sustainable development projects in exchange for emission reduction credits that the developed nations could use to comply with emission targets. Due to ineffective results, post-Kyoto policy discussions indicate a transition towards mitigation commitments from major developed and developing emitters, likely supplemented by market-based mechanisms to reduce mitigation costs. Although the likelihood of achieving substantial emission reductions is increased by the new plan, there is a paucity of consideration to how an ethic of development might be advanced. Therefore, this research empirically investigates the role that CO_2 plays in advancing human development (in terms of the Human Development Index or HDI) over the 1990 to 2010 time period. Based on empirical evidence, a theoretical CO_2-development framework is established, which provides a basis for designing a novel policy proposal that integrates mitigation efforts with human development objectives.

Empirical evidence confirms that CO_2 and HDI are highly correlated, but that there are diminishing returns to HDI as per capita CO_2 emissions increase. An examination of development pathways reveals that as nations develop, their trajectories generally become less coupled with CO_2. Moreover, the developing countries with the greatest gains in HDI are also nations that have, or are in the process of moving toward,

outward-oriented trade policies that involve increased domestic capabilities for product manufacture and export.

With these findings in mind, future emission targets should reduce current emissions in developed nations and allow room for HDI growth in developing countries as well as in the least developed nations of the world. Emission trading should also be limited to nations with similar HDI levels to protect less-developed nations from unfair competition for capacity building resources. Lastly, developed countries should be incentivized to invest in joint production ventures within the LDCs to build capacity for self-reliant and sustainable development over the long-term.

DEDICATION

This work is dedicated to my mother, Jill Morlock Spierre, whose passion for conservation and the love of nature instilled in me the motivation to study the problem of climate change, and to the memory of my grandmother, Ruth Walker Morlock, who taught me the importance of hard work, family and faith.

ACKNOWLEDGEMENTS

Special thanks to the distinguished faculty members who served on my committee: Dr. Thomas P. Seager (chair), Dr. Braden Allenby, and Dr. Sonja Klinsky. As my advisor, Dr. Seager provided guidance and encouragement throughout the process of preparing for and conducting this research. His mentorship has undoubtedly improved my abilities in research and education, but has also made me a much more confident and self-aware person. I am also grateful to Dr. Allenby and Dr. Klinksy for their comments and support in my writing and ideas over the past few years. My thanks also go to Dr. Evan Selinger for his efforts in teaching me the language of moral philosophy and for his comments on the included manuscripts.

I am also appreciative of my fellow graduate students in the Sustainable Energy and Environmental Decision Making Science (SEEDS) research group for their insights, but especially thankful to Claire, Valentina and Ben for their continued support and friendship.

Last but not least, I would like to thank my family, especially my parents and twin sister for understanding my commitment to this research. Most of all I am indebted to my husband, Bill, for his unwavering encouragement, his belief in my abilities, and for the sacrifices he has made to enable me to achieve this goal.

This research would not have been possible without the financial support from the Nation Science Foundation, the School of Sustainable Engineering and the Built Environment and the School of Sustainability, as well as the Arizona Board of Regents.

TABLE OF CONTENTS

CHAPTER Page

CHAPTER Page

APPENDIX

A MORAL LEADERSHIP AND CLIMATE JUSTICE

Chapter 1

INTRODUCTION:

AN INTERDISCIPLINARY APPROACH TO CLIMATE CHANGE

Climate change is a complex phenomenon. Emissions of greenhouse-gases (GHGs) from any geographical location on the Earth's surface travel to the upper atmosphere and play a role in affecting climate globally. Hence, the impact of any particular emission of GHGs is not realized solely at its source, either individual or geographical; rather impacts are dispersed to other actors and regions of the Earth. GHGs are also temporally diffuse, some having atmospheric lifetimes on the order of tens of thousands of years. Consequently, GHG emissions are responsible for a myriad of impacts including changes to Earth's climate system, manifested in events such as drought, floods, sea-level rise, temperature changes, extinction of species, and spread of vector-borne diseases.

In failing to cooperate and limit overall emissions, the current generation does not simply pass along an existing problem to future people, rather it adds to it, making the problem even more severe. For example, waiting to act increases the magnitude of future climate change, increases mitigation costs, and allows additional investment in fossil fuel based infrastructure in developed and especially less developed countries (Gardiner, 2006). Furthermore, the current generation does not add to the problem in a linear fashion. Instead, it is rapidly accelerates the climate change problem, since global emissions are increasing at an exponential rate (Hofmann, Butler, & Tans, 2009). Figure 1 illustrates how the net global climate response becomes increasingly more severe as CO_2 levels, and the associated global temperature change, continue to increase.

Moreover, it remains unclear if/when human forcing will cause the climate system to cross thresholds, associated with potentially large, abrupt, and possibly irreversible changes to the world as we know it (Alley et al., 2003). Therefore, there is an urgent need for effective and sustainable methods of mitigating GHG emissions to stabilize the climate system.

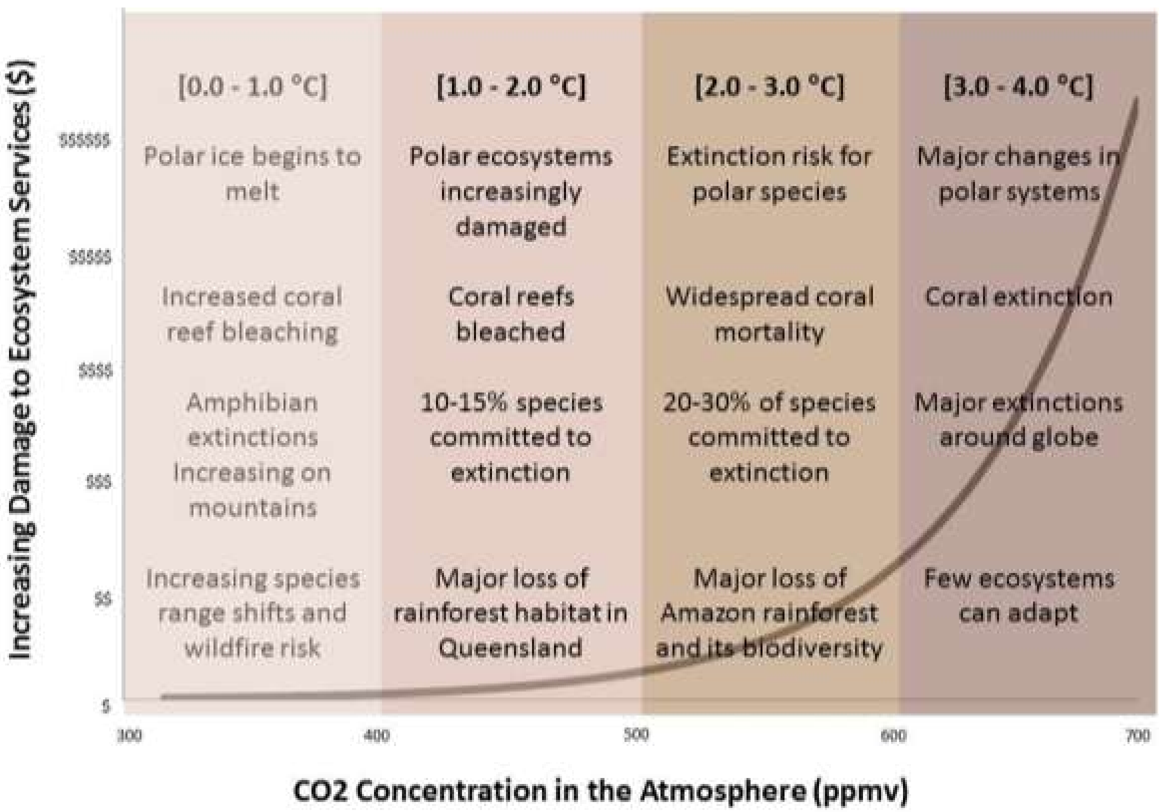


Figure 1. The exponential climate change damage function shows escalating damages to ecosystem service as the concentration of CO_2 increases in the atmosphere. The example temperature changes and damages are adapted from the IPCC 2007 report. Note that the specific link between atmospheric CO_2 concentration and specific damages remains unclear.

Addressing the problem of climate change is just as complex because it involves questioning the norms of how our society currently functions. Defining society's norms is in itself a challenge because it varies depending on the values of the discipline employed.

The traditional approach to climate policy, and other environmental issues, appeals to issues of economic productivity, for instance focusing on GDP losses as a result of a warmer world (Tol, 2009). When social impacts are considered, they are integrated into analysis by placing an estimated monetary value on non-market goods (e.g., human health impacts) so that they may be internalized by the market. Thus, the familiar approach to climate policy design is to reduce GHG mitigation costs for developed nations through market-based mechanisms (i.e., emissions trading or carbon tax). This enables an economically efficient allocation of emissions, since parties that can make significant reductions inexpensively will, and those that find reductions too expensive will instead pay for their right to emit. However, this approach fails to adequately address the social implications of the problem. That is, there are fundamental ethical considerations needed to adequately address both the *inter*generational and *intra*generational aspects of climate change. For instance, where the global limit of GHG concentration is set depends on how the interests of the current generation are weighed against those of future generations. Also, how emissions are distributed under the global cap depends in part on various beliefs about the appropriate role of energy consumption in people's lives, the importance of historical responsibility for the problem, and the current needs and future aspirations of particular societies. Consequently, addressing climate change through the lens of a single discipline may create unintended consequences in another.

Alternatively, this research frames global climate change as a *sustainability* problem. The most common (but not universally agreed upon) definition of sustainability is associated with the concept of *sustainable development* or 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Bruntland, 1987). Implicit in this definition is the notion that the natural environment will not be able to indefinitely meet escalating human demands. As shown in Figure 1, the climate system cannot absorb an infinite amount of GHG emissions and maintain the ecosystem services on which society depend. Thus, addressing sustainability problems implies understanding the interdependencies between natural and human systems, which necessitates an *interdisciplinary* perspective of the issue. Therefore, to examine a sustainable approach to global climate policy, this research is concerned with more than the environmental objective of limiting GHG emissions at minimum economic costs, but also integrates non-monetized social indicators to account for the implications of climate policy on the human experience.

With these overarching concepts in mind, this dissertation is organized in the following way: Chapter 2 provides an overview of the current debates surrounding international approaches to climate policy, which reveals a lack of attention to the implications of global climate policy on development around the world. Based on this overview, the specific objectives and hypothesis motivating this research are provided. In Chapter 3, the independent and dependent variables utilized in this work are discussed. Specifically, indicators of consumption-based CO_2 emissions and human development (in terms of the Human Development Index or HDI) are employed at the country level. The reasons for focusing on these particular indicators are also revealed. Next, Chapter 4 begins investigating the relationship between CO_2 and human development, beginning with a sensitivity analysis of the 2010 HDI methodology and the examination of development pathways over time. Chapter 5 takes a closer look at the implications of traded CO_2 (embodied in traded goods and services) for climate policy design. Using the results from previous chapters (and evidence from other studies), Chapter 6 establishes a theoretical framework for understanding the CO_2-development relationship, which serves as a basis for critiquing unrestricted market-based strategies for GHG mitigation. Chapter 6 also provides a novel climate policy proposal geared to prevent unintended development consequences. Additionally, Appendix A examines how students make decisions about common-pool resources when confronted with a collective action problem, which is simulated by game-theoretic tensions. Although not directly related to the other chapters, the goal is to examine potential models of cooperation that may alleviate some of barriers to sustainable decision-making among diverse groups of stakeholders.

Note that this is a multipaper dissertation, meaning that Chapters 4, 5, 6 and Appendix A are structured for inclusion in peer-reviewed journal articles. At the time that this dissertation was written, Chapter 4 had already been accepted by the *Journal of Sustainable Development*, Chapter 5 and Chapter 6 were ready to submit for review, and Appendix A remained under review by *Ethics, Policy, and Environment*. All co-authors (Thomas P. Seager, Evan Selinger, and Jathan Sadowski) have given the author permission to include these manuscripts in this dissertation.

Chapter 2

THE CLIMATE CHANGE POLICY DEBATE

I begin by reviewing the current state of global climate policy by outlining the terms of the Kyoto Protocol and highlighting the current debates related to designing Kyoto's predecessor. Building on the major concerns of diverse negotiating groups, I offer and describe three major objectives of future climate policy that will promote wide participation. This provides a basis for identifying the particular knowledge gap that my research seeks to clarify, which enables me to define specific research questions that I will investigate in forthcoming chapters.

Current State of International Climate Policy

The Kyoto Protocol

The major international attempt at addressing the problem of climate change began in 1992 with the establishment of the United Nations Framework Convention on Climate Change (UNFCCC), which is aimed at stabilizing greenhouse gas (GHG) concentrations in the atmosphere to prevent 'dangerous anthropogenic interference with the climate system'. The treaty established the principle of *common but differentiated responsibilities* as one of the fundamental principles in global climate change cooperation. This principle recognizes historical differences in the contributions of developed and developing regions to global environmental problems, and differences in their respective economic and technical capacity to tackle these problems. This is codified by the Kyoto Protocol, which set binding greenhouse gases emissions reduction targets for major developed countries (Annex I nations) to collectively reduce emissions on average by 5.2% relative to 1990 during the period of 2008－2012. The Protocol includes three flexible mechanisms that help developed nations meet their emission reduction targets. These include permit trading between developed nations, clean development mechanisms (CDMs), and joint implementation (JI). The CDM involves developed countries investing in sustainable development projects that reduce emissions in developing countries, whereas the JI allows developed nations to work with other developed nations towards this effort. Kyoto was recently extended for a second commitment period from 2013 to 2020, which requires GHG emission reductions by at least 18% below 1990 levels by Annex I Parties (note that the Parties involved in the second commitment period are different from the first and are referred to as Annex B nations).

The overall consensus is that Kyoto, although an important first step, has been ineffective at addressing climate change. CO_2 emissions from fossil fuel combustion have grown 41% since 1990 and although emissions generated in developed countries have generally stabilized, emissions produced in the exempt developing countries have doubled (Le Quéré et al., 2009). Also, the UNFCCC recognizes development as a priority in its commitment to 'common but differentiated responsibilities', yet the major finding of a review article in *Climate Change* finds that the market-based CDM does not significantly contribute to sustainable development in developing countries, since sustainable benefits are not monetized and therefore do not drive investments (Olsen, 2007). Kyoto has also been criticized for its priority of cost-effectiveness, which shifts the focus of negotiations away from ethical issues (Victor, 2001; Brown, 2002; Gardiner, 2004).

Post-Kyoto Policy Negotiations

As Kyoto approaches expiration, international climate discussions have turned to designing the next climate change policy regime to be implemented in 2020. In 2011, the Parties to the UNFCCC adopted the Durban Platform for Enhanced Action with the objective of developing "a protocol, another legal instrument or an agreed outcome with legal force under the Convention and applicable to all Parties" by 2015 and to be fully implemented in 2020 (UNFCCC, 2011). The Durban Platform addresses the demands of the European Union, backed by small-island and least developed countries, to negotiate a new legally-binding system that engages all countries and allows for a more 'symmetrical' response among nations, the primary concern of the U.S. in future climate policy. At the same time, the Durban Platform allowed for an extension of the Kyoto Protocol, which was the main demand of the BASIC group (Brazil, South Africa, India, and China) since it prevents legally binding reductions in developing nations until at least 2020. However, the objectives of the small-island and least developed countries (the countries most vulnerable to climate change impacts), related to an urgent increase of ambition by all Parties, was arguably not addressed by the Durban Platform, which does not specify a time period for enhanced action (Bodansky, 2012).

Still, many of the details of the post-Kyoto policy regime have yet to be negotiated, and various like-minded country groupings have expressed conflicting perspectives on future policy design. For example, the Group of Eight (G8), which includes France, Germany, Italy, Japan, the United Kingdom, the United States, Canada and Russia, called for a global reduction of GHG emissions by 50% by 2050, including a reduction of 80% by developed countries. The G8 leaders agreed that mitigation efforts by all countries were critical to tackle climate change: developed nations would be responsible for significant emission reductions, and the developing countries would undertake actions to deviate from business as usual emissions (G8, 2009). On the other hand the BASIC group calls for a framework entitled “Equitable Access to Sustainable Development”, which is a resource-sharing approach that determines a global carbon budget (e.g., from 1850 to 2049) which is then divided on an equal per capita basis determined by the global population in a given base year. The remaining entitlements for each nation are then estimated by subtracting its historical emissions from its total entitlements (BASIC expert group, 2011). The Least Developed Countries (LDCs), made up of 49 countries characterized as having low income, weak human assets and high economic vulnerability, also convey their desire for principles of equity to be maintained in post-Kyoto policy. The latest LDC submission to the UNFCCC expresses concern for flexible options and/or voluntary approaches to mitigation for nations in their group, as well as the inclusion of finance, capacity building, and technological development and transfer mechanisms (LDC Submission, 2013). Despite having distinct priorities, the G8, BASIC, and LDCs all express concern for the cost of mitigation and generally support the use of market-based mechanisms to efficiently distribute emission rights after initial allocation is accomplished. For example, the BASIC group explicitly calls for an emission trading scheme that allows financial transfers from developed to developing nations. Surprisingly, there is also a common call for a system that includes all Parties to the Convention post-Kyoto, recognized as a critical component for an effective policy regime. All of these perspectives and priorities will no doubt be debated at the 19th

Session of the UNFCCC Conference of the Parties, to be held in Warsaw, Poland this November.

Objectives of the Durban Platform

From the previous discussion that highlights the current state of policy and debates occurring at the international level, it is possible to simplify the objectives of the Durban Platform negotiations (that are likely needed for broad support) into three main categories: 1) effectively reducing GHG emissions globally, 2) minimizing the economic costs of emission reductions, and 3) achieving numbers 1 & 2 while maintaining common principles of climate justice. This section will briefly discuss the concepts underlying these three goals, as discussed in the literature.

Reducing GHG Emissions

The UNFCCC ultimate objective is to stabilize atmospheric concentrations of GHGs at levels that would prevent 'dangerous anthropogenic interference with the climate system' (UNFCCC, 1998), achieved through overall reductions in GHG emissions. According to the UNFCCC, the reductions necessary to meet this objective includes an agreement on the target for allowable temperature increase (e.g., limit warming to 2ºC), the associated concentration levels needed to keep warming below the allowable temperature (e.g., 450 parts per million CO_2), and an emission pathway to achieve that concentration level (UNFCCC, 1992). As Bodansky (2012) points out, the last two factors remain unclear. The scientific link between temperature change and atmospheric concentrations is not fully understood, although the 2007 IPCC report estimates a 2ºC temperature increase is associated with about 350 parts per million CO_2 (a level we have already passed) based on current understanding of the climate system response to radiative forcing and feedback mechanisms. Also, the sought emission pathway for society is coupled with many other factors, including mitigation costs and issues of climate justice. Scott and Barret (2003) argue that a policy's emission reduction effectiveness is a function of strong commitments, levels of participation, and compliance. Therefore, more stringent requirements may be necessary to increase emission reductions but they will fail to achieve these reductions if they promote low levels of participation and/or compliance. Thus, a delicate balance is needed to maintain all three factors for effective GHG reductions at the global level. Participation and compliance issues are also tied to costs and the perceptions of fairness, which are discussed next.

Minimizing Mitigation Costs

Climate policy geared toward minimizing mitigation costs seeks to maximize net benefits over time, so reducing emissions makes sense only if the benefits of doing so are greater than the costs. This analysis is accomplished through cost-benefit analysis (CBA), where benefits and costs are conveyed in terms of monetary value and are adjusted over time using discount rates, which convert future costs and benefits (assumed to be worth less than today) into their net present value. Thus, if the net benefits are positive the policy being analyzed promotes economic efficiency (Kotchen, 2010). However, when applied to climate policy, CBA becomes controversial because reducing emissions involves non-market goods that are difficult to value in terms of money, such as the extinction of a species or the melting of the ice caps. Also, the unknown time horizons of climate change impacts and the choice of discount rates can greatly influence the results. For example, benefits occurring far in the future count much less against costs that must be incurred over the short-term (see Tol, 2009 for a discussion about the limitations of CBA to climate change).

CBA can also be used to estimate a price of a unit of carbon, which internalizes the externalities associated with CO_2 emissions (e.g., health impacts and agricultural setbacks). Carbon pricing can promote cost-effective CO_2 emission mitigation through market-based mechanisms, such as a tax and/or emission trading (Aldy & Stavins, 2011). In terms of CO_2 emissions, pursuing the objective of minimizing global mitigation costs allocates emissions to those that produce the most economic output with the least emissions (e.g., units of GHG emissions produced per dollar GDP). There is wide support for the use of market-based mechanisms across the negotiating groups to reduce mitigation costs, the G8 and the BASIC groups explicitly call for an emissions trading scheme after obligations are determined.

Concepts of Climate Justice

A wealth of literature exists that discuss ideal methods of emission allocates based on varying perspectives of distributive justice. For example, Klinksy and Dowlatabadi (2009) offer a comprehensive list of international climate policy prescriptions, organized by their distribution rules and how they define the climate change problem. Although a complete synthesis of approaches is beyond the scope of this work, the aim is to discuss the details surrounding the justice issues most central to the current policy debates, including the ‘polluter pays’ principle, equal entitlement to the atmosphere, and development-equity. Approaches based on these major equity principles share the notion that future climate policy should advantage the developing and least developed nations of the world.

Polluter Pays. This strategy has considerable intuitive appeal because it focuses on the notion that those who cause a problem are morally responsible for solving it. The principle however becomes somewhat nebulous in the context of global climate change, since it is impossible to link specific costs to a particular activity or actor (Caney, 2005). The common remedy is to associate the current generation with their ancestors, from whom they have inherited benefits of industrial activity (Shue, 1999; Neumayer, 2000). Also, the 'polluter pays' principle may be used to assign responsibility to different polluters depending on the time frame examined. For example, Kyoto operationalizes this principle because it requires emission reductions only by member developed nations based on emissions in 1990. For the Durban Platform, the BASIC group considers using cumulative emissions to assign national entitlements to emission rights from 1850 (the start of the industrial revolution) and 1970 (when society began to understand the impacts of GHG emissions), in both cases responsibility for emissions is carried on the shoulders of developed nations (BASIC expert group, 2011).

Equal Entitlements. The idea that climate policy should distribute rights on an equal per capita basis is reverberated in the policy and ethics literature (e.g., Jamieson, 2001; Singer, 2002; Agarwal & Narain, 1991). In general, it requires scientific agreement on the total amount of GHG emissions we can continue to allow, divided by the total world population. Each country, then, would be allowed to emit the sum of their population (indexed to a baseline year) times the allowable emissions per person. The BASIC group includes an equal per capita allocation in their proposal reasoning that this approach to equity recognizes the need for greater emission entitlements for larger nations. An equal per capita emission allocation would also advantage the developing nations, and is therefore viewed as way to allocate resources to the least well-off (Traxler, 2002). This approach is criticized for its lack of consideration for the differentiating role that emissions play in peoples' lives (Gardiner, 2004; Shue 1993).

Development Equity. From this perspective, priority should be given to those who are worst-off or least advantaged. In the context of climate change, the principle suggests that the most vulnerable populations (which are also the least developed nations) should not be expected to pay for costs associated with climate change (Shue, 1999; Lomborg, 2001; Gardiner 2004). This principle does not necessarily compete with the 'polluter pays' principle, but does suggest that it should be supplemented with an additional principle that poor polluting countries should not pay, even if they are to blame for some emissions (Caney, 2005). Allocation based on development equity suggests that the developed countries should take the lead in mitigation because mitigation efforts in underdeveloped countries would unfairly inhibit their development process, a process that was unrestricted to already industrialized nations. This principle is often addressed through mechanisms that transfer resources to developing countries (e.g., Schelling, 1998; Aldy, Orszag, & Stiglitz, 2001; Baumert and Goldberg, 2006). The Kyoto Protocol also operationalizes this approach by exempting developing nations from emission reduction targets. The LDCs, in particular, call for need-based considerations of mitigation policy, that takes into account the capacities and circumstances of the most vulnerable nations (LDC Submission, 2013).

Knowledge Gap

From this review, it is clear that the ultimate objective of the UNFCCC is to effectively reduce GHG emissions globally, but achieving this goal depends on the ability of future climate policy to also minimize CO_2 mitigation costs and promote common appeals to equity concerns, as indicated by negotiating groups. If emission reduction targets are implemented in countries at all development levels, as the Durban Platform and post-Kyoto policy discussions indicate, the likelihood of achieving significant mitigation is greatly increased, *but it remains unclear how major equity concerns will be addressed*. Furthermore, the default mechanism for reducing mitigation costs at the international level is a CO_2 permit market, yet *the implications of market-based mitigation mechanisms on underdeveloped nations have yet to be understood*. For one, the use of CO_2 emissions trading has been limited to developed nations so far (i.e., the European Union Trading System and other GHG emission markets in New Zealand, Australia, and the U.S.). Plus, all existing carbon trading schemes grant the largest amount of emission rights to biggest polluters (i.e., countries, firms, power plants) that are most responsible for the pollution in the first place (Gilbertson & Reyes, 2009). This would at least partially negate attempts to assign emission rights based on a 'polluter pays' principle and/or development equity. Therefore, not only are the implications of emissions trading on developing nations unknown, but *an unlimited CO_2 permit market may undermine the core equity principles advanced primarily by the developing countries (BASIC group) and least developed nations (LDCs) of the world.*

Research Objectives

With the above considerations in mind, this research seeks to understand the ethical implications of emission restrictions and an unlimited CO_2 permit market on international socio-economic development. To investigate, I examine the role that CO_2 plays in human development, and if significant, how that role may be integrated into post-Kyoto mitigation policy. Therefore the principle hypotheses motivating this research are:

- The diminishing returns to the 2010 United Nation's Human Development Index (HDI) with respect to energy and CO_2 emissions are independent of the normalization method employed (chapter 4),
- Nations that are primarily carbon exporters experience greater improvement in HDI over time compared to countries that are primarily carbon-importers (chapter 5),
- Current market-based mitigation methods will result in perverse human development outcomes (chapter 6).

The next chapter outlines the specific methodology I employ to investigate these hypothesis.

Chapter 3

METHODOLOGY

Nation-State Scale of Analysis

As stated in Chapter 2, this research is framed to inform global climate policy. In particular, the relationship between CO_2 and human development is investigated with the intent to better integrate development equity objectives into post-Kyoto policy design. Consequently, the methods employed and the partitioning of results are at the nation-state scale, which is applicable for use within the UNFCCC policy structure (the only existing international governing body to date). Note however that this research does consider transfers of emissions between nations to account for the increasing trans-boundary flows of emissions in the globalized market.

Logistically, the state level provides the most data availability for both GHG emission inventories and human development indicators. For example, the Millennium Development Goals (ranging from halving extreme poverty to halting the spread of HIV/AIDs) use indicators at the national levels to assess progress. Furthermore, due to the inability to directly link specific costs from climate change to particular actors, addressing the problem at alternative scales becomes morally problematic. As a few authors point out, it remains unclear who the appropriate moral agents are in climate change (Caney, 2005; Klinsky & Dowlatabadi, 2009). For example, in the case of a carbon-intensive industry that releases a high level of CO_2, it is impossible to pick out a specific individual or localized cost resulting from those particular emissions. Thus, in determining responsibility for the impacts of climate change, many authors revert to the country-level unit of analysis, which allows an indirect link between the actions of a particular group and their collective pollution (Shue 1999, Neumayer, 2000). That is not to say that the nation-state is the only or the best scale for climate mitigation efforts.

The literature provides examples of alternative scales of mitigation efforts. For example, Ostrom (2009) argues that policies adopted at the global scale are unlikely to generate enough trust among citizens and firms to facilitate collective action, and promotes a polycentric approach by small to medium scale governance units linked via information networks. Also, Lutsey and Sperling (2008) discuss many of the sub-national efforts to reduce GHG emissions within the U.S., such as energy efficiency funding, renewable fuel requirements, and regulatory standards, that are distinct from the relative inaction at the national level. Additionally, the role of the state (in terms of authority and power) has come under scrutiny as a result of 'globalization', or the increasing integration of economies around the world, particularly through trade and financial flows (IMF, 2000). Some argue that globalization is creating a borderless world in which global companies are the primary actors (Ohmae, 1990, 1995; Strange, 1996), others maintain that states are the major actors in international politics and economics (Hirst & Thompson, 1996; Pauly & Reich, 1997). The collection of articles edited by Higgott, Underhill, and Bieler (2000) demonstrate that the role of the state has not diminished, but has changed due to the increasing capabilities of non-state actors, especially private corporations and non-governmental organizations (NGOs). Nevertheless, it is clear that including non-state actors in current and future climate management initiatives is likely critical for achieving climate stabilization. Thus, the focus of this research on a nation-based metric is not intended to downplay the importance of action at these alternative scales, but aimed at informing the scale most applicable to current international policy discussions.

Measuring GHG Emissions

Under the Intergovernmental Panel on Climate Change (IPCC) accounting rules (which informs UNFCCC policy), mitigation only applies to "greenhouse gas emissions and removals taking place within national territory and offshore areas over which the country has jurisdiction", also known as a country's *territorial emissions* (IPCC, 2008). However, recent studies emphasize the criticality of life-cycle considerations in climate policy design, due to the increasing trend of international trade flows of CO_2 in the global economy (Carbon Trust, 2006, 2011; Peters & Hertwich, 2008; Weber & Matthews, 2007; Davis & Caldeira, 2010; Wiebe, Bruckner, Giljum, & Lutz, 2010; Davis, Peters, & Caldeira, 2011; Nakano et al., 2009; Peters et al. 2009; Peters, Minx, Weber & Edenhofer, 2011; Peters, Davis & Andrew, 2012). The basic idea is that in today's globalized economy, goods and services consumed in one country are often produced in another country. Known as *consumption-based* emission inventories, emissions generated during the production of goods and services are attributed to the consuming nation.

Unlike territorial based emission accounting (that do not take trade into account), consumption-based inventories show that most developed countries have significantly increased their GHG emissions since 1990, despite their Kyoto commitments, through the consumption of goods and services produced in developing nations (Peters et al., 2011). They also result in higher correlations with human development indicators (i.e., life expectancy, income, literacy, & HDI) when compared to territorial emission accounting (Steinberger et al., 2012). That is, shifting from territorial to consumption-based emissions results in countries moving closer to the regression curve (Figure 2); in general, developed nations (or net importers) move right and many developing countries (net exporters) tend to shift left on the graph. Additionally, a change in emission allocation changes the rank of countries. For example, production-based inventories indicate that China is first and the U.S. is second in terms of total emissions generated, but these positions are swapped using a consumption-based perspective since the U.S. is a net importer and China is a net exporter. The results are useful to understand the drivers of GHG emissions, the distribution of final goods and services, as well as the benefit gained by consumers from the embodied emissions of products, both reasons why we employ consumption-based emission data in this research.

Peters, Mix, Weber, and Edenhofer (2011) provide us with a consumption-based emission data-set that considers emission transfers between nations via international trade from 1990 to 2010. The data-set uses territorial emission inventories (from Boden, Marland, & Andres, 2009) that are adjusted using estimates of net emission transfers (defined as CO_2 emissions in each country minus the emissions in other countries to produce imported goods and services). The emission transfers (or embodied emissions) are not physical carbon transfers (e.g., trade of fossil fuels) but are emitted in the production of exports (where the fuel is oxidized). The data-set uses inventories that include CO_2 from fossil-fuel combustion, cement production, and gas flaring but do not include emissions from land-use change, such as deforestation (due to lack of data). To adjust territorial data for trade, emissions that occur in the supply chain of consumer goods and services are allocated to the appropriate nation based on environmentally extended input-output analysis (IOA), using annual estimates of GDP (from the United

Nations Statistics Division). For example, if Norway extracts and exports crude oil, which is imported by the Netherlands to be refined into petroleum, which is imported by Germany for transportation fuel, The methodology used by Peters et al. (2011) allocate the Norwegian emissions from extraction to the Netherlands, and the refining emissions generated in the Netherlands to Germany (see methods section and supporting information appendix of Peters et al. 2011 for more detail).

The uncertainties associated with environmentally-extended IOA include aggregation and cutoff errors, missing data, as well as geographical and temporal uncertainties (e.g., Lenzen, 2001; Williams, Weber, & Hawkins, 2009). Also, studies suggest that uncertainty is higher for consumption-based emissions compared with territorial emissions (Lenzen, Wood, & Wiedmann, 2010), however they also indicate that the trends and absolute values are consistent across data, methods, and independent studies (Peters, Davis, & Andrew, 2012; Wiedmann, Lenzen, Turner, & Barrett, 2007; Wiedmann, 2009). To remain consistent with the consumption-based emission data-set from Peters et al. (2011), this research distinguishes developed nations as the countries included in Annex B and the developing and/or underdeveloped nations are classified as the non-Annex B countries under the second commitment period of the Kyoto Protocol.

Measuring Human Development

Defining and measuring development is a topic of extensive literature and depends on the values and frameworks employed within disciplines concerning what should be developed (e.g., Parris & Kates, 2003; Woolcock, 1998; Baster, 1972). Three distinct categories of what should be developed are found in the literature: people, economy, and society (Parris & Kates, 2003). Early literature focuses on developing the

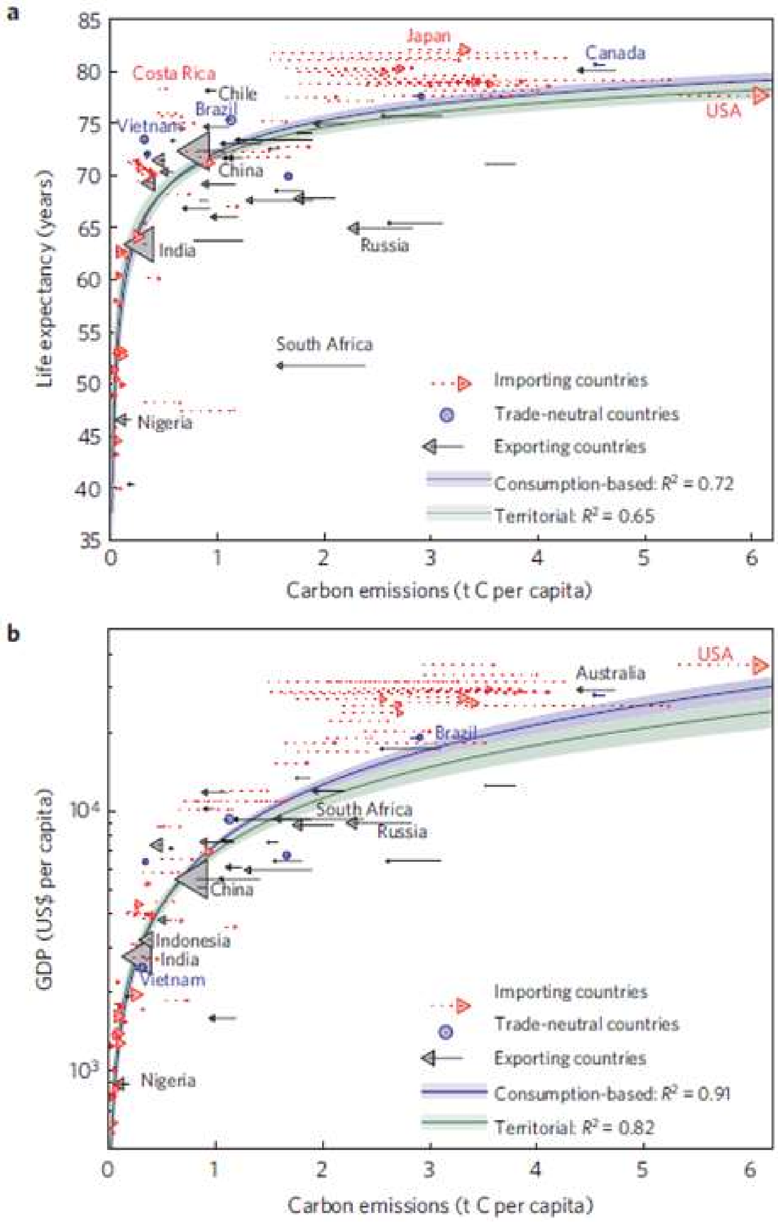


Figure 2. Correcting for trade in CO_2 emission inventories. Each arrow represents a country/region moving horizontally from territorial to consumption-based carbon emissions, in the year 2004. The vertical axes are life expectancy (a) and income (b). The arrowhead size represents national population. Carbon importers are red; exporters, grey; net-neutral countries are blue circles. The fit curves are shown for both consumption-based (blue) and territorial (green) emissions, with the shaded bands corresponding to one standard error intervals. Note that the arrows do not represent residuals from the fit curves. Reprinted by permission from Macmillan Publishers Ltd: Nature Climate Change (Steinberger et al. (2012). Pathways of human development and carbon emissions embodied in trade. Nature Climate Change). Copyright (2012).

economy, including employment, consumption and wealth (e.g., Solow, 1956; Lucas, 1988; Azariadis & Drazen, 1990). More recently, the focus has shifted toward a greater emphasis in people in terms of human development, commonly indicated by life expectancy, education, equity, and opportunity (UNDP, 2002; IMF, 2000; Sen 1999a, 1999b; Nussbaum and Sen, 1992). There are also authors who are concerned with developing society in the context of national states, regions, institutions and social capital (Putnam, 1995; Woolcock, 1998). Depending on the scale of application, the indicators may be very broad (consensus among varied stakeholders) or narrow (independent efforts). Although there is much ambiguity in characterizing development, measuring it is critical for decision-making and management purposes (Parris & Kates, 2003), at the same time it is important to bear in mind the underlying preferences and choices of indicators used and their potential implications (Ravallion, 2011).

To inform the post-Kyoto UNFCCC process, this research calls for a broad method of measuring development in a way that embodies the Parties of the convention, relies on widely available data, yet offers a single informative value. Moreover, to maintain the interdisciplinary approach to climate policy in this study, individual indicators such as GDP (development in terms of economic standards) or ecological footprint measurements (impacts of human activity on the environment) are too narrow in scope. Thus, this research seeks a multidimensional view of development available via a composite index. Table 2 outlines some of the available options for measuring development given these criteria.

Table 1. Composite Indices of Development-related Data

Index	Number of Indicators	Countries covered	Focus	Temporal Coverage	Reference
Human Development Index	4	186	Socio-economic measure of development	1980-2012	UNDP, 2013
Well-being of Nations	123	183	Quality of Life and Environment	1990-2000	Prescott-Allen, 2001
National Well-Being Index	4	171	Life satisfaction	Data from multiple years (1990-1997) to create one index	Vemuri & Costanza, 2006
Happy Planet Index	3	151	Sustainable well-being	2006, 2012	Happy Planet Index, 2012
Multi-dimensional Poverty Index	10	104 developing countries	Poverty/ poorest individuals	2012	Alkire & Santos, 2010
Economic Freedom of the World Index	42	141	Economic freedom	1997-2012	Gwartney, Lawson & Hall, 2012
Worldwide Governance Indicators	6	212	Governance	1996-2008	Kaufmann, Kray, Mastruzzzi, 2009
Country Policy Institutional Assessments	14	77	Governance	2005-2009	World Bank, 2013

From the examined list of indices in Table 2, this research employs the Human Development Index (HDI) for several reasons. First, the temporal and geographical coverage of the data is critical for examining recent human development achievements and enables the study of development trajectories of many countries over time (the temporal coverage aligns with the consumption-based CO_2 emission data-set employed). Second, the HDI is an index published by the United Nations Development Programme, thus it is already aligned with the overall objectives and structure of the United Nations. Third, the index includes indicators in the *health* (average life expectancy), *education* (combined measures of expected and mean years of schooling), and *income* (gross nation income per capita) dimensions of development, providing average measures valued by both the economic and social disciplines. Most importantly, the HDI has been found to play a significant role in raising the political profile of health and educational policies (Atkinson et al. 1997) to be a measure of a nation's vulnerability to climate-related extreme events (Patt et al., 2010) and its dimensions determinants of vulnerability and adaptive capacity at the national level (Brooks, Adger, & Kelly, 2005). All HDI data used in this research were retrieved from the United Nations Development Programme's database (available at http://hdr.undp.org/en/statistics/).

In Chapter 4, the methodology used to calculate a nation's HDI level is outlined, and a discussion of aggregation and normalization issues is provided. Additionally, a sensitivity analysis on the HDI in performed in relation to this research. It is important to recognize that the HDI (and other composite indices) use techniques to average data and therefore do not offer insights into the inequalities present within nations, but is nevertheless informative for the current nation-based policy structure of the UNFCCC.

A CO_2-HDI Framework

The HDI is inspired by the capabilities approach to justice (Sen 1999a, 1999b; Nussbaum and Sen, 1992; Nussbaum 2000, 2006), which is a theory of basic human entitlements that provides a standard for determining whether people possess the various capabilities necessary for living a genuinely human life (a list of ten entitlements is provided by Nussbaum (1997), which are outlined in Figure 3). The capabilities approach provides a framework for thinking about development in terms beyond those used in traditional welfare economics, where the focus is not only on the rights individuals have but also on what those rights enable people to do. For example, Sen (1990) observes that societies typically differ in their capacity to convert income and commodities into valuable human achievements. Figure 3 illustrates the types of mechanisms needed to transform income, commodities, and rights into actual achievements, such as communication, transportation, education, and health care. For example, a U.S. citizen has the right to life under the Bill of Rights, but to actually attain a life of normal length a person requires access to adequate and affordable health care. The theory of the capabilities approach also inspired the creation of the HDI.

This research extends the capabilities approach framework (illustrated in Figure 3) to understand the relationship between CO_2 and human development through *energy*. Energy can be thought of as a co-requisite for transforming rights into capabilities because it enables modern forms of communication, transportation, education, and health care (which are important for human development). This is supported by the empirical relationship between energy consumption and HDI for many countries shown by Figure 4.

Figure 3. Conceptual Framework of the Capabilities Approach extended to CO_2, energy and Development

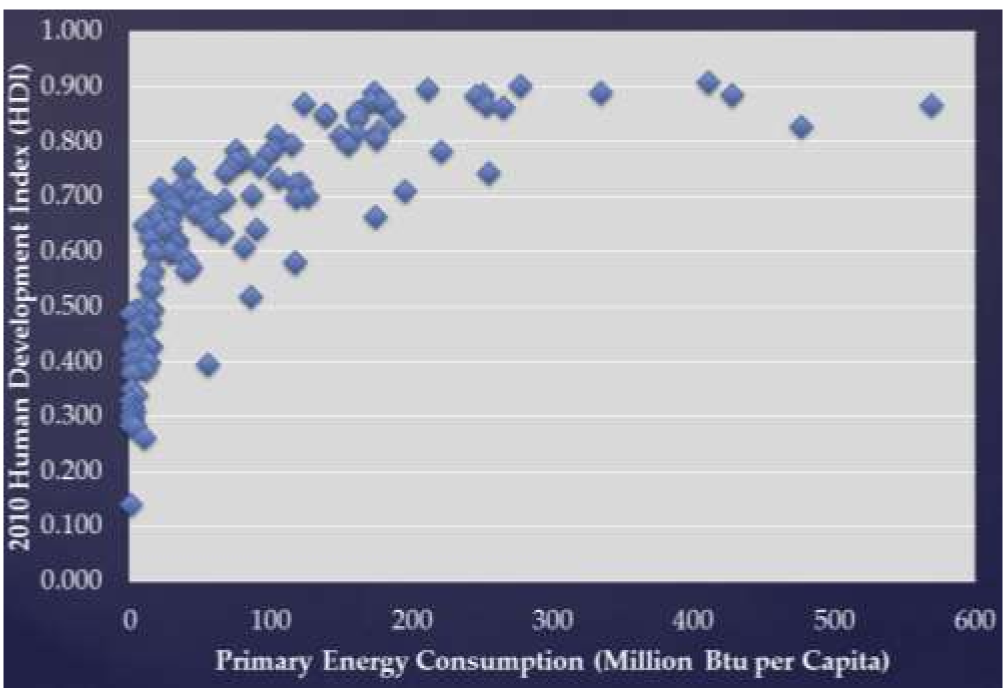


Figure 4. Empirical comparison of energy consumption and HDI levels for many countries. Primary energy consumption data was retrieved from the Energy Information Administration.

Moreover, under current technology constraints, energy production generates emissions of CO_2, a byproduct of fossil fuel combustion. Note that renewable-energy technologies are at least several decades away from substantially replacing oil, coal, and natural gas energy sources (Ayres & Ayres, 2010). Therefore, the HDI (dependent variable) offers a relative measure of the health and education achievements, as well as an indicator of income, experienced by an average citizen in each country. Thus, comparing the HDI level to the consumption-based, per capita CO_2 emissions (independent variable) allows the examination of a nation's ability to transform consumed goods and services (enabled by the production of energy, which generates CO_2 emissions) into human development achievements. In this work, correlations between HDI and CO_2 emissions are completed for many countries, and at all ranges of HDI levels. The comparisons will help clarify the role CO_2 plays in enabling human development, and will inform policymakers about how to allocate CO_2 emissions without inhibiting development progress.

Chapter 4

EXAMINING THE DIMINISHING RETURNS OF THE 2010 HUMAN DEVELOPMENT INDEX

Susan G. Spierre[1], Thomas P. Seager[2], Evan Selinger[3]

[1] School of Sustainability, Arizona State University, Tempe, AZ

[2] School of Sustainable Engineering and the Built Environment, Arizona State University, Tempe, AZ

[3] Department of Philosophy, Rochester Institute of Technology, Rochester, NY

Abstract

Human development, energy, and greenhouse gases are inherently linked under current technology constraints. An empirical comparison illustrates that nations with higher human development values (in terms of the United Nation's Human Development Index (HDI)) contribute more carbon dioxide (CO_2) emissions as a result of greater energy consumption. This finding seemingly places environmental sustainability at odds with advances in human development. However, the comparison also exposes the *diminishing returns* in HDI that accrue as emissions increase. If accurate, this relationship suggests that the developed world *can* make emission cuts without experiencing major set-backs in human well-being. It also suggests that under a global mitigation system, emission cuts in developed nations could enable emission increases in underdeveloped countries that result in major improvements to the human condition. Therefore, we investigate the diminishing returns to HDI in the context of sustainable climate policy design. We find that the saturation-like trend is inherent to development indicators and not driven by the functional form of the HDI. Also, the global trend is not consistently

detected when the development pathways of individual nations are examined. Nevertheless, a clear relationship between CO_2 and HDI emerges within the least developed nations; fourteen of which show consistent advances in HDI as emissions increase over time. These findings suggest that sustainable climate policy should not allocate emission rights away from these nations. Furthermore, most developed nations exhibit periods of HDI improvement while emissions decline, reinforcing the criticality of employing broader development measures beyond indicators of income for sustainable policy design.

Introduction

The Energy-CO_2-Development Nexus

It is undeniable that energy is fundamental for human development. The exploitation of inexpensive fossil fuels has historically been the foundation of the industrial and agricultural revolutions, which enabled remarkable increases in the standard of living for hundreds of millions people. On the other hand, countries with poor access to modern energy resources remain in poverty; over 1.6 billion people (almost one third of humanity) have no electricity and consequently lack essential energy services for schools, health centers and income generation (Birol, 2007). In fact, no country consuming the energy equivalent to 750kg of oil per year per capita achieves an average life expectancy of over 75years (World Bank, 2011).

However, energy also has a down-side under current technology constraints. The combustion of fossil fuels for energy production is the primary source of harmful greenhouse gas (GHG) emissions contributing to climate change (Barker et al., 2007). Also, it will be at least several decades before renewable-energy industries can substantially replace oil, coal, and natural gas energy sources (Ayres & Ayres, 2010). A further complication is that the inequities of how energy is consumed globally translate into differentiating responsibilities for contributing to global warming. In 2004, developed countries (Annex I countries under Kyoto) had 20% of the world's population, but accounted for 46% of global GHG emissions. On the other hand, 80% of the population living in developing nations (non-Annex I countries under Kyoto) emitted 54% (Barker et al., 2007). In terms of regional per capita emissions, the difference is even more pronounced; The US and Canada are home to 5.0% of the population and emits 19.4% of GHG emissions, while 30.3% of the population in South Asia emits just 13.1% (Barker et al., 2007).

The deleterious effects of climate change, resulting from GHG emissions, are also likely to be heterogeneous. Some regions will experience significant negative effects such the loss of life and property due to sea level rise, climate extremes, loss of agricultural productivity, and damage to infrastructure from the melting of permafrost and/or more frequent extreme weather events. Others may experience minor negative effects or successfully adapt to changing environmental conditions. Lastly, certain countries (such as Russia and Canada) may experience net benefits such as lower winter heating costs due to warmer temperatures, a longer agricultural growing season, increased forest productivity, or an expansion of tourism due to land use changes (UNDP, 2007). These inequalities in impact and adaptive capabilities suggest that global climate change is likely to create both winners and losers (Tol, 2009). Under any climate scenario, the poorest individuals will likely suffer the most. Underdeveloped countries that have contributed minimally to the problem are already suffering from rising temperatures (e.g., from sea-level rise and/or agricultural setbacks), and typically lack the ability to adapt in terms of things like financial resources, poor infrastructure, and weak institutions (O'Brien & Leichenko, 2006).

Consequently, there is an inequitable distribution of the benefits as well as damages associated with energy consumption and anthropogenic climate change. An empirical comparison between a nation's human development level (according to the United Nations Human Development Index or HDI) and per capita carbon dioxide (CO_2) emissions (we look particularly at consumption-based emissions; reasons for this provided in the next section) shows a clear correlation: nations with higher per capita CO_2 emissions exhibit greater achievements in human development (Figure 5). However, the comparison also reveals the diminishing returns to HDI as nations transition to higher level of per capita emissions (indicated by the regression of the data in Figure 5). This relationship is also referred to as "plateau" by Pasternak (2000) or "saturation" by Martinez and Ebenhack (2008). We hypothesize that the diminishing returns we observe is an artifact of human well-being indicators (such as proxies for health and education) becoming less dependent on energy and carbon as nations develop. If accurate, the implication is that emission reductions on the part of the developed countries may *not* mean significant sacrifices to human well-being. Furthermore, Figure 5 suggests that under global CO_2 limits (e.g., to keep temperature increases below 2º C) emission reductions by developed countries could enable major improvements in the quality of life for individuals within the world's least developed nations. Thus climate policy and sustainable development, i.e., development that gives priority to the needs of the poor and recognizes the limitations of the environment's ability to support humanity (United

Nations, 1987), are inherently interrelated; efforts to address one without considerations of the other will likely be unsuccessful (Beg et al., 2002; Swart, Robison, & Cohen, 2003). This research therefore explores the relationship between per capita CO_2 emissions and the observed diminishing returns to HDI in many countries to clarify its implications for sustainable global climate policy.

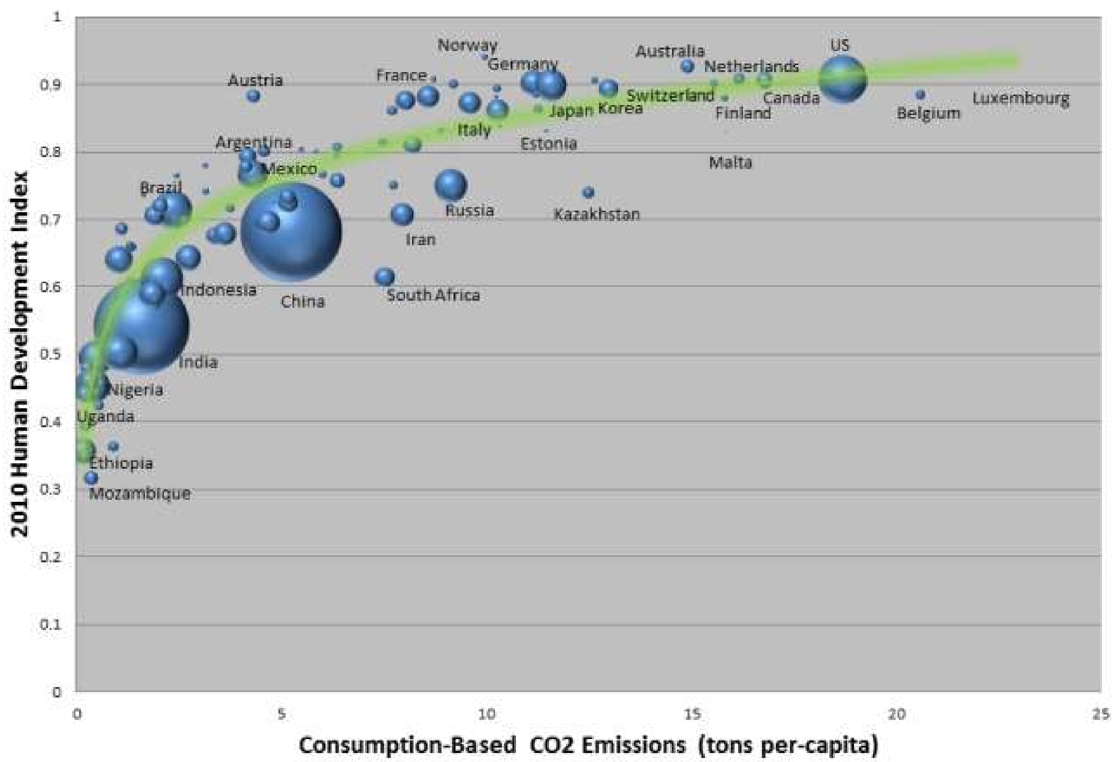


Figure 5. Comparison between consumption-based per capita emissions (includes emissions transfers from international trade) and HDI by country in 2010. The size of the bubbles indicates each country's relative population. Select countries are labeled. Singapore is excluded from the figure due to its very high per capita emissions (48 tons per capita and HDI of 0.864). The green trend-line is the logarithmic regression of the data with an R2 value of 0.845 (the closer the R2 value is to 1, the better the fit).

Literature Review

The diminishing returns to HDI when compared with energy and/or CO_2 emissions have been identified previously. For example, Pasternak (2000) examined the relationship between HDI and per capita electricity consumption for 60 countries and estimated the electricity consumption needed to bring all countries to the 4,000kWh per year level, the threshold for achieving an HDI of 0.9 or greater in 1997. Martinez & Ebenhack (2008) showed that the diminishing return to HDI from per capita energy consumption for 120 countries was stronger when major energy exporting countries (e.g., OPEC nations) were filtered out. Also, Mechtenberg et al. (2012) found that human development is exponentially related to electricity consumption and uses the relationship to identify nations with low HDI that may benefit from human powered electricity generation. However, what these authors fail to elucidate is how the aggregation of the data included in the HDI influences the relationship they observe. That is, the methodology used to aggregate diverse data-sets (e.g., with different units and distinct ranges) may oversimplify or exaggerate important aspects of data, thereby potentially misleading decision-makers (Prado, Rogers, & Seager, 2012).

Moreover, there is a paucity of information on how the relationship between HDI and energy or CO_2 indicators changes over time. In a few instances, authors have compared an early data set (circa 1960's & 1970's) to more recently reported data (1990's and early 2000's), noting improvements in the HDI attainable at different levels of energy (Suarez, 1995; Pasternak, 2000). Also, HDI and ecological footprint were found to increase together when country-level data for both indicators are contrasted for the years 1975 and 2003 (Moran, Wackernagel, Kitzes, Golfinger, & Boutaud, 2008). There are, however, only two studies (by the same lead author) that consider changes in HDI for more than two points in time (necessary to observe the saturation-like effect). One study computed regressions for HDI versus per capita primary energy at the aggregate level (for 80 countries) and territorial based carbon emissions data (for 93 countries) from 1975 to 2005 (Steinberger& Roberts, 2010). They found that HDI levels were achieved at decreasing levels of energy and carbon emissions over time and show the differences in energy/carbon trends with increasing HDI for six select countries over the same time period. A more recent study compared both energy and carbon emissions to human development indicators (life expectancy and GDP) for many countries in 2004. The diversity in development trajectories of thirteen select nations was also shown. One of the key findings was that high life expectancy can be achieved at a large range of carbon emission levels, whereas income is much more closely linked with carbon. This is an important finding, as it suggests that mitigation on the part of the developed nations, even if it negatively impacts income, does not necessarily mean significant costs to non-income components of human well-being (Steinberger, Roberts, Peters, & Baiocchi, 2012). This latter study, in particular, emphasizes the criticality of considering broader measures of development, beyond measures of income, when assessing sustainable climate policy.

Research Objectives

The key point is that the relationship between CO_2 and human development has critical implications for global climate policy. If CO_2 is a necessary component for human development advances, than sustainable climate policy would include mechanisms that protect the minimum amount of CO_2 needed for sufficient development. This research seeks to clarify this relationship further in two specific ways. First, we investigate the 2010 HDI methodology to determine how the index calculation influences the diminishing returns to HDI as per capita CO_2 emissions increase. This will elucidate how valuable the HDI is in terms of informing sustainable climate policy. Second, we examine individual development pathways of countries from 1990-2010 to determine if the diminishing returns to HDI we observe at the global level is also exhibited by individual countries, as their consumption-based per capita CO_2 emissions increase over time. Studying the distinct development pathways of nations compared to their CO_2 emissions is important to assess the implications of mitigation efforts on country-level human development.

Methodology

Taking a systems approach to the sustainability issues of climate change and sustainable development require considerations of economic, social and environmental aspects of these challenges. Our investigation is therefore designed to include indicators for each sustainability pillar. The environmental pillar is reflected in our independent variable: consumption-based CO_2 emissions per capita. The economic and social dimensions are represented via indicators within the HDI, our dependent variable. In this section we describe the reasons for using these particular variables for this research.

Independent variable: Consumption-Based Per capita CO_2 Emissions

Under the Intergovernmental Panel on Climate Change (IPCC) accounting rules, mitigation only applies to "greenhouse gas emissions and removals taking place within national territory and offshore areas over which the country has jurisdiction", also known as a country's *territorial emissions* (IPCC, 2008). The problem is that inventories of territorial emissions do not include life-cycle considerations. That is, it assigns the carbon-dioxide of goods produced for export to the producing countries (i.e., the exporters), rather than the consuming countries (i.e., the importers). Consequently, results indicate that CO_2 emissions in developed nations have generally stabilized, while emissions from developing nations have about doubled since 1990 (Le Quéré et al., 2009).

Alternatively, Peters, Mix, Weber, and Edenhofer (2011) provides us with a *consumption-based emissions* accounting methodology that considers emission transfers between nations via international trade from 1990-2010; territorial emission inventories are adjusted using estimates of net emission transfers (defined as CO_2 emissions in each country minus the emissions in other countries to produce imported goods and services). The consumption-based emission data used in this research use inventories that include CO_2 from fossil-fuel combustion, cement production, and gas flaring and do not include emissions from land-use change, such as deforestation. To adjust territorial data for trade, emissions that occur in the supply chain of consumer goods and services are allocated to the appropriate nation based on environmentally extended input-output analysis (see methods section of Peters et al. 2011). Studies suggest that uncertainty is higher for consumption-based emissions compared with territorial emissions (Lenzen, Wood, & Wiedmann, 2010), however they also indicate that the trends and absolute values are consistent across data, methods, and independent studies (Peters, Davis, & Andrew, 2012; Wiedmann, Lenzen, Turner, & Barrett, 2007; Wiedmann, 2009). To remain consistent with the consumption-based emission data-set from Peters et al. (2011), this paper distinguishes developed nations as the countries included in Annex B and the developing and/or underdeveloped nations are classified as the non-Annex B countries to the Kyoto Protocol.

Unlike territorial based emission accounting (that do not take trade into account), consumption-based inventories show that most developed countries have significantly increased their GHG emissions since 1990, despite their Kyoto commitments, through the consumption of goods and services produced in developing nations (Peters et al., 2011). They also result in higher correlations with human development indicators (i.e., life expectancy, income, literacy, & HDI) when compared to territorial emission accounting (Steinberger et al., 2012). That is, shifting from territorial to consumption-based emissions results in countries moving closer to the regression curve (i.e., the green curve in Figure 5); in general, developed nations (or net importers) move right and many developing countries (net exporters) tend to shift left on the graph (see Figure 1 in Steinberger et al., 2012). The results are useful to understand the distribution of final goods and services as well as the benefit gained by consumers from the embodied emissions of products, both reasons why we employ consumption-based emission data in this research.

One drawback is that trade-corrected inventories do not apportion emissions to the indirect socio-economic gains that may accrue in a nation from product manufacture and export (e.g., employment, technology advancements). For example, the impact of foreign direct investments on the human development of host countries is a popular topic in development studies (e.g., Reiter, 2010; Rodrik 2006; Sharma & Gani, 2004). Moreover, development theory and case studies suggest that manufacturing (whether it's driven by foreign investors or domestic efforts) has been the cornerstone of development (especially economic growth) in many nations (e.g., Gereffi 1989; Hartwick & Peet, 2009; Anwar, 2008). The implications of this for our results are included the discussion section of this paper. Here, we focus on per capita consumption-based emissions (total emissions attributed to a nation, divided by the population), which approximates the distribution of emissions among individuals within a nation.

Dependent Variable: Human Development Index

We measure human development in terms of the United Nations Human Development Index (HDI), which provides a composite measure of a nation's income, education and health standards. The HDI is inspired by the capabilities approach to justice, which is a theory of basic human entitlements that provides a standard for determining whether people possess the various capabilities necessary for living a genuinely human life (Sen, 1999a, 1999b; Nussbaum and Sen, 1992; Nussbaum, 2000, 2006). Using the HDI for measuring human welfare establishes a broader understanding of human well-being (compared with consumption measures alone), which is important for climate mitigation policy because it addresses factors that are basic for human life to function and flourish, which will be critical if we are to implement a concept of climate justice that allows for the basic functioning of human communities and the environment (Schlosberg, 2009). All HDI data used in this research were retrieved from the United Nations Development Programme's database (available at http://hdr.undp.org/en/statistics/).The next section outlines the methodology employed to determine a nation's HDI level, and how the process influences the CO_2/development relationship.

2010 HDI Calculation

The HDI is inherently complicated by the task of aggregating data in different units and diverse scales of measurement. The HDI dimension of *education* combines mean years of schooling for adults and expected years of schooling for children (weighted equally), with a range of zero to about twenty years. Also, *health* is measured by life expectancy at birth with a range of 20 to about 80 years. Lastly, the *income* dimension is reported in Gross National Income (GNI) per capita PPP$ (which includes international economic transfers), with a range from $100 to $108,000. In most cases, the goalposts for each dimension are observed maxima and minima for all countries (Table 3). Before aggregating the data, the HDI uses a rescaling procedure to normalize the indicators to an identical range between zero and one. Both life expectancy and years of schooling are transformed linearly (equation 1). The income index is normalized differently using a logarithmic transformation (equation 2). Finally all three indices are aggregated using a geometric mean (equation 3), assigning equal weight to each dimension (Klugman, Rodrigues, & Choi, 2011). For a graphical depiction of this normalization procedure, refer to Figure 6.

Table 2. Dimensions, indicators and goalposts used to calculate the 2010 HDI

Dimension	Indicator	Observed Maximum	Minimum
Health	Life Expectancy (years)	83.2 (Japan, 2011)	20
Education	Mean Years of Schooling	13.2 (United States, 2000)	0
	Expected Years of Schooling	20.6 (Australia, 2002)	0
Standard of Living	Per capita income (PPP$)	108,211 (United Arab Emirates, 1980)	163 (Zimbabwe, 2008)

$$Dimension\ index = \frac{actual\ value - minimum\ value}{\text{maximum value} - minimum\ value} \quad (1)$$

$$Income\ Index = \frac{\ln(actual\ PPP\$) - \ln(163\ PPP\$)}{\ln(108{,}211\ PPP\$) - \ln(163\ PPP\$)} \quad (2)$$

$$HDI = (H_{Health} * H_{Education} * H_{Living\ standard})^{1/3} \quad (3)$$

The normalization, weighting, and aggregation inherent to the HDI could distort outcomes (Prado & Seager, 2011), especially since normative judgments are used to justify procedures (Kovacevic, 2010). For example, the 2010 HDI assigns equal weights to all three dimensions, reflecting the notion that health, education and income are equally important to human development (it is also statistically justified, see Noorbakhsh1998). Furthermore, the logarithmic normalization of the income index is based on the assumption that increases in income have a diminishing marginal effect on human well-being (Kovacecic & Aguna, 2010; Stanton, 2007; Cahill, 2002; Haq, 1999). In other words, the logarithmic transformation reflects the notion that people do not need excessive financial resources to ensure a decent standard of living.

Using a natural logarithm to normalize income is of particular concern for this research, since it produces a saturation-like trend between GNI and per capita CO_2 that is not observed before the normalization procedure (see Figure 6(c) and 6(d)). Consequently, countries with GNI levels near the reported minimum see greater returns in HDI than those with high GNI levels for the same income increase. For example, the highest valuation of income comes from Zimbabwe (lowest HDI value of 0.140 in 2010), with a 4.1% increase in HDI for each 1% increase in income, while Liechtenstein has the lowest income valuation (highest HDI of .938 in 2010), with a 0.05% increase in HDI for a 1% increase in income (Kovacevic, 2010). Another significant component of the HDI methodology is the use of a geometric mean (multiplicative aggregation) to combine the dimensions, since it implies diminishing marginal returns in each of the sub-indices and Intensifies the diminishing returns of the logarithmic transformation of GNI due to its exponential form (equation 3) (Klugman et al., 2011).

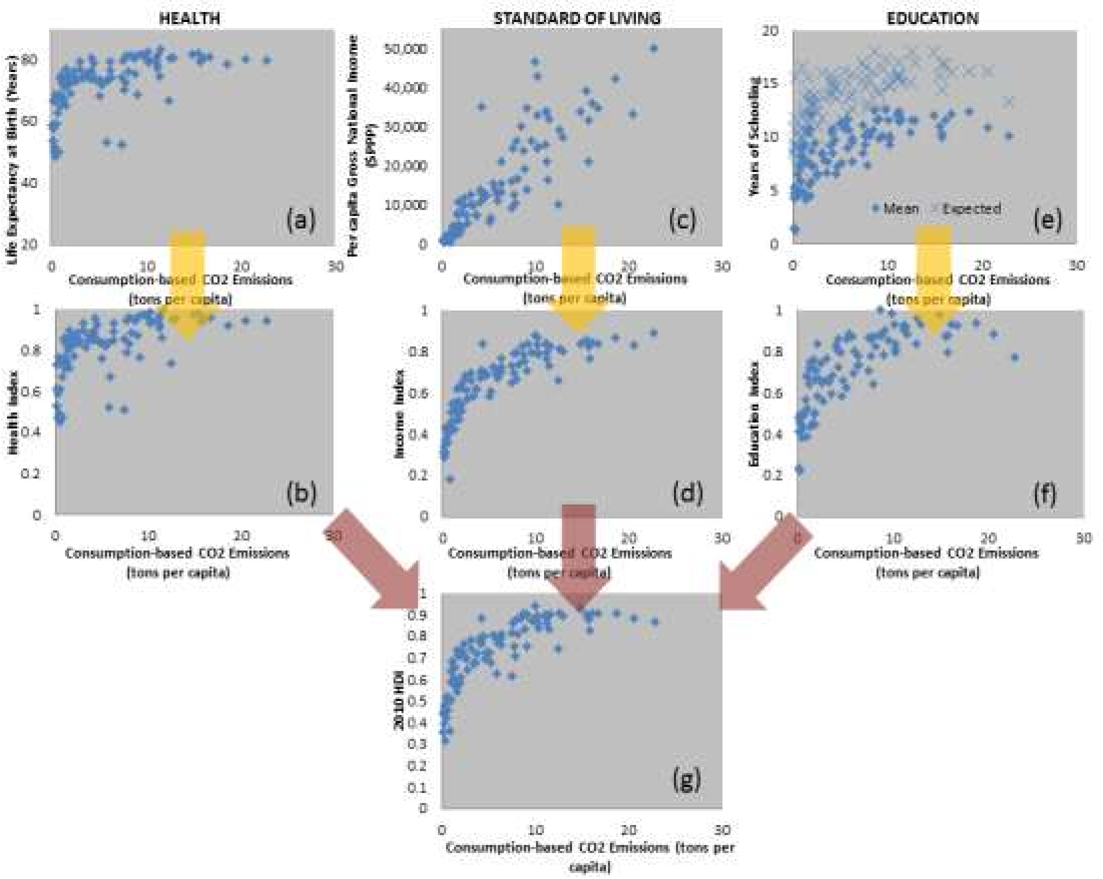


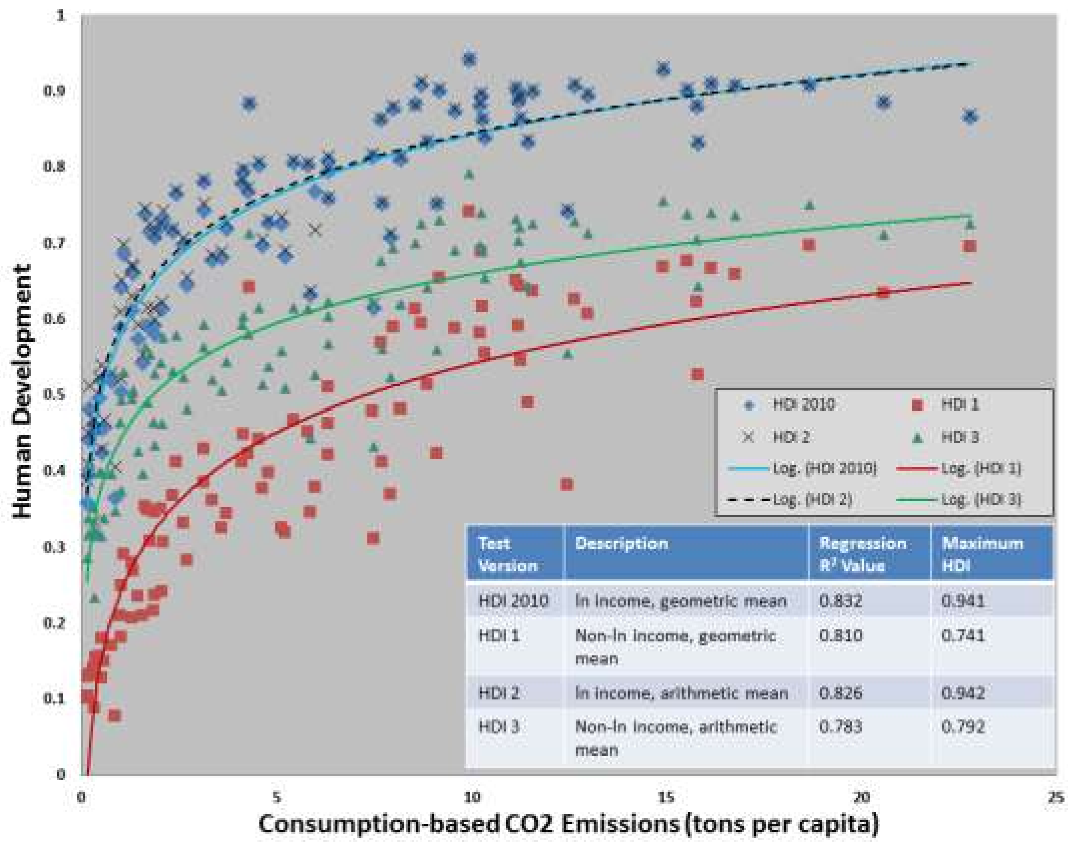
Figure 6. Graphical depiction of how the 2010 HDI is calculated. All graphs contain consumption-based per capita CO_2 emissions on the x-axis. Both mean and expected years of schooling (e) are weighted equally and combined using a geometric mean. The orange arrows show the process of normalization, where each data-set is rescaled to a range between zero and one. Life expectancy (a) and combined measures of education (e) are normalized using equation 1 (results shown in (b) and (f)). GNI (c) is normalized using equation 2 (result shown in (d)). The red arrows show the aggregation of each dimension via equation 3 (final result shown in (g)). Data on the development indicators was retrieved from United Nations Development Programme, 2010 consumption-based CO_2 emissions data provided through personal communication with Dr. Glen Peters.

Therefore, examination of the HDI methodology demonstrates that diminishing returns, especially to the income dimension, are inherent to the HDI calculation. Plus, from Figure 6(a) and 6(e), it is apparent that even before the normalization and aggregation occurs, both life expectancy and measures of education exhibit diminishing returns as per capita CO_2 emissions increase by country. This means that the diminishing returns to HDI is inherent to some of the indicators chosen and not just an artifact of its functional form. However, the question remains how the methodological judgments of the index influence the shape of the resulting saturation-like curve.

Sensitivity Analysis

To bolster the robustness of the HDI functional form and to clarify its influence on determining the diminishing returns relationship observed between gains in human development to increasing CO_2 emissions, we conducted our own sensitivity analysis using 2010 HDI and consumption-based CO_2 emission data. We are interested in clarifying how the logarithmic transformation of the income dimension and the geometric mean of all dimensions influence the observed saturation-like effect shown in Figure 5. We compared the results of the 2010 HDI methodology to other computed versions of the HDI, which lack the logarithmic and exponential qualities that may be enhancing the diminishing returns to HDI.

We computed several test versions of the 2010 HDI and their logarithmic regressions (of the form:$HDI = A * ln(CO2) + B$), displayed in Figure 7. HDI 2010 (blue diamonds) is the result of using the 2010 HDI methodology and serves as a point of comparison for the three test versions. Test version *HDI 1* (red squares) employs the non-logarithmic normalization formula (equation 1) for the income dimension, and aggregates with a geometric mean (multiplicative aggregation). Version HDI 2 (green triangles) uses the natural logarithmic function to normalize the income dimension (equation 2), but employs an arithmetic mean (additive aggregation) to combine the data. The final test version HDI 3 (black crosses) uses a non-logarithmic formula (equation 1) to normalizethe income dimension, and an arithmetic mean to aggregate the three dimensions, this version therefore has no logarithmic or exponential transformations of the data.



Test Version	Description	Regression R^2 Value	Maximum HDI
HDI 2010	ln income, geometric mean	0.832	0.941
HDI 1	Non-ln income, geometric mean	0.810	0.741
HDI 2	ln income, arithmetic mean	0.826	0.942
HDI 3	Non-ln income, arithmetic mean	0.783	0.792

Figure 7. A comparison between the results of the 2010 HDI methodology and three other test versions. To quantify the differences between results, the logarithmic regressions (of the form $HDI=A*\ln(CO_2)+B$) and maximum achieved HDI are displayed for each version. The R^2 values of the regressions are also reported in the table, representing the goodness of fit for each trendline (the closer the R^2 value is to 1, the better the fit).

Sensitivity Results

As a result of the methodological comparisons in Figure 7, we can infer that the use of the natural logarithmic transformation in the income dimension (HDI 2010 & HDI 2) results in an upward shift of HDI values, relative to when the non-logarithmic normalization procedure is used for all dimensions (HDI 1 & HDI 3). Also, the indices with the same aggregation procedures but different normalization methods (e.g., HDI 2010 & HDI 1) exhibit large differences in HDI values when compared to the indices with same normalization procedures and different aggregation methods (e.g., HDI 2010 & HDI 2). This suggests that the normalization method (logarithmic or not) has a greater impact on the results than the choice of aggregation. The change in the rate of return of the trend-line is also determined by the version employed, since HDI 3 shows a faster decline in HDI advances than the other versions. Most importantly, all test versions, including HDI 3 that contains no logarithmic or exponential transformations of the data, show diminishing returns, indicating that the saturation-like effect of HDI is not caused by the functional form of the composite index and is an artifact of the indicators included in the index. However the rate of diminishing returns, range of HDI values attained, and potential saturation levels vary depending on the methodology employed.

Human Development Pathways at the Country Level

Country Level Analysis

Sustainable climate policy must consider more than global trends in GHG emissions and human development, especially given the diversity in socio-economic aspects, political factors, and climate change impacts across nations (Mendelsohn, 2000; Ostrom, Burger, Field, Norgaard, & Policansky, 1999; Adger, 2001). That is, an equitable (and likely effective) mitigation system would consider the variability of the CO_2/HDI relationship among individual nations. To better understand the applicability of the global trend to the country level, we examine the development pathways of individual countries from 1990-2010 (determined by data availability) in terms of their consumption-based CO_2 emissions and attained HDI. Although 93 countries were included in Figure 5, three nations (Belarus, Georgia, and Nigeria) did not have adequate historical HDI and consumption-based emissions data to be examined in this part of the study. We constructed graphs of the remaining 90 development pathway at five year-intervals and visually examined them for saturation-like trajectories. Figure 8a shows the pathways for 24 of the countries studied, selected to show a variety of development levels and pathways. In Figure 8b we zoom in on the 14 developing nations whose HDI levels were below 0.5 in 1990 and display trends consistent with the regression ins Figure 5. As expected, very diverse development pathways are exhibited at the country level.

Country Level Results

Nations generally experience increases in HDI throughout the time period, although a small minority did see some declines (e.g., South Africa, Ukraine, Zambia, and Zimbabwe). For this research it is helpful to classify the 90 pathways examined into three categories relative to our original hypothesis, that nations experience diminishing returns to human development as their per capita emissions increase, even at the country level:

Support. Thirty-two of the nations (35.5%) have pathways that *support* the hypothesis, by displaying trajectories consistent with a saturation-like trend for the entire 20 year time period). The majority (29/32) of these nations are developing countries, fourteen of which had 1990 HDI levels under 0.5 (Figure 8b). This category includes developing nations, like Uganda and Pakistan, which even today show major growth in HDI for very small increases in CO_2, but also developed nations, like Belgium and Singapore, who exhibit very gradual increases in HDI for large increases in per capita CO_2.

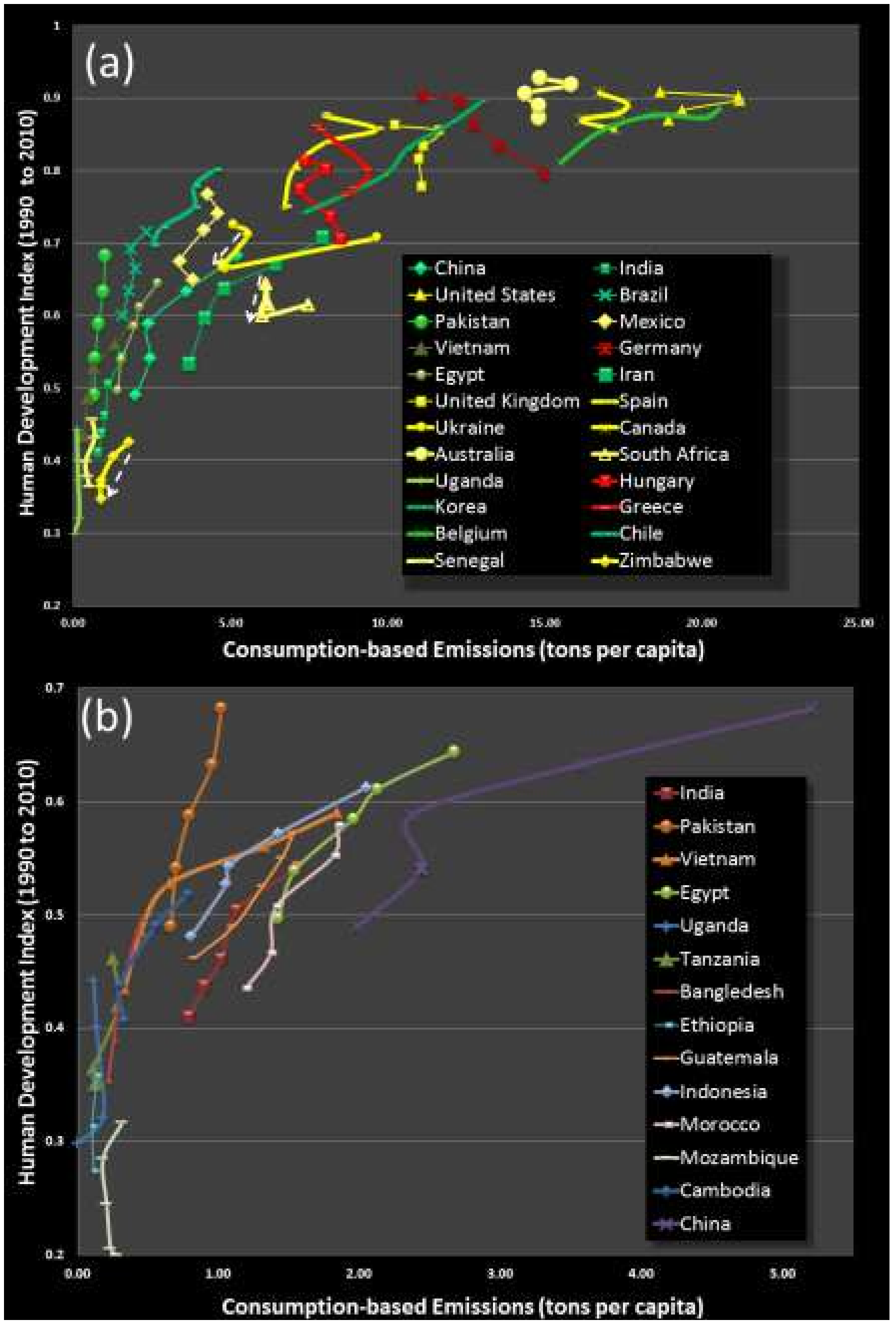


Figure 8. Country Level Development Pathways. On the top (a), the development pathways of 22 countries (out of 90 examined) are displayed, showing examples of trajectories at a range of development levels. The pathways are shaded different colors, depending on the shape of their development trajectory; green pathways are consistent with the global diminishing returns trend, red pathways undermine the global trend and show alternative trajectories, and pathways in yellow are labeled as inconclusive. On the bottom(b), we zoom in on fourteen of the world's least developed nations that support our hypothesis, all having 1990 HDI levels below 0.5. HDI levels are increasing throughout the 1990-2010 period except when the white arrows indicate otherwise.

Undermine. Seven of the nations (8%) *undermine* the hypothesis, by showing an alternative relationship. For these nations the trend is indirect, where they experience increasing HDI with decreases in CO_2 emissions (e.g., red pathways in Fig. 8a). Five of the pathways belong to Annex I nations (Czech Republic, Germany, Greece, Lithuania, United Kingdom) and six (add Hungary to the group) have 2010 HDI levels over 0.8. The declines in emissions for these particular nations may be due in part to renewable energy promotion policies like the feed-in tariff and renewable portfolio standard (Lipp, 2007; Martinot, 2007). There are also other drivers of GHG declines in these countries. For example, one study concludes that 60% of energy related CO_2emission reductions in Germany during the 1990's were due to the restructuring of the East German economy after reunification and the liberalization of energy markets significantly reduced emissions in the UK from 1990-2000 (Eichhammer et al., 2001). Another attributes significant decreases in energy consumption in Hungary to the deterioration of energy intensive industries since 1989 (Szlavik & Csete, 2012). Madagascar, which remains under 0.5 in HDI, also shows a declining trend in per capita emissions. Although the total emissions have increased in this country overall, the decline we see in per capita emissions is likely attributed to recent population growth, 90% of which live below the $2-a-day extreme poverty level indicator used by the World Bank (Clark, 2012).

Inconclusive. Fifty-one of the pathways (56.6%) are *inconclusive*, exhibiting periods of development that are consistent with global trends but contain alternative trajectories at other times. These nations show a range of development levels. Out of the 36 Annex I nations examined, 26 of them are in this category. Also, 33 of these nations (64.7%) have 2010 HDI levels above 0.7, and 6 countries remain below 0.6 in HDI including Malawi, Zambia and Zimbabwe with 2010 HDI's around 0.4. However, some notable patterns emerge from nations in this category that provide hope for a sustainable energy transition.

Among the large group of nations labeled as 'inconclusive', we found two distinct patterns, particularly among the more developed nations. Ten countries with HDI levels above 0.7 tend to follow an increasing trajectory from 1990-2000, but from 2005-2010 exhibit a sharp decline in CO_2 and an increase in HDI (e.g., Australia, U.S., United Kingdom) (Figure 9a). There is also a smaller group of seven nations with HDI levels above 0.6 that show declines in CO_2 from 1990-1995, display increasing pathways from about 1995-2005, and another decline in CO_2 over the last 5 years of the time period (e.g., Canada, Austria, Switzerland) (Figure 9b). In this latter group, most declines in CO_2 are associated with increasing HDI as well, the exceptions being declines in Estonia and Albania from 1990-1995. These patterns of declining CO_2 emissions are evidence of two economic recessions that occurred in the early 1990's and late 2000's. The recession of the early 1990s (associated with the beginning of the Gulf War and resulting spike in oil prices) affected the US economy greatly as well as other economies closely linked with them, such as Canada, Australia, the United Kingdom, as well as Europe and Japan to a lesser degree (McNees, 1992). The more recent recession (associated with the U.S. housing bubble) damaged financial institutions in developed nations around the world (Gore, 2010). In most cases, the declines in CO_2 coincide with little to no growth in income, whereas health and education continue to prosper, resulting in an overall increase in HDI for those time periods. This could be good news for climate policy because it is an

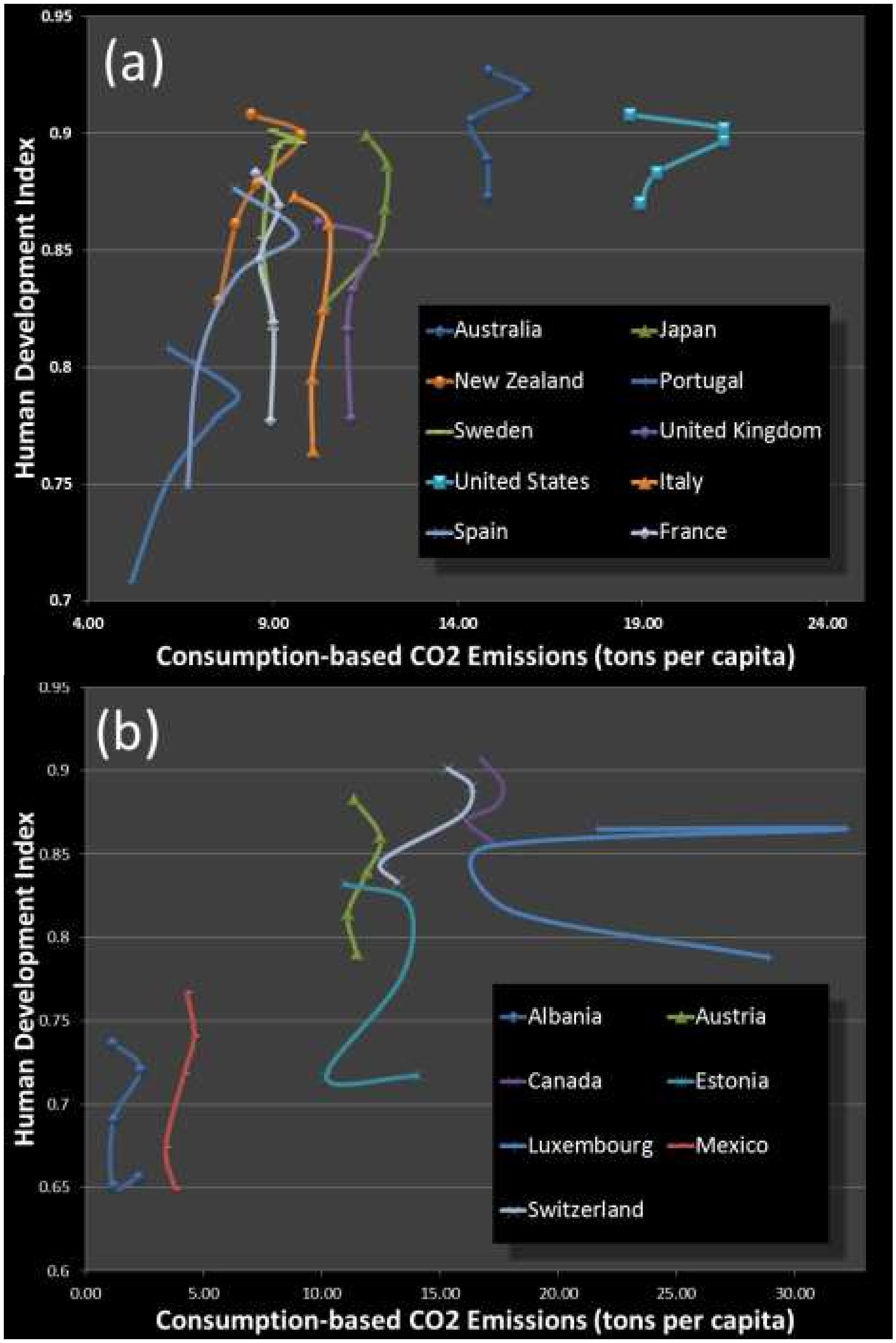


Figure 9. Examples of HDI increases while CO_2 emissions decline over time. Two distinct patterns emerge when the inconclusive development pathways are examined. Ten developed nations show increasing trajectories from 1990-2005, then a sharp decline in CO_2 and increases in HDI from 2005-2010 (shown in (a), top). The other group of seven countries exhibits the same recent decline in CO_2 and increase in HDI, but also display decreases in CO_2 from 1990-1995, most of which are associated with increases in HDI as well (shown in (b), bottom).

indication that some developed economies are able to maintain human development improvements despite the potential negative economic impacts of mitigation policies. Of course, our analysis does not tell us anything about the long term ability of these nations to withstand economic declines without sacrifices in health and education.

Discussion

According to the consumption-based emission data we employ in this research, a typical American emits just under 19 tons of CO_2 a year, which is about 12 times that of an average Indian and 60 times that of an average individual living in Mozambique. This research shows that the HDI level attained at these wide ranges of emissions is driven by both the indicators chosen and how the indicators are aggregated. In terms of income, education, and health indicators it is clear that industrialized nations are emitting far more CO_2 than necessary to maintain high levels of human well-being. The HDI sensitivity analysis shows that neither the method of normalization or aggregation actually causes the diminishing returns to HDI from CO_2 emissions, but does influence the rate of return, the range of HDI values attained by nations, as well as the saturation level of the data regression curves. Bearing this mind, the HDI is particularly valuable for country comparisons and ranking (Kovacecic & Aguna, 2010) but should not be the basis for specific climate policy design. That is, Figure 5 is helpful to show the relative achievements of nations at various levels of CO_2 emissions, and thus useful in determining which nations are being more efficient with their emissions than others in terms of human development, but it should not be the sole basis for assigning emission reduction targets to individual nations.

The country-level investigation reinforces this claim. A little over a third of the nations we examined (mostly developing nations) have pathways from 1990-2010 consistent with the global 2010 trend (shown in Fig. 5), and a small minority display alternative trajectories during that time. This means that over half the nations exhibit more complex development pathways (many of them developed nations) than our hypothesis suggests, a portion of which can be explained by declines in per capita CO_2 emissions and income during two economic recessions (see Figure 9). That leaves about one third of nations whose development pathways differ from the aforementioned patterns; reinforcing the fact that a generalizable model of development for all nations is non-existent.

Nevertheless, this analysis does reveal important findings for designing future climate policy. Although developed nations generally do not display consistent development trends at the country level, most reveal times when their HDI levels continue to increase while their per capita CO_2 emissions decrease. We see this most clearly among developed nations during times of economic recessions (Figure 9). These declines in CO_2 are typically reflected in little to no growth in the income dimension of the HDI, whereas life expectancy and years of schooling typically continue to rise, resulting in an overall higher HDI level. However, given the relatively short time period examined here, the sustainability of these non-income parameters in unknown.

Regardless, if policy-makers use income as the sole proxy for human development, it is clear that mitigation efforts become equated with a lower quality of life, which reduces the likelihood of mitigation support. However, if development is viewed in a broader sense, as in the HDI, mitigation doesn't necessarily mean sacrifices to a person's overall well-being. The challenge is then to shift the focus of development away from material consumption and more towards less GHG intensive goals, such as quality of education and healthier lifestyles. Simultaneously, the challenge of further decoupling energy from carbon needs to be addressed, in which renewable energy technology development will likely play a significant role.

On the other hand, when we zoom in on the pathways of the least developed nations (such as those with 1990 HDI levels under 0.5; some of which are displayed in Figure 8b), they overwhelmingly show large gains in HDI from little to no increases in consumption-based CO_2 emissions. The instances where developing nations do experience HDI increases with no increase in CO_2 (or even declines in CO_2) could be the result of rapid population increases during the time period or may be a result of nations that primarily manufacture goods and services for export and consumption elsewhere. As mentioned previously, domestic manufacturing, even if the products are consumed elsewhere (meaning that the emissions would be allocated to another country), can lead to local human development improvements in the form of jobs and wages which under the right circumstances may also lead to health and education improvements (e.g., Heintz, 2007; Chudnovsky & Lopez, 2002; Reiter, 2010). Nevertheless, the fact that fourteen of the nations examined display consistent upward trends in HDI as their per capita CO_2 emissions increase indicates that under current technology constraints, CO_2 emissions are likely a co-requisite for human development improvements within the least developed nations of the world.

Moreover, our findings inform discussions of equitable CO_2 distributions in the context of sustainable policy design. On the one hand, some propose that carbon emissions should be allocated on an equal per capita basis (e.g., Singer, 2004; Jamieson, 2005). Alternatively, others appeal to the fact that emissions play very different roles in people's lives and therefore emission rights should be allocated in a way that those differences are reflected (Shue, 1993; Lomborg, 2001). For example, Shue (1993) points out the differences between what he calls 'subsistence' and 'luxury' emissions and argues that it would be unjust to ask individuals to surrender necessities so that others can retain luxuries. Our analysis supports the latter, since, CO_2 is found to play a significant role in the ability of developing countries to achieve improvements in HDI, yet not always necessary to improve HDI levels within developed nations.

Furthermore, the fact that underdeveloped nations experience significant gains in HDI from relatively small increases in per capita emissions suggests that under a system of global mitigation, emission rights should be allocated towards (and not away from) these nations. Typically, market-based approaches to mitigation seek the opposite by allocating emissions in a way that optimizes profitability (i.e., maximizes GDP per unit of emission). Consequently, emission rights are allocated to the richest and most developed nations. Alternatively, if climate policies were framed to optimize advances in human development per unit of emission, the policy structure would protect the emission rights of the least developed nations, while enforcing emission reductions on the already sufficiently developed nations. Although the details of Kyoto's predecessor have yet to be determined, country leaders are currently discussing a "universal, legally binding international agreement" under which all nations would contribute to the mitigation effort at some level (UNEP, 2012). Our findings suggest that emission reductions or limits placed on developing nations (especially in the 14 nations identified in Figure 8b) would likely inhibit necessary human development improvements (such as access to modern energy sources) within those nations. This result would be in direct opposition of the United Nation's definition of sustainable development (1987), since it would take priority away from fulfilling the essential needs the world's poor.

References

Adger, W. N. (2001). Scales of Governance and Environmental Justice for Adaptation and Mitigation of Climate Change. *Journal of International Development* ,13, 921-931. http://dx.doi.org/10.1002/jid.833

Anand, S., & Sen, A. (2000). The Income Component of the Human Development Index. *Journal of Human Development,* 1(1), 83–106. http://dx.doi.org/10.1080/14649880050008782

Anwar, S. (2008). Foreign investment, human capital and manufacturing sector growth in Singapore. Journal of Policy Modeling, 30(3), 447-453. http://dx.doi.org/10.1016/j.jpolmod.2007.12.008

Ayres, R. & Ayres, E. (2010). *Crossing the Energy Divide: Moving from Fossil Fuel Dependence to a Clean-Energy Future*. New Jersey: Prentice Hall. ISBN: 7980137015443

Barker T., Bashmakov, I., Bernstein, L., Bogner, J.E., Bosch, P.R., Dave, R., … Zhou, D. (2007). Technical Summary. In B. Metz, O. R. Davidson, P. R. Bosch, R. Dave, & L. A. Meyer (Eds). *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* . Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. http://www.ipcc.ch/publications_and_data/ar4/wg3/en/ts.html

Beg, N., Morlot, J.C., Davidson, O., Afrane-Okesse, Y., Tyani, L., Denton, F., … Rahman, A.A. (2002). Linkages between climate change and sustainable development. *Climate Policy*, 2, 129-144. http://dx.doi.org/10.3763/cpol.2002.0216

Birol, F. (2007). Energy Economics: A Place for Energy Poverty in the Agenda. *The Energy Journal,* 28(3), 1-6. http://dx.doi.org/10.5547/ISSN0195-6574-EJ-Vol28-No3-1

Cahill, M. (2002). Diminishing returns to GDP and the Human Development Index. *Applied Economics Letters*, 9, 885- 887. http://dx.doi.org/10.1080/13504850210158999

Clark, M. (2012). Deforestation in Madagascar: Consequences of Population Growth and Unsustainable Agricultural Processes. *Global Majority E-Journal*, 3(1), 61-71. Available at: http://www.american.edu/cas/economics/ejournal/upload/Global_Majority_e_Journal_3_1.pdf

Chudnovsky, D. & Lopez, A. (2002). Globalization and Developing Countries: Foreign Direct Investment, Growth and Sustainable Human Development, UNCTAD Occasional Paper. Available at: http://www.tci-network.org/media/asset_publics/resources/000/000/788/original/globalization-chudnovsky.pdf

Eichhammer, W., Boede, U., Gagelmann, F., Jochem, E., Kling, N., Schleich, J., Schlomann,B., …Ziesing, H. J. (2001). Greenhouse gas reductions in Germany and the UK-Coincidence or policy induced. Fraunhofer Institute for Systems and Innovation Research, Karlsruhe. Available at: http://www.isi.fraunhofer.de/isi-media/docs/x/de/publikationen/wallfall/co2report-isi-e-final.pdf

Gerreffi, G. (1989). Rethinking Development Theory: Insights from East Asia and Latin America. Sociological Forum, 4(4), 505-533. http://www.jstor.org/stable/684423

Gore, C. (2010). The global recession of 2009 in a long-term development perspective. *Journal of International Development*, 22(6), 714-738. http://dx.doi.org/10.1002/jid.1725

Haq, U. (1999). *Reflections on Human Development*. Oxford: CUP. ISBN: 9780195101935

Hartwick, E. & Peet, R. (2009). *Theories of Development: Contentions, Arguments, Alternatives*. New York, NY: Guilford Publications. PMid:18757519

Heintz, J. (2007). Human Development and Clothing Manufacturing in Cambodia: Challenges and Strategies for the Garment Industry. Political Economy Research Institute. http://wiego.org/sites/wiego.org/files/publications/files/Heintz-Cambodia-Garment-Report.pdf

Intergovernmental Panel on Climate Change (IPCC). (2008). 2006 IPCC Guidelines for National Greenhouse Gas Inventories – A primer, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Miwa K., Srivastava N. and Tanabe K. (eds). Published: IGES, Japan. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

Jamieson, D. (2005). Adaptation, Mitigation, and Justice. *Advances in the Economics of Environmental Resources,* 5, 217–248. http://dx.doi.org/10.1016/S1569-3740(05)05010-8

Klugman, J., Rodriguez, F., & Choi, H.J. (2011). Human Development Research Paper 2011/01: The HDI 2010: New Controversies, Old Critiques. Available at: http://hdr.undp.org/en/reports/global/hdr2011/papers/HDRP_2011_01.pdf

Kovacevic, M. (2010). Review of HDI Critiques and Potential Improvements. United Nations Development Programme. http://hdr.undp.org/en/reports/global/hdr2010/papers/HDRP_2010_33.pdf

Kovacevic, M. & Aguna, C.G. (2010). Uncertainty and Sensitivity Analysis of the Human Development Index 2010. United Nations Development Programme. Available at: http://hdr.undp.org/en/reports/global/hdr2010/papers/HDRP_2010_47.pdf

Lenzen M, Wood R, & Wiedmann T (2010). Uncertainty analysis for Multi-Region Input-Output Models—A case study of the UK's carbon footprint. *Econ Syst Res*, 22, 43–63. http://dx.doi.org/10.1080/09535311003661226

Le Quéré C., Raupach, M.R., Canadell, J.G., Marland, Bopp, L., Ciaia, P., …Woodward, F. I. (2009). Trends in the sources and sinks of carbon dioxide. *Nature Geoscience,* 2, 831–836. http://dx.doi.org/10.1038/ngeo689

Lipp, J., (2007). Lessons for effective renewable electricity policy from Denmark, Germany and the United Kingdom. *Energy Policy,* 35 (11), 5481–5495. http://dx.doi.org/10.1016/j.enpol.2007.05.015

Lomborg, B. (2001). Global Warming. In B. Lomborg (Ed.).*The Skeptical Environmentalist* (pp. 258–324). Cambridge: Cambridge University Press. ISBN-13: 978-0521010689

Martinot, E. (2007). Renewables 2007 Global Status Report. Renewable Energy Policy Network Available at: http://www.martinot.info/RE2007_Global_Status_Report.pdf

Martínez, D. M. & Ebenhack, B.W. (2008). Understanding the role of energy consumption in human development through the use of saturation phenomena. *Energy Policy,* 36,1430–1435. http://dx.doi.org/10.1016/j.enpol.2007.12.016

McNees, S. (1992). The 1990-91 Recession in Historical Perspective. *Board of Governors of the Federal Reserve System*. http://www.bos.frb.org/economic/neer/neer1992/neer192a.pdf

Mechtenberg, A., Borchers, K. Miyingo, E.W., Hormasji, F., Hariharan, A., Makanda, J.V., Musaazi, M.K. (2012). Human power (HP) as a viable electricity portfolio option below 20 W/Capita. *Energy for Sustainable Development*, 16, 125-145. http://dx.doi.org/10.1016/j.esd.2011.12.006

Mendelsohn, R., Morrison, W., Schlesinger, M.E. & Andronova, N.G. (2000). Country Specific Market Impacts of Climate Change. *Climate Change*, 45 (3-4), 553-569. http://dx.doi.org/10.1023/A:1005598717174

Moran, D.D., Wackernagel, M., Kitzes, J.A., Goldfinger, S.H., & Boutaud, A. (2008). Measuring sustainable development – nation by nation. *Ecological Economics*, 64 (3), 470–474. http://dx.doi.org/10.1016/j.ecolecon.2007.08.017

Noorbakhsh, F. (1998). The Human Development Index: Some Technical Issues and Alternative Indices. *Journal of International Development,* 10(5), 589–605. http://dx.doi.org/10.1002/(SICI)1099-1328(199807/08)10:5<589::AID-JID484>3.0.CO;2-S

Nussbaum, M., A. Sen. (1992). *The Quality of Life*, Oxford: Oxford University Press. ISBN 9780198287971

Nussbaum, M. (2000). *Women and Human Development: The Capabilities Approach*. Cambridge: Cambridge University Press. http://dx.doi.org/10.1017/CBO9780511841286

Nussbaum, M. (2006). *Frontiers of Justice: Disability, Nationality, Species Membership*, Cambridge, MA: Harvard University Press. ISBN 9780674024106

O'Brien, K. & Leichenko, R. (2006). Climate Change, Equity and Human Security. *Die Erde* 137(3): 223-240.

Ostrom, E., Burger, J., Field, R.B., Norgaard, R.B. & Policansky, D. (1999). Revisting the Commons, *Science*, 284 (5412), 278-282. http://dx.doi.org/10.1126/science.284.5412.278

Prado, V., Rogers, K., & Seager, T.P. (2012). Integration of MCDA Tools in Valuation of Comparative Life Cycle Assessment. In M.A. Curran (Ed.). *Life Cycle Assessment Handbook: A guide to Environmentally Sustainable Products* (Part 3, Chapter 19). DOI: 10.1002/9781118528372.ch19

Pasternak, A.D., (2000). Global Energy Futures and Human Development: a framework for analysis. US Department of Energy, Oak Ridge.

Peters, G.P., & Hertwich, E.G., (2008). CO_2 embodied in international trade with implications for global climate policy. *Environmental Science & Technology*, 42 (5), 1401–1407. http://dx.doi.org/10.1021/es072023k

Peters, G. Minx, J.C., Weber, C., & Edenhofer, O. (2011). Growth in emission transfers via international trade from 1990-2008. *PNAS*, 108(21), 8903-8908.

http://dx.doi.org/10.1073/pnas.1006388108
PMid:21518879 PMCid:3102371

Peters, G., Davis, S.J., & Andrew, R. (2012). A synthesis of carbon in international trade. *Biogiosciences*, 9, 3247-3276. http://dx.doi.org/10.5194/bg-9-3247-2012

Reiter, S.L. (2010). Human Development and Foreign Direct Investment in Developing Countries: The Influence of FDI Policy and Corruption. *World Development*, 38(12), 1678-1691. http://dx.doi.org/10.1016/j.worlddev.2010.04.005

Rodrik, D. (2006) What's So Special about China's Exports? *China & World Economy,* 14(5), 1-19. http://dx.doi.org/10.1111/j.1749-124X.2006.00038.x

Sen, A. (1999a). *Commodities and Capabilities*, Oxford: Oxford University Press.

Sen, A. (1999b). *Development as Freedom*, New York: Anchor.

Schlosberg, D. (2009). Climate Justice, the Capabilities Approach, and Potential Policy Implications. Prepared for presentation at the final seminar in the series on The EU, Climate Change, and Global Environmental Governance, University of Edinburgh.

Sharma, B. & Gani, A. (2004). The Effects of Foreign Direct Investment on Human Development. *Global Economy Journal*, 4(2), Article 9. http://dx.doi.org/10.2202/1524-5861.1049

Shue, H. (1993). Subsistence Emissions and Luxury Emissions. *Law & Policy,* 15(1), 39-60. http://dx.doi.org/10.1111/j.1467-9930.1993.tb00093.x

Singer, P. (2004). One Atmosphere. In P.Singer (ed.). *One World: The Ethics of Globalization*. New Haven, CT: Yale University Press.

Stanton, E. A. (2007). The Human Development Index: A History, Political Economy Research Institute. UMass Amherst, Working paper series no. 127. Available at: http://www.peri.umass.edu/fileadmin/pdf/working_papers/working_papers_101-150/WP127.pdf

Steinberger, J. & Roberts T. (2010). From constraint to sufficiency: The decoupling of energy and carbon from human needs, 1975-2005. *Ecological Economics*, 425-433. http://dx.doi.org/10.1016/j.ecolecon.2010.09.014

Steinberger, J. Roberts, T. Peters, G. & Baiocchi, G. (2012). Pathways of human development and carbon emissions embodied in trade. *Nature Climate Change*. http://dx.doi.org/10.1038/nclimate1371

Suarez, C.E. (1995). Energy needs for sustainable human development. In J. Goldemberg, T.B. Johansson (Eds.) *Energy As An Instrument for Socio-Economic Development*. New York United Nations Development Programme.

Swart, R., Robinson, J., & Cohen, S. (2003). Climate change and sustainable development: expanding the options. *Climate Policy*, 3S1, S19-S40. http://dx.doi.org/10.1016/j.clipol.2003.10.010

Szlavik, J., & Csete, M. (2012). Climate and Energy Policy in Hungary. *Energies*, 5, 494-517. http://dx.doi.org/10.3390/en5020494

Tol, R. (2009). The Economic Effects of Climate Change. *Journal of Economic Perspectives*, 23 (2), 29–51. http://dx.doi.org/10.1257/jep.23.2.29

United Nations (1987). United Nations Report of the World Comission on Environment and Development, Our Common Future: Brundtland Report. Retrieved from http://www.worldinbalance.net/intagreements/1987-brundtland.php

United Nations Development Programme (UNDP). (2007*). Human Development Report 2007/2008, Fighting climate change: Human solidarity in a divided world*. New York, NY: Palgrave Macmillan. Available at: http://hdr.undp.org/en/reports/global/hdr2007-8/

United Nations Development Programme (UNDP). (2011). International Human Development Indicators. Available at: http://hdr.undp.org/en/statistics/hdi/

United Nations Environment Programme. (2012). Doha Climate Conference Opens Gateway to Greater Ambition and Action on Climate Change. UNEP News Centre Available at: http://www.unep.org/newscentre/default.aspx?DocumentID=2700&ArticleID=9353

Wiedmann, T., Lenzen, M., Turner, K., & Barrett, J, (2007). Examining the global environmental impact of regional consumption activities—Part 2: Review of input output models for the assessment of environmental impacts embodied in trade. *Ecol Econ,* 61:15–26. http://dx.doi.org/10.1016/j.ecolecon.2006.12.003

Wiedmann, T. (2009). A review of recent multi-region input-output models used for consumption-based emissions and resource accounting. *Ecol Econ*, 69:211–222. http://dx.doi.org/10.1016/j.ecolecon.2009.08.026

World Bank (2011) World Development Indicators. Retrieved February 18, 2013, from http://databank.worldbank.org/ddp/home.do

Chapter 5

ASSESSING THE LINK BETWEEN CARBON DIOXIDE EMISSION TRANSFERS AND HUMAN DEVELOPMENT ADVANCEMENT

Susan Spierre[1], Thomas P. Seager[2], Evan Selinger[3]

[1] School of Sustainability, Arizona State University, Tempe, AZ

[2] School of Sustainable Engineering and the Built Environment, Arizona State University, Tempe, AZ

[3] Department of Philosophy, Rochester Institute of Technology, Rochester, NY

Abstract

Efforts to stabilize the climate system will undoubtedly place limits on emissions of carbon dioxide (CO_2), a major green-house gas contributing to global warming but also the byproduct of fossil-fuel derived energy. These energy related restrictions threaten development progress because energy consumption and its resulting emissions are highly correlated with *human* development. If post-Kyoto policy discussions transition towards a universal mitigation system as policy discussions indicate, CO_2 limitations on the developing world may be detrimental to achieving society's development goals if not approached with caution. Therefore, this research evaluates the impact of emission reductions on underdeveloped nations to inform future climate policy. In particular, the relationship between internationally traded CO_2 (embodied in goods and services) and human development advancements (in terms of changes in the Human Development Index or HDI as well as the non-income HDI) in underdeveloped nations is examined from 1990 to 2010. In addition, HDI changes are correlated with different types of governing institutions of nations using the 2010 Polity IV dataset. We find that nations who are net exporters of CO_2, or have increased their exports of CO_2 over time,

experience the greatest gains in HDI and non-income HDI. Moreover, the underdeveloped nations with autocratic governance structures see the greatest improvements in HDI. We conclude that the establishment of *domestic capabilities* for manufacture and export at some level is important for sustainable development, which will undoubtedly generate increased CO_2. Thus, we recommend that CO_2 allocation, which under Kyoto was based on 1990 emission levels, be adjusted to consider the future development needs of underdeveloped nations.

Introduction

The economic, social, and environmental impacts of climate change are, and will continue to be, heterogeneous. The symptoms range from more frequent and intense storms in the United States like Superstorm Sandy, to the evacuation of islands in the South Pacific due to sea-level-rise, to water shortages, drought, and reduced crop yields in India, Brazil, and Argentina. A country's vulnerability to climate change depends on its geography, governance, financial resources as well as technological capabilities (World Bank, 2010a). Thus, the most vulnerable are individuals within the world's least developed nations, many of which depend on climate sensitive economic sectors like agriculture and lack the technological and financial resources to adapt (Beg et al., 2002). Yet, these individuals have made a minimal contribution to the climate change problem. In fact, a recent study found a significant *negative* correlation between per capita CO_2 emissions and vulnerability to climate among 120 nations (Samson, Berteaux, McGill, & Humphries, 2011). In other words, the people within underdeveloped countries are least responsible for greenhouse gas (GHG) emissions, yet are the most susceptible to the impacts of a warmer world.

The problem of climate change therefore only exacerbates the challenges of international development. Renewable-energy technologies are at least several decades away from substantially replacing oil, coal, and natural gas energy sources (Ayres & Ayres, 2010). Consequently, efforts to stabilize the climate system will undoubtedly place limits on emissions of carbon dioxide (CO_2), a major GHG contributing to global warming but also the byproduct of fossil fuel derived energy. These energy-related restrictions threaten development progress because energy consumption and its resulting emissions are highly correlated with achieved *human* development (Alam, Bala, Huq, & Matin 1991; Alam, Roychowdhury, Islam, & Huq, 1998; Suarez, 1995; Pasternak, 2000; Goldenberg, Rovere, Coelho, 2004; Dias, Mattos, Balestieri, 2006; Martinez & Ebenhack, 2008; Moran, Wackernagel, Kitzes, Goldfinger & Boutaud, 2008; Sanchez, 2010; Steinberger & Roberts, 2010; Mechtenberg et al., 2012; Steinberger, Roberts, Peters, Baiocchi, 2012; Spierre, Seager, Selinger, *in press*), which encompasses more than economic growth and relates to expanding the choices people have (Sen, 1999a, 1999b).

The reality is that about 1.6 billion people (almost a third of humanity) have no electricity, and up to a billion more only have access to unreliable electricity networks, and consequently lack essential energy services for schools, health centers and income generation (Birol, 2007; United Nations, 2010). For example, in 2011 only 41.5% of Zimbabwe's population had access to electricity (World Development Indicators, 2013), a factor (one of many) contributing to the relatively short life expectancy, small per capita income, and low mean years of schooling (51.4 years, $376 GNI per capita PPP, and 7.2 years, respectively in 2012) experienced by the average Zimbabwean (UNDP, 2013). Thus, the challenge for future climate policy is to effectively mitigate global GHG emissions without inhibiting human development progress for underdeveloped nations like Zimbabwe.

Currently, the United Nation's Framework Convention on Climate Change (UNFCCC) does recognize development as a priority for CO_2 allocation, under its principle of "common but differentiated responsibilities". This is codified in the Kyoto Protocol, which exempts developing nations (non-Annex I countries) from binding emission reduction targets required of developed nations (Annex I nations). Additionally, they can be the recipients of financed sustainable development projects in exchange for certified emission reduction credits that the developed nations use to comply with emission targets (known as the Clean Development Mechanism or CDM). Despite Kyoto, fossil fuel CO_2 emissions have grown 41% since 1990. Also, emissions generated in developed countries have generally stabilized, while emissions produced in the exempt developing countries have doubled (Le Quéré et al., 2009). Moreover, the major finding of a review article in *Climate Change* finds that the market-based CDM does not significantly contribute to sustainable development in developing countries, since sustainable benefits are not monetized and therefore do not drive investments (Olsen, 2007).

Given that the climate policy goals of the UNFCCC are contingent on the development trajectories of underdeveloped nations, improved methods of integrating mitigation policy with development objectives for future climate policy are needed (Schipper & Pelling, 2006). This is especially warranted now, as the details of Kyoto's predecessor are being determined. Discussions of post-Kyoto climate policy among world leaders (i.e., in Durban and Doha) indicate a transition towards mitigation commitments from all parties in the UNFCCC after 2015 (implemented in 2020). Due to the coupled nature of energy, CO_2 and development under current technology constraints, these CO_2 limitations on the developing world may be detrimental to achieving society's development goals (e.g., the Millennium Development Goals) if not approached with caution. Therefore, this research evaluates the impact of emission reductions on underdeveloped nations to inform future climate policy.

CO_2, Trade, and Development

Recent studies emphasize the criticality of CO_2 life-cycle considerations in climate policy design, due to the increasing trend of international trade flows of CO_2 in the globally economy (Carbon Trust, 2006, 2011; Peters & Hertwich, 2008; Weber & Matthews, 2007; Davis & Caldeira, 2010; Wiebe, Bruckner, Giljum, & Lutz, 2010; Davis, Peters, & Caldeira, 2011; Nakano et al., 2009; Peters et al. 2009; Peters, Minx, Weber & Edenhofer, 2011; Peters, Davis & Andrew, 2012). The basic idea is that in today's globalized economy, goods and services consumed in one country are often produced in another country. Known as *consumption-based* emission inventories, emissions generated during the production of goods and services are attributed to the consuming nation. Unlike territorial-based emission accounting (like those used by the UNFCCC to assess emission target compliance under Kyoto), consumption-based inventories show that most developed countries have increased their GHG emissions since 1990, despite their Kyoto commitments through the consumption of goods and services produced in developing nations (Peters et al., 2011). In fact, the net emission transfers from developing to developed countries increased from 0.4 $GtCO_2$ in 1990 to

1.6 Gt CO_2 in 2008, which exceeds the Kyoto Protocol reduction target of about 5% (or ~ -0.7 GtCO_2 relative to 1990 emissions (Peters et al. 2011). Consumption-based inventories also improve the correlation between per capita carbon emissions and human development indicators (Steinberger, Roberts, Peters & Baiocchi, 2012). Understanding the flow of international CO_2 trade is critical from a climate policy perspective, since it helps to elucidate the drivers of emissions, tells us who is ultimately benefiting from carbon intensive products, and indicates who is likely to suffer from CO_2 limiting policies.

Trade is also important for development, as extensive literature provides theoretical and empirical support for the notion that international trade (in general) is an ingredient for successful development (e.g., Stiglitz & Charlton, 2005; Rodrik, Subramanian, & Trebbi 2002; Mikic, 2011; Beck, 2002; Krueger, 1997). For example, trade allows access to needed resources at cheaper prices and in greater variety and qualities than would otherwise be available, and can enable specialization and reduction in the unit costs of production. Thus, trade influences income directly but can also facilitate cross-cultural knowledge and technology diffusion, which may promote both education and improved health services (Mikic, 2011; Davies & Quinlivan, 2006).

Alternatively, studies indicate that open trade policies do not automatically guarantee human development advancement. For example, governance structures may inhibit the link between trade and development (Haggard, 2004; Rodrick et al. 2002) and open trade policies may harm infant domestic industries in underdeveloped nations (Greenwald & Stiglitz, 2006). Also, the recent economic crisis has revealed that globalization has left many countries vulnerable to external shocks, especially in nations that depend on too few product exports and markets (Economic and Social Commission for Asia and the Pacific (ESCAP), 2009). The consensus is that in order for trade to transform into achieved human development improvements trade policies must be accompanied with appropriate institutional, regulatory and other reforms which are often implemented at the national level (Rodrik, 2001). Consequently, trade *can* be a mechanism for development if a society has sufficient capacity in other domestic areas.

Particular to the trade of embodied CO_2, Steinberger and Roberts (2010) indicate that CO_2 trade balances might also have implications for development. They find that many countries with low GDP and relatively short life expectancies are carbon importing nations that depend on carbon intensive goods and services produced elsewhere. At the same time they suggest that carbon-exporting economies (e.g., countries from former Soviet Union, Eastern Europe, Middle East and South Africa) are at a disadvantage in accruing socio-economic benefits, relative to net importers, since many of them remain below the global trend even when their emissions are corrected for trade (ibid). This finding contradicts the notion that trade can be a mechanism for development advancement.

Despite their relative disadvantage when compared with all carbon importers (many of which are highly developed nations), we hypothesize that developing and carbon-exporting countries may actually be at an advantage in terms of improving human development *relative to other underdeveloped nations*, especially if the appropriate governance structures are in place to transform export revenue into human development advancements. If substantiated, the implication is that the CO_2 required of developing nations to produce goods and services domestically may be warranted, even under a global mitigation system, if it is a viable option to escape the poverty trap and establish a process of self-sustaining development (Sachs et al., 2004; Bowles, Durlauf, & Koff, 2006). We investigate our hypothesis by comparing changes in human development over time to CO_2 emission trade data, authority characteristics of governing institutions, and income inequality within nations, for many underdeveloped countries. Because the goal is to inform global climate policy, the scale of this research prohibits the examination of specific trade and development linkages in every nation or region, although exemplarity nations are discussed. Instead, we employ statistical analysis to convey patterns of trade, governance, and development across many countries.

Methodology

Measuring Development

Defining and measuring development is a topic of extensive literature and depends on the values and frameworks employed within disciplines (e.g., Parris & Kates, 2003; Woolcock, 1998; Baster, 1972). Here, we are primarily concerned with the implications of CO_2 mitigation policies on human development related to energy services in underdeveloped nations. The notion that access to energy enables human capabilities related to desirable end-states like adequate health care, education, mobility, and communication stems from the Capabilities Approach developed by Amartya Sen and Martha Nussbaum (Nussbaum & Sen, 1992; Sen, 1999a, 1999b). Consequently, we employ a composite index, inspired by the Capabilities Approach and used by the United Nations Development Programme, for country level development known as the Human Development Index (HDI).

The HDI aggregates indicators of health (life expectancy at birth), education (combined measures of expected and mean years of schooling) and economic development (gross nation income per capita) for many countries. It therefore offers a broader measure of development than single component indicators, which is valuable when comparing the development of very diverse nations. However, it is important to recognize that composite indices like the HDI use techniques to average data and therefore do not offer insights into the inequalities present within nations, but is nevertheless informative for the current nation-based policy structure of the UNFCCC. For this research we are interested in a country's change in HDI associated with CO_2 emission transfers over time. Note that published HDI figures for different years are not comparable, since methodological adjustments occur between publications. However, the UNDP recalculates historical HDI figures using the current year's methodology. Here, we employ HDI figures from 1990 to 2010 using the 2010 HDI calculation methodology (for details see Klugman, Rodriguez, & Choi, 2011).

We also compare changes in non-income HDI values (equally weighted education and health indicators) with CO_2 emission transfers over time to account for cases where income may be driving increases in HDI yet may not be enabling improvements in health and education (e.g., countries that primarily export fossil fuels, such as Iran). It is these non-income components that allow us to examine the relationship between CO2 trade and improvements in the human condition**.** Our dependent variables are calculated using equation (1) and (2).

$$\Delta HDI = HDI_{2010} - HDI_{1990} \tag{1}$$

$$\Delta Non-income\ HDI = Non-income\ HDI_{2010} - Non-income\ HDI_{1990} \qquad (2)$$

Drawing Boundaries

We start our analysis by examining a 2010 snapshot of the CO_2-HDI relationship for the 77 countries that had adequate HDI and CO_2 data for this research. Figure 1 shows the relationship between 2010 HDI levels and consumption-based CO_2 emissions per capita (from Peters et al., 2011) and identifies which nations are net importers and exporters of embodied CO_2 emissions in goods and services (calculated by subtracting the net CO_2 emission transfers from territorial emissions of a nation). A pattern emerges from this relationship. In general, achieved HDI and per capita CO_2 tend to increase together, but at a diminishing rate. In the aggregate, the nations with the lowest HDI tend to be net importers, whereas the net exporters are predominately countries with medium levels of HDI (although many are net importers). Also it is apparent that most of the developed nations (above 0.8 HDI) are mostly net importers of CO_2. (The lone exception is Australia).

This figure helps us to narrow our investigation, since it illustrates a transition zone (around 0.8 HDI) between the predominately importing and highly developed nations (that have a wide range of per capita emissions) and the mixed group of exporting and importing countries with medium and low HDI values (that report a narrower range of per capita emissions). In our analysis we focus on the 42 nations in the latter category (enclosed in the dashed-red rectangle in Figure 10a), since these are the nations that are most likely to be constrained in terms of HDI improvements if CO_2 limitations are imposed. These nations all report less than 10 tons of per capita CO_2 emissions and were under the 0.8 HDI level in 2010.

We further categorize the 42 underdeveloped nations for analysis by dividing them into two groups based on their HDI level in 1990 (Figure 10b). This enables us to correlate changes in HDI among net importers and exporters who began the 1990 to 2010 time period with comparable development levels. The low developed countries (LDCs) are defined here as nations with HDI levels less than 0.5 in 1990. There are eighteen LDCs with 1990 HDI levels ranging from 0.2 to 0.497. The medium developed countries (MDCs) are characterized by HDI levels above 0.5 in 1990. There are 24 MDCs with HDI levels from 0.625 to 0.780.

Emission Transfers

As emphasized earlier, taking emission transfers into account when attributing CO_2 to a country, significantly changes the distributive view of emissions. Territorial-based inventories currently used by the UNFCCC only capture the production stage of the CO_2 supply chain (where emissions are generated), which can be misleading, especially if you're interested in understanding the drivers and/or benefits of CO_2 emissions to inform climate policy.

Fortunately, Peters et al. (2012) provides country level CO_2 *net emission transfer* data (defined as CO_2 emissions generated in each country minus the emissions in other countries to produce imported goods and services) from 1990 to 2010. The emission data include CO_2 from fossil-fuel and cement production but do not include emissions from land-use change, such as deforestation. This data also does not include physical transfers of carbon, such as traded fossil fuels (Davis et al., 2011). Note that the net emission transfers do include emissions generated by fossil-fuel extraction, but the emissions produced by burning traded fossil fuels is already encompassed by territorial emission

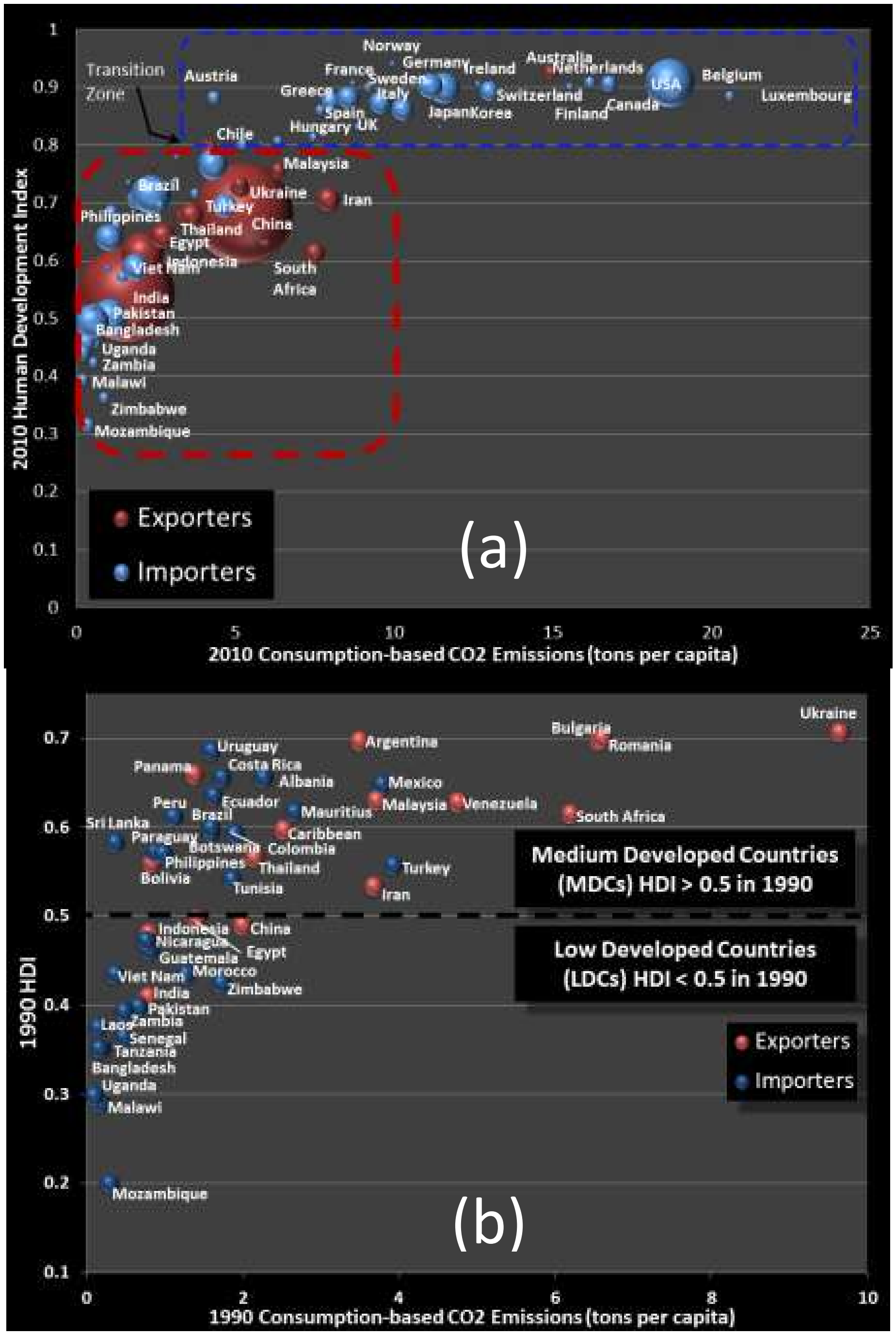


Figure 10. Both (a) and (b) compare per capita consumption-based CO_2 emissions (Peters et al., 2012) and HDI level for many countries. Red bubbles are net exporters; blue bubbles are net importers. In (a), 2010 data for countries at all development levels are shown, where the sizes of the bubbles indicate the relative population of each country. The nations enclosed in the red rectangle are the focus of this research, all of which have 2010 HDI levels below 0.8. In (b), 1990 data are shown for only the countries used in this analysis, which are divided into two categories: Medium Developed Countries (MDCs) and Low Developed Countries (LDCs).

inventories. To help clarify the methodology, consider the case where Norway extracts oil, exports it to the Netherlands where it is refined, and then exported to Germany to be used as transportation fuel. Peters et al. would allocate the emissions generated from extraction to the Netherlands, and the emissions generated from refinement to Germany. Nonetheless, understanding these net emission transfers is essential to quantify the embodied CO_2 for traded goods and services and allows us to: identify which MDCs and LDCs are net importers and exporters of embodied CO_2, compare their economic intensities of CO_2 trade, and examine how net emission transfers have changed over time.

First, we calculate the average net emission transfer (NET) for each country over the 1990 to 2010 time period and normalize to the nation's average Gross National Income (GNI) for the same time period to account for the size of a nation's economy (World Bank, 2013a). The result is a CO_2 intensity of average NETs of CO_2 embodied in traded goods, according to equation (2). Here, a negative (positive) CO_2 intensity indicates a nation is a net exporter (importer) of embodied CO_2.

$$CO2\ Intensity = \frac{\overline{NET}_{1990\ to\ 2010}}{\overline{GNI}_{1990\ to\ 2010}} \tag{2}$$

Second, to capture changes in economies over time (i.e., growth in intensities of CO_2 imports or exports) we calculate the slope of a least squares linear regression of the net emission transfers for the LDCs and MDCs from 1990 to 2010. We will compare both these independent variables to changes in HDI over the same time period (calculated using equation 1).

Governance Structure

To characterize the governance structures of nations, data from the Polity IV Project is employed. The quality of governance (in terms of democratic and autocratic authority in governing institutions) of a nation is captured in its *Polity score*, a 21 point scale ranging from -10 (hereditary monarchy) to +10(consolidated democracy). A nation's Polity score considers six components of a nation's central government structure that measure executive recruitment, constraints on executive authority, and political competition. It also records changes in the institutionalized qualities of governing authority. There is a three-part characterization of governance types: 'autocracies' (-10 to -6), 'anocracies' (-5 to +5), and 'democracies' (+6 to +10). Marshall and Cole (2011) define these types of governance structures as the following:

Democracies (+6 to +10). Characterized by institutions with 'open, competitive, and deliberative political participation; chooses and replaces chief executives in open, competitive elections; and imposes substantial checks and balances on the discretionary powers of the chief executive'. Elected governments that score less than a perfect +10 have 'weaker checks on executive power, some restrictions on political participation, or shortcomings in the application of the rule of law to, or by, opposition groups'.

Autocracies (-10 to -6). Characterized by institutions where 'citizens participation is sharply restricted or suppressed; chief executives are selected according to clearly defined (usually hereditary) rules of succession from within the established political elite; and, once in office, chief executives exercise power with no meaningful checks from legislative, judicial, or civil society institutions'. Autocracies scoring higher than -10 'allow some space for political participation or impose some effective limits on executive authority'.

Anocracies (-5 to +5). Characterized as 'institutions and political elites that are far less capable of performing fundamental tasks and ensuring their own continuity.

Anocratic regimes very often reflect inherent qualities of instability or ineffectiveness and are especially vulnerable to the onset of new political instability events, such as outbreaks of armed conflict, unexpected changes in leadership, or adverse regime changes'.

The Polity IV dataset covers all nations with populations over 500,000 from 1800-2011. Here we compare a country's change in HDI from 1990 to 2010 to their 2010 Polity score (Marshall, Jaggers, & Gurr, 2010). Note that the Polity data is open to critiques, like any other composite index, due to aggregation and redundancy issues. In particular, the Polity Index is criticized for its omission of an indicator of citizen participation but it is overall credited for it comprehensive empirical scope of democracy (Munck & Verkuilen, 2002).

Results

Average Intensities of CO_2 and Changes in HDI

Figure 11 displays the results of the comparison between average CO_2 intensities of NETs for both the LDCs (Figure 11a, top) and MDCs (Figure 11b, bottom). The figures confirm that there are few net exporters of CO_2 compared to the number of net importers, supporting the notion that CO_2 exports are predominately embodied in goods and services produced in China, India, and a few other emerging markets and consumed in the developed world (Davis et al., 2011). The two largest increases in HDI are exhibited by China (LDC in 1990) and Iran (MDC in 1990), respectively, which are both net exporters, although China has more than double the CO_2 intensity of Iran (169 compared with 69 ktCO_2 per billion dollars PPP). Tunisia comes in third, but is a net importer with relatively low CO_2 intensity. Overall, the mean change in HDI is slightly greater for both LDC and MDC exporters than importers (+0.11 and +0.10, respectively), which weakly supports our hypothesis.

Focusing on the LDCs for a moment, among the importers there is a large range of CO_2 intensities (from Pakistan's 27 to Mozambique's 334 $ktCO_2$/ billion dollars PPP) and changes in HDI (from Zimbabwe's -0.06 to Vietnam's +0.16). For the exporters (China, Egypt, India, and Indonesia), the range in CO_2 intensities is smaller (from Egypt's -26 to China's -169 ktCO2/billion dollars PPP). The change in HDI is also relatively high among all the LDC net exporters (from India's and Indonesia's +0.13 to China's +0.19). These four net exporters are also the nations that had HDI levels just below 0.5 in 1990. The LDC that stands out the most is China, a net exporter reporting an increase in HDI well over one standard deviation above the mean change. However, we also have Zimbabwe and Zambia, net importers with HDI changes much less than one standard deviation below the mean. Zimbabwe is the only LDC with a *decrease* in HDI from 1990 to 2010. The mean change in HDI for the LDCs is greater for exporters (+0.15) than importers (+0.10), which supports our hypothesis.

When we look just at the MDCs, the results are less clear. The net importers exhibit a smaller range in CO_2 intensities (from Chile's 4 to Latvia's 219 $ktCO_2$/billion dollars PPP) and changes in HDI (from Botswana's +0.037 to Tunisia's +0.156) when compared to the net exporters range of CO_2 intensities (from Bolivia's -19 to South Africa's -351 $ktCO_2$/billion dollars PPP) and HDI changes (from no change in South Africa to Iran's +0.173). The most notable nations are Iran, a net exporter with gains in HDI over one standard deviation of the mean change, but also Tunisia, a net importer that also achieves relatively large HDI improvements over the mean. However, we also have the net exporter of South Africa, which reports no overall change in HDI and a very high CO_2 intensity. The mean change in HDI for the MDCs is the same for importers and exporters (+0.10), which does not support our hypothesis.

Average Intensities of CO_2 and Changes in non-income HDI

By taking income out of the HDI calculation, we see a slightly different pattern of nations achieve the greatest changes in human development (Figure 12). China drops significantly down with only average gains in social indicators, with Egypt taking over the lead the LDCs. Zimbabwe and Zambia remain well-below other LDCs in terms of social development. For the MDCs, Iran actually increases its achievements in terms of social indicators and is the leading nation in terms of human development advancement measured by life expectancy and years of schooling. Tunisia and Turkey (net importers) also report relatively high improvements, the same as when income is included. Unfortunately, South Africa exhibits negative changes in non-income HDI. The other notorious fossil fuel exporting nation included in this analysis is Venezuela, who displays greater improvement in social indicators than when income is included.

Change in Net Emission Transfers and Changes in HDI

Figure 13 displays the results of the comparison between the change in NETs (calculated by taking the slope of the regression line when the yearly net emission transfers were plotted from 1990 to 2010) and change in HDI from 1990 to 2010 for the LDCs (Figure 13a, top) and the MDCs (Figure 13b, bottom). Thus, the nations in red are those that have experienced increases in net exports of embodied CO_2 and blue nations show increases in net imports of embodied CO_2 over the time period. Nations near the vertical axis have not experienced significant changes in their net trade of CO_2 over the examined time period.

Among the LDCs, the nations who were average net exporters also show growth in their exports of embodied CO_2 over time, although Morroco is new on the left side (which is on average a net importer but over time has increased its net exports). Also, China and India exhibit extreme growth. China increased its net exports of embodied CO_2 by 1.12 trillion metric tons of CO2 (a 685% increase from 1990) and India by 183 million metric tons of CO_2 (a 2,139% increase from 1990). On the other hand, Vietnam and Bangladesh achieve relatively high increases in HDI at the same time as they increase their net imports of embodied CO_2. Zimbabwe, which experienced a net decrease in HDI, exhibits no change in its net emission transfer. Also, Zambia shows a small increase in HDI while increasing its CO_2 imports.

The MDCs show a more even distribution, since 14 nations saw increases in their net imports and 10 increased their net exports of CO_2. For the most part, nations remain on the same side of the axis as in Figure 12b, but three average net importers (Turkey, Tunisia, Brazil) show increases in their net exports in Figure 13b. There are also two average net exporters (Venezuela and Bulgaria) who have experienced increases in their net imports of embodied CO_2. This is interesting, since the nations that move left (by increasing in net exports) are the average net importers with the greatest improvements in HDI. This is not the case for the nations moving right (by increasing net imports). Venezuela and Bulgaria exhibit HDI changes just above and below the mean change. The standouts are once again Iran and Tunisia, both achieving relatively high increases in HDI and both exhibiting overall increases in exported CO_2. On the other hand, South

Africa has also significantly increased its CO_2 exports yet experienced no change in HDI. Thailand also stands out as a nation that has large growth in exported CO_2, but its gains in HDI only slightly above the mean and about the same as Mexico who experienced relatively large growth in imported emissions.

Polity Score and Changes in HDI

Figure 14 shows the comparison between the 2010 Polity score and changes in HDI from 1990 to 2010. Overall, there is an indirect relationship between HDI advancements and democratic qualities of governing institutions. Among the medium and low developed countries we examined, the nations that achieved the greatest gains in HDI (China, Iran, Vietnam) are characterized as types of autocracies, where citizen participation is not a priority, but a strong central authority governs the nation. Tunisia, which experienced relatively high gains in HDI is classified as an anocracy (although it is much closer to an autocracy then a democracy). Zimbabwe, with its decrease in HDI from 1990 to 2010 is also in the anocracy category. Most nations (29/42) are identified as different types of democracies, many of which do experience HDI increases above the mean change, but not as high as some of the autocracies. South Africa, with no change in HDI, is one of these democratic nations (with a Polity score of 9).

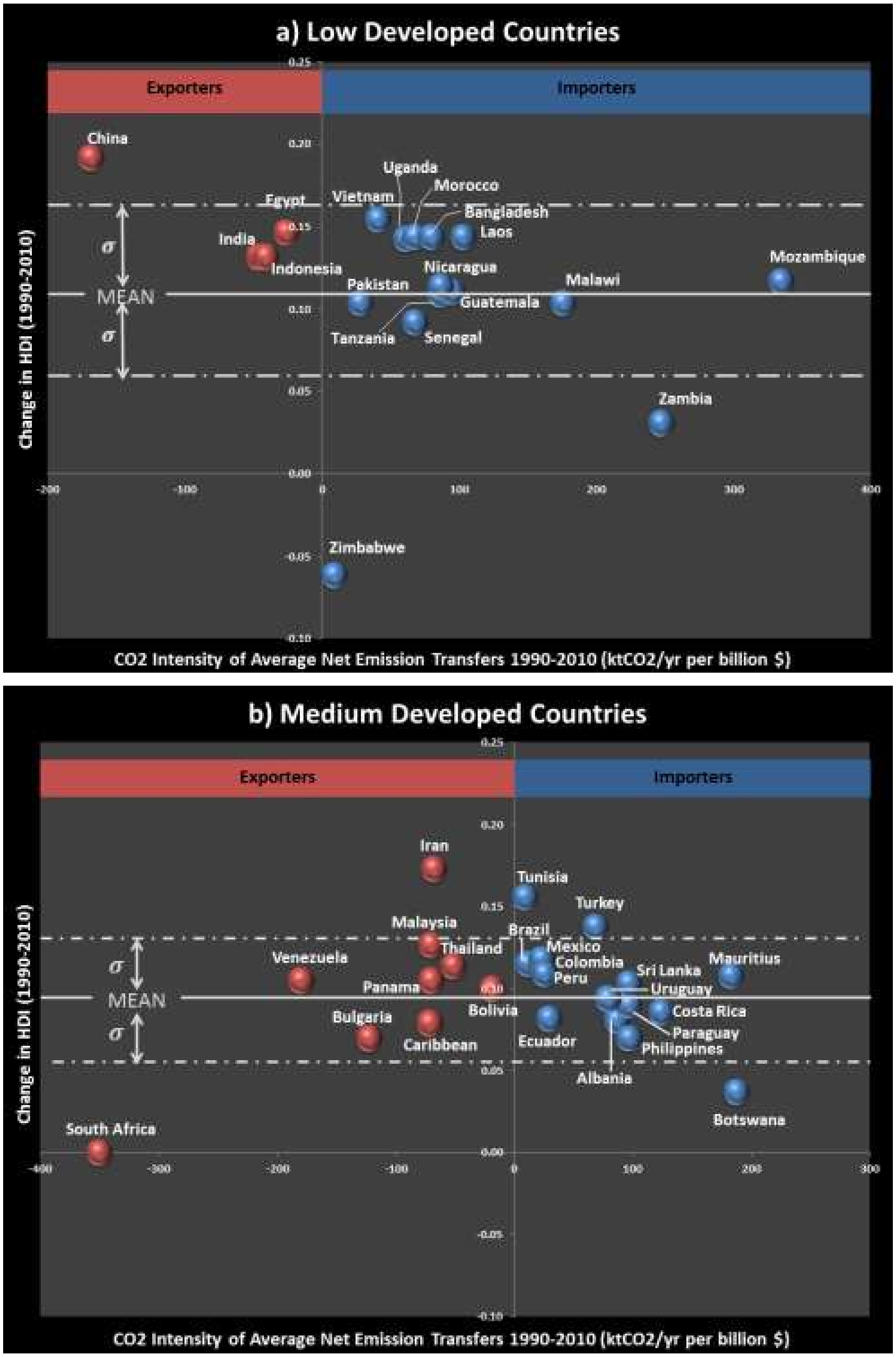


Figure 11. Comparison between average net emission transfers (normalized to total GNI) and change in HDI for a) LDCs (top), and b) MDCs (bottom). Blue bubbles are average net importers and red bubbles are average net exporters from 1990 to 2010. The mean and stand deviations are in each figure.

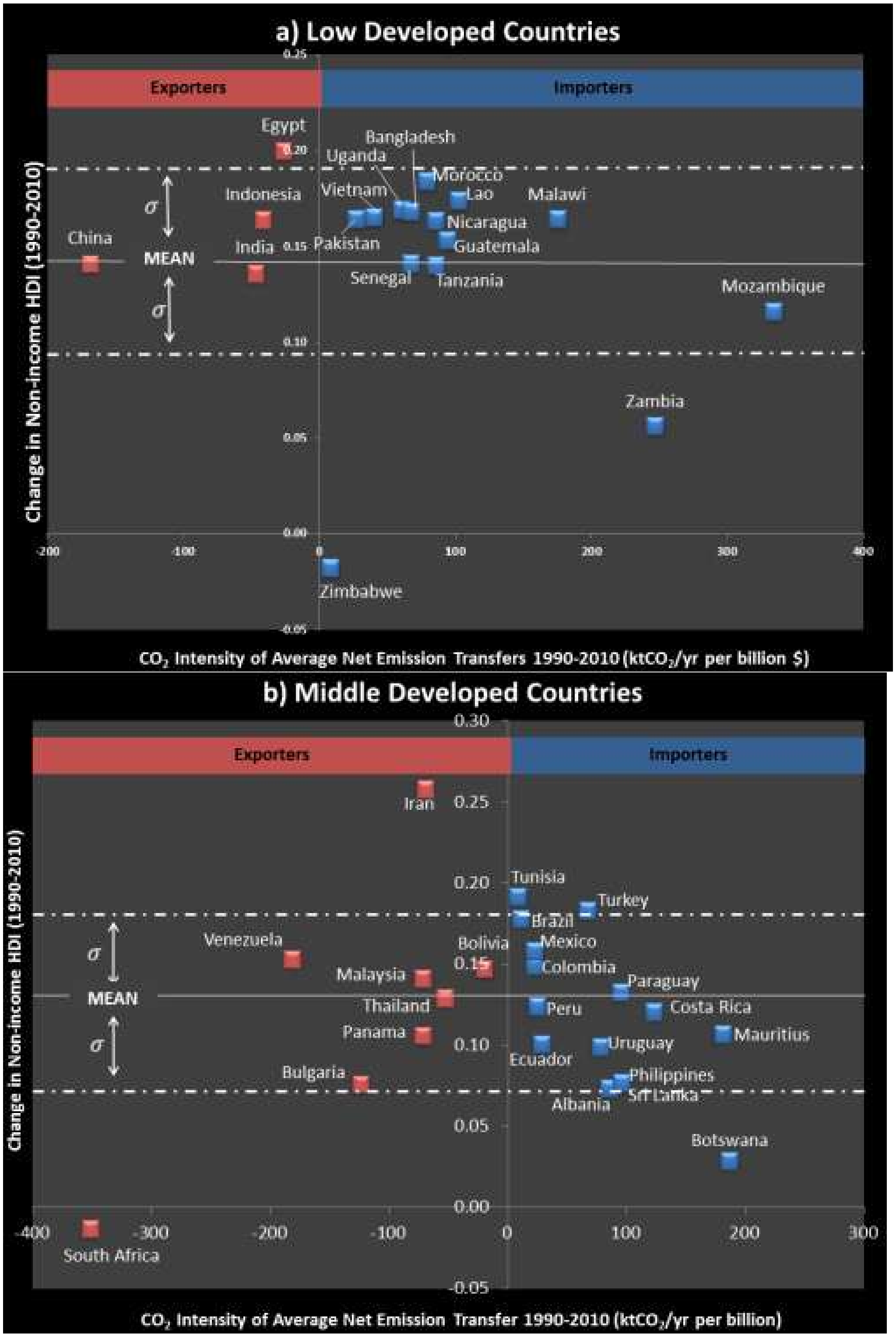


Figure 12. Comparison between average net emission transfers (normalized to total GNI) and change in non-income HDI for a) LDCs (top), and b) MDCs (bottom). Blue squares are average net importers and red squares are average net exporters from 1990 to 2010. The mean and stand deviations are indicated in each figure

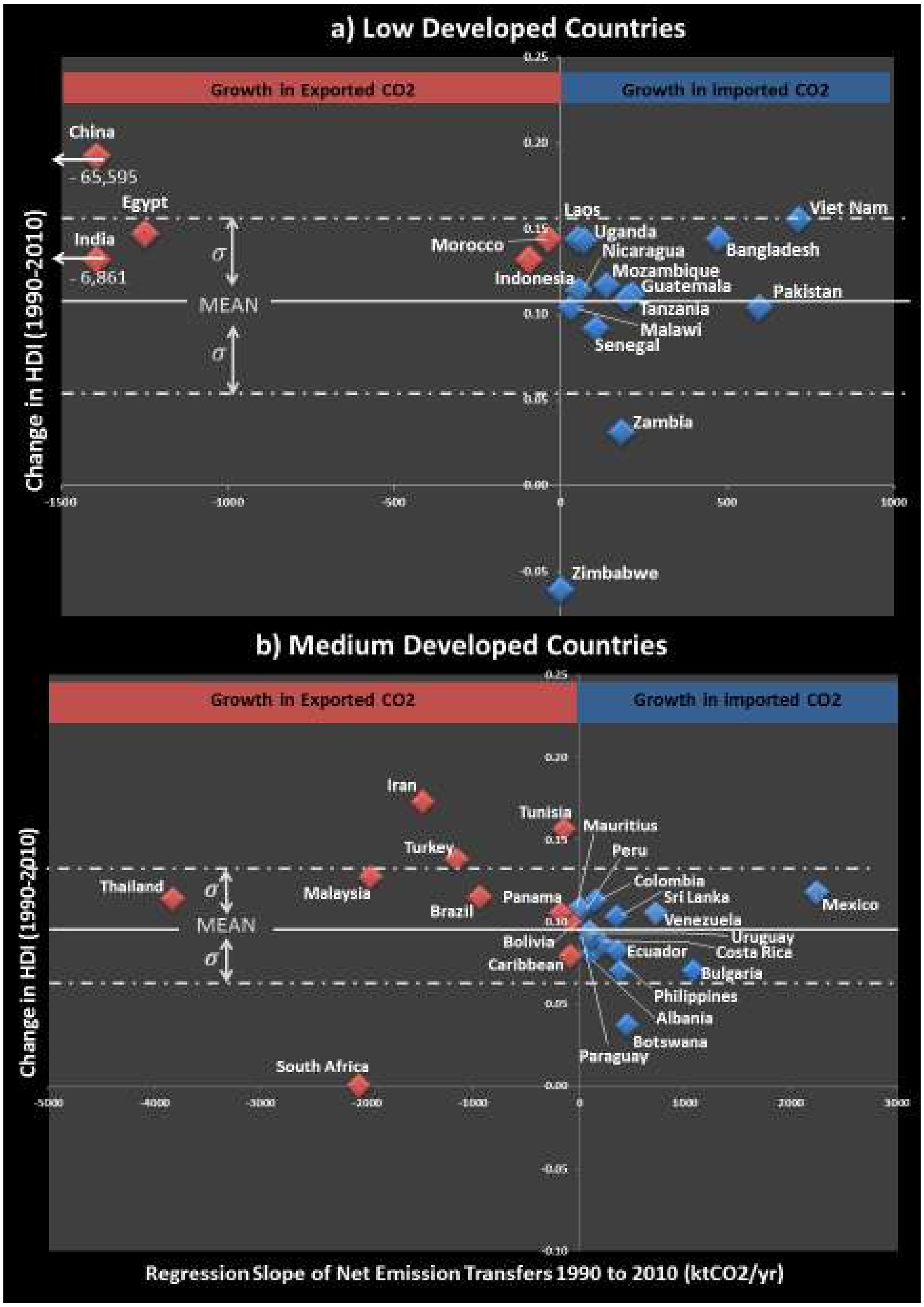


Figure 13. Comparison between the change in net emission transfers (slope of regression as transfers are plotted over the 1990 to 2010 period) and change in HDI for (a) LDCs (top), and (b) MDCs (bottom). Blue diamonds are countries that have increased their exports of embodied CO_2. Red diamonds are nations that have increased their imports of embodied CO_2. The mean and stand deviations of HDI changes are indicated in each figure.

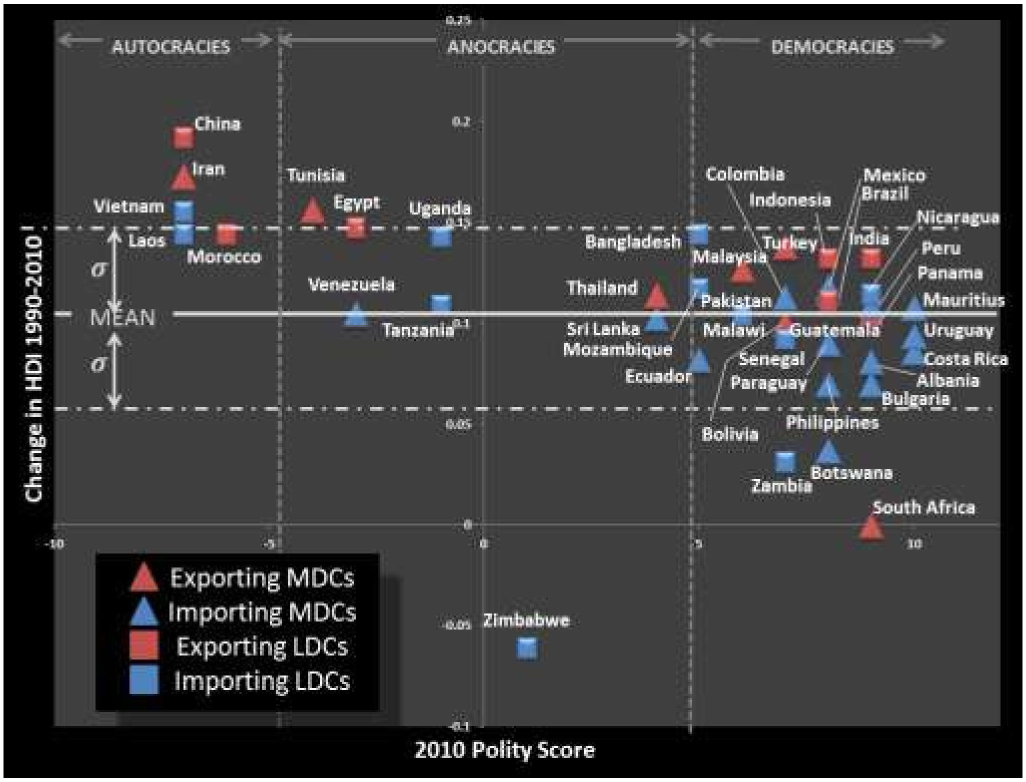


Figure 14. Comparison of 2010 Polity Score and Changes in HDI for both MDCs and LDCs. Nations with a Polity score between -10 and -6 are classified as autocracies, countries with Polity scores between -5 to +5 are anocracies, and nations scoring between +6 and +10 are democracies. Countries that have increased their CO_2 exports from 1990-2010 are shaded red and those that have increased their CO_2 imports are blue. The MDCs are denoted by triangles, whereas the LDCs are indicated with squares.

Discussion

While we recognize that every country has distinct social, economic, and environmental drivers of trade, our analysis does not elucidate these factors. For example, India and China are both major exporters that achieved relatively large gains in HDI, yet are very different in government style and culture. They are also arguably very different from many other nations in our analysis. With this in mind, our results and discussion are limited in terms of clarifying the specific causes behind HDI changes. Our goal is therefore to discuss some common trade attributes between nations with similar human development achievements.

Our analysis shows that some CO_2 exporting nations do experience great increases in HDI from 1990 to 2010 (i.e., China and Iran), and on average, net exporters perform slightly better than importers for the countries we examined. However, some net carbon importers also experience relatively high increases in HDI, such as Turkey and Tunisia for example (although not as high as some exporters). This indicates that nations *can* achieve relatively high improvements in HDI at a range of CO_2 trade balances and intensities, but a few nations that predominately export embodied CO_2 experience the highest gains in HDI. Interestingly, when we look at the non-income components of the HDI China performs significantly worse, yet Iran actually increases its gains in human development. The case for greater HDI advances through exporting CO_2 is strengthened by our regression analysis; top performers among the average net importers (e.g., Tunisia, Turkey, Brazil, Morocco) show overall growth in their CO_2 exports. Surprisingly, the Polity scores of nations indicate that the greatest gains in HDI were experienced by nations with non-democratic institutions.

The intensity of traded CO_2 for a nation does not seem to correlate with HDI success, since the most CO_2 intense economies (China, South Africa, Mozambique, and Zambia) exhibit a wide range of HDI advances. It is true that China exhibits a relatively high CO_2 intensity (the highest among the low developed nations) and achieves the highest gains in HDI, however other countries with relatively high HDI improvements (e.g., Iran, Tunisia, and Turkey) have modest CO_2 intensities of their emission transfers. The differences in CO_2 intensities stem from differences in the energy mixes of these nations. China and South Africa have relatively high CO_2 intensities due to their heavy reliance on coal for energy production, whereas Iran and Tunisia rely predominately on natural gas and oil sources, which have less carbon content (EIA, 2013).

Among the countries examined, China is the leader in HDI improvement from 1990 to 2010. Based on the non-income development data, China's success in terms of socio-economic indicators is driven mainly by GNI increases. China is an exporting country with relatively high CO_2 intensity for emission transfers and has experienced extreme growth in the embodied CO_2 it exports. In 2005, about a third of Chinese emissions were due to production of exports, which is a substantial increase from 12% in 1987 and 21% in 2002 (Weber et al., 2008). According to the literature, China's development gains are attributed to low labor and material costs, outward oriented trade, and government policies that require joint ventures between foreign and domestic firms, which encourage technological transfers that enhance domestic capabilities (McKinsey Global Institute, 2003; Rodrik, 2006; Park, 2009). Other studies indicate that the level of sophistication (Schott, 2006; Wang & Wei, 2010) and diversification (Lemoine & Unal-Kesenci, 2004; Feenstra & Kee, 2007) of China's manufactured exports has also contributed to recent growth. However, China's success and competition may be hurting other developing countries growth prospects (Gu, Humphrey, & Messner, 2007; Yang, 2003), and its dependency on coal-powered energy is not sustainable (Weber et al., 2008)

Iran comes in second for its gains in HDI, and first in non-income HDI over the time period. Iran is also an exporter, but its CO_2 emission transfers are less intense than China, and its growth in CO_2 exports, while strong, pale in comparison. Economic development in Iran is closely connected to oil revenues, which has contributed to steady growth in recent years, but sheds doubt on the sustainability of its growth path (Karshenas, 1990; Esfahani & Pesaran, 2008). However, Iran's growth in non-income development sectors suggests that oil revenues may be aiding the nation in providing better health care and educational opportunities to its citizens. It is important to note, however, that Iran comes in 76 in terms of the UNDP's Gender Inequality Index, which can negatively impact development progress (Klasen & Lamanna, 2009; Busse & Spielmann, 2006). In addition to the investments that Iran's oil revenues enabled, studies credit post-war recovery (in the early 1990's), institutional reform, deregulation and trade liberalization for Iran's development gains (Salarpour 2007; Esfahani & Pesaran, 2008). Also, in recent decades, Iran's non-oil exports have become more diversified and sophisticated (like China) as well as more geographically diverse, a result of U.S. trade sanctions (Amid & Hadjikhani, 2005; Esfahani & Pesaran, 2008)

Other exporters that see relatively high improvements in HDI are the Southeast Asian nations of Thailand, Malaysia, and Indonesia. These nations are three of the eight economies recognized for development successes in the World Bank's *East Asian Miracle* (1993) and the focus of many more recent economic and development studies (e.g., Kuznets, 1988; Storm and Naastepad, 2005; Haggard, 2004; Freeman & Hew, 2002; Page, 1994).There however remains little consensus on the specific determinants of this region's success (Kwon & Kang, 2011). Nevertheless, most studies acknowledge the role of manufacturing and mass production for export, their reliance on foreign direct investment (FDI) from multinational companies for capital, as well as their relatively cheap and well-educated labor force (Freeman & Hew, 2002).

Also, Turkey and Tunisia's relatively high HDI and non-income HDI improvements are noteworthy because they both have average importing trade balances yet their increasing trend towards exportation. In the case of Turkey, economic policies have become more outward oriented since 1980, including the establishment of a free market economy, export promotion policies, and new foreign investments. The variety of exports has also changed, from 1990-2002 the percentage of exported agricultural and husbandry products, as well as mining by-products, decreased substantially, while industrial products greatly increased (Alici & Sengun, 2003). In Tunisia, the World Bank has been leading a program aimed at increasing exports and removing trade constraints, including export initiatives and diversification of markets and products. According to the World Bank (2010b), the program had increased exports by more than $400 million from 2005 to 2009 and has created an estimated 98,500 new jobs. In particular, Tunisia has great export potential for health services in the Middle East and North Africa regions (Lautier, 2008).

Our analysis and evidence from the literature indicate that many of the countries with the greatest gains in HDI (and many with the greatest gains in non-income HDI) from 1990 to 2010 are also nations that have, or are in the process of moving toward, outward oriented trade policies which involve increased domestic capabilities for product manufacture and export. This is not surprising since domestic manufacture can facilitate innovation (Eaton & Kortum, 1997; Liu, 1997; Jin, Lee, & Kim, 2008) and knowledge spillovers (Howells, 2001), not to mention enable employment and income, all of which helps to establish and sustain long-term capabilities and enhance the well-being of communities and individuals. Studies also indicate that foreign direct investment may amplify socio-economic gains in developing countries because it drives technology transfers from more developed nations, but only if there is adequate absorptive capacity of the technologies in the host country (Borensztein, Gregorio, & Lee, 1998). Of course not all countries can realistically export their way to high HDI, as other factors certainly play a role in a nation's ability to transform direct benefits from exports into human development gains, including the government's involvement in trade policies, quality institutions, strong and able leadership, the diversification and sophistication of export products and markets, as well as an educated and skilled labor force. Maintaining a balance between open trade policies and protection of domestic interests appears to be critical for success (Lee and Mathews, 2010).

South Africa's results in particular indicate that outward oriented trade is not sufficient for socio-economic advancement. Social, economic and political challenges within these nations likely have impeded any human development benefit that would have otherwise accrued in these nations from CO_2 trade. South Africa's abolition of apartheid in 1990 played a role in HDI increases through the mid-1990's, but challenges such as high unemployment (Arora & Ricci, 2006; Kingdon & Knight, 2005), and the HIV/AIDS pandemic (Youde, 2007; Stephenson 2009) have contributed to declines in HDI more recently. Nearby Zimbabwe (a net importer) experienced a decline in HDI from 1990 -2010. Although the country also faces a severe epidemic of HIV/AIDS, the major decline in HDI is likely due to the country's land reforms (land was forcibly redistributed from whites to blacks starting in 2000), which lead to a sharp decline in agricultural exports and a severe currency shortage and hyperinflation (Matondi, 2002;

Richardson, 2004). The country also has sanctions imposed by the US and the EU due to human right abuses and other government actions (Vines, 2012).

The LDC nations of Mozambique, Malawi, and Zambia are all relatively CO_2 intense net importers with average to relatively modest gains in HDI. They are also the countries that receive the most Official Development Assistance (ODA) among the nations examined. On average, 35% of Mozambique's GNI was from ODA, followed by Malawi at 24%, and Zambia at 21% over the 1990 to 2010 time period (World Bank, 2013b), interestingly the same order as their magnitude in HDI changes. The received ODA has undoubtedly enabled these countries to import goods and services manufactured in other nations. For example, Malawi imports just under 70% of the goods and services it consumes from South Africa, the Middle East, India, China, and other countries (Davis et al., 2011). These nations depend on both foreign aid and imported goods for their livelihoods, which is arguably well below satisfactory standards. All three nations remain below 0.5 HDI levels in 2010.

Our examination of Polity scores of nations reveals some surprising insights into the types of institutions that may facilitate HDI advancements among underdeveloped nations, in particular. One would hypothesize that HDI improvements would tend to accrue more effectively in nations with democratic institutions, since public participation in elections and inherent checks and balances in the system ought to promote quality institutions that protect human and civil rights. This is precisely the dominate approach to development thinking which is echoed in many theoretical and empirical investigations (e.g., Lipset 1959, Pourgerami, 1988; Hurd, 1990). Yet others suggest that democracy is a luxury that can only be afforded after development is accomplished (e.g., De Schweinitz, 1959, La Palombara, 1963; Leftwich, 1993). According to Huntington and Nelson (1976, 23), “political participation must be held down, at least temporarily, in order to promote economic development”. Figure 14 shows evidence for the latter, that autocractic governments are associated with greater HDI gains in underdeveloped nations from 1990-2010. Marshall and Cole (2011) explain this finding in part by the fact that autocracies, although very different from democratic governance strategies, do have similar capacities to maintain central authority in terms of articulating uniform policy agendas and managing near term political dynamics, such as deep conflict between social groups. However, they also note that autocracies are more vulnerable to armed insurrections and separatism over the longer-term (Marshall & Cole, 2011, pg. 10). Note that many Africa nations included in this research decolonized relatively recently (following World War II, in the 1950’s and 1960’s), which is reflected in the less stable forms of government exhibited by many of these nations in Figure 14. We reason that a strong central government (whether it is democratic or autocratic) will have a greater ability to balance domestic interests with foreign investments, relative to less stable institutions, during the development process.

Regardless of the governance structure, it is clear that important for sustainable development. It is not only a mechanism for resiliency against external shocks (e.g., market prices, natural disasters, conflict), but it is also a driver of technological innovation and diffusion, as well as a means of maintaining diversity and competitiveness within the world market. We reason that the countries with domestic manufacturing capabilities, especially those that can enhance their capabilities through foreign investments, will not only experience an easier transition toward renewable energy technologies but will perhaps play a significant role in its development. However, the reality is that under current technology constraints, outward oriented development strategies mean increases in domestically generated CO_2, which conflicts with global climate policy.

Empirical evidence presented in this research indicates that the ability to emit CO_2 is at least a co-requisite in the export oriented development strategies of nations that attained the greatest gains in HDI from 1990-2010. Moreover, evidence in the literature support the notion that countries that do have domestic manufacture for export capabilities are more likely to self-sustain future development advances. Therefore, we reason that CO_2 limitations on underdeveloped nations will inhibit the potential gains from outward oriented trade policies. This is especially true if the CO_2 emission reduction targets for developing economies are based on current or past trends in domestic emissions, as was the case in allocating emission rights under Kyoto based on 1990 emission levels. That is, the method of CO_2 allocation rights in future climate policy is critical to development progress, since it will determine (and could potentially perpetuate) the location of major exporting processes.

Our concern is therefore primarily directed towards low developed nations that have yet to establish their niche in the world economy, many of which reside in Sub-Sahara Africa. For them, escaping the poverty trap and establishing self-sustained growth will require outside help in building their domestic capabilities (such as infrastructure, institutions and human capital) through increased ODA and trade reforms appropriate for the region before they can benefit from market-based sustained growth (Sachs et al., 2004). Once their capabilities are sufficient, our research indicates that their best hope is to invest in export oriented development strategies, which will undeniably result in increased CO_2 emissions. Therefore, to maintain development as a priority in future climate policy, it may be necessary for the UNFCCC to adjust past methods of determining emission targets and/or limitations if both developed and developing nations have legally-binding restrictions. We recommend that emission allocation should involve emission reductions among the already developed nations (e.g., nations with HDI greater than 0.8) and consideration for future human development needs in underdeveloped nations (e.g., nations below 0.8 HDI), which includes the ability to self-sustain export-oriented, and CO_2 generating, processes.

References

Alam, M.S., Bala, B.K., Huq, A.M.Z., Matin, M.A. (1991). A model for the quality-of-life as a function of electrical energy-consumption. *Energy* 16 (4), 739–745.

Alam, M.S., Roychowdhury, A., Islam, K.K., Huq, A.M.Z. (1998). A revisited model for the physical quality of life (PQL) as a function of electrical energy consumption. *Energy* 23 (9), 791–801.

Alici, A.A. & Sengun, M.S. (2003). Foreign Direct Investment, Exports and Output Growth of Turkey: Causality Analysis. Paper to be Presented at the European Trade Study Group (ETSG) Fifth Annual Conference. Deptember 11-13, 2003, Universidad Carlos III de Madrid

Amid, J. & Hadjikhani, A. (2005). *Trade, Industrialization and the Firm in Iran*. London: I.B. Tauris. ISBN 1850436819

Arora, V. & Ricci, L.A. (2006). Unemployment and the Labor Market. In Nowak, M. & Ricci, L.A. (eds.). *Post-Apartheid South Africa: the First Ten Years. International Monetary Fund. Retreievd from: http://www.imf.org/external/pubs/nft/2006/soafrica/eng/pasoafr/index.htm*

Baster, N. (1972). Measuring Development: The Role and Adequecy of Development Indicators. Totowa, NJ: Frank Cass and Company Limited.

Beck, T. (2002). Financial development and international trade: Is there a link? Journal of International Economics, 57(1), 107-131.

Beg, N., Morlot, J.C., Davidson, O., Afrane-Okesse, Y., Tyani, L., Denton, F., Sokona, Y., Thomas, J.P., La Rovere, E.L., Parikh, J.K., Parijh, K., Rahman, A.A. (2002). Linkages between climate change and sustainable development. Climate Policy,2, 129-144.

Birol, F. (2007). Energy Economics: A Place for Energy Poverty in the Agenda. *The Energy Journal,* 28(3), 1-6. http://dx.doi.org/10.5547/ISSN0195-6574-EJ-Vol28-No3-1

Borensztein, E., Gregorio, J.D., Lee, J.W. (1998). How does foreign direct investment affect economic growth? *Journal of International Economics*, 45, 115-135.

Bowles, S., Durlauf, S.N., & Koff, K. (2006). *Poverty Traps*. Princeton, NJ: Princeton University Press.

Carbon Trust. (2002). International Carbon Flows: Global Flows

Carbon Trust. (2006). The carbon emissions generated in all that we consume.

Davis, S.J., Peters, G.P., Caldeira, K. (2011). The supply chain of CO_2 emissions. *PNAS.* www.pnas.org/cgi/doi/10.1073/pnas.1107409108

Davis, S. & Caldeira, K. (2010). Consumption-based accounting of CO_2 emissions. *PNAS*, 107 (12) 5687-5692.

Davies, A., & Quinlivan, G. (2006). A Panel Data Analysis of the Impact of Trade on Human Development. The Journal of Socio-Economics, 35(5), 868-867.

Dias, R.A., Mattos, C.R., Balestieri, J.A.P., 2006. The limits of human development and the use of energy and natural resources. Energy Policy 34 (9), 1026–1031.

Eaton, J. & Kortum, S. (1997). Engines of growth: Domestic and foreign sources of innovation. *Japan and the World Economy*, 19(2). 235-259. http://dx.doi.org.ezproxy1.lib.asu.edu/10.1016/S0922-1425(97)00011-X

EIA (Energy Information Administration). (2013) Independent Statistics & Analysis. http://www.eia.gov/countries/data.cfm

ESCAP (2009). Asia-Pacific Trade and Investment Report 2009: Trade-led Recovery and Beyond. *United Nations publication*. ISBN: 978-92-1-120586-2

Esfahani, H.S. & Pesaran, M.H. (2008) Iranian Economy in the Twentieth Century: A Global Perspective. Cambridge Working Papers in Economics, number 0815. Retrieved from: http://www.dspace.cam.ac.uk/bitstream/1810/229367/2/0815.pdf

Feenstra, R.C. & Kee, H.L. (2007) Trade Liberalization and Export Variety: A Comparison of Mexico and China. *The World Economy*, 30(1), 5-21.

Freeman, N.J. & Hew, D. (2002) Introductory Overview: Rethinking the East Asian Development Model. ASEAN Economic Bulletin, 19(1), 1-5. http://www.jstor.org/stable/25773705

Goldenberg, J., La Rovere, E.L., Coelho, S.T. (2004). Expanding access to electricity in Brazil. *Energy for Sustainable Development*, 8(4), 86-94.

Greenwald, B. & Stiglitz, J.E. (2006). Helping Infant Economies Grow: Foundations of Trade Policies for Developing Countries. American Economic Review, 96(2), 141-146. http://www.jstor.org/stable/10.2307/30034630

Gu, J., Humphrey, J. and Messner, D. (2007). Global Governance and Developing Countries: The Implications of the Rise of China. Bonn, Germany: The German Development Institute. ISBN: 978-3-88985-356-1

Haggard, S. (2004). Institutions and Growth in East Asia. *Studies in Comparative International Development*, 38(4), 53-81.

Howells, J.R.L. (2001). Tacit Knowledge, Innovation and Economic Geography. Urban Studies, 39 (5-6), 871-884.

Huntington, S.P. & Nelson, J.M. (1976*). No easy choice: Political participation in developing countries*. Cambridge, MA: Harvard University Press.

Hurd, D. (1990). Promoting good government. Crossbow, Autumn, 4-5.

Matondi, P.B. (2002). Fast Track Land Reform in Zimbabwe. *Human Rights Watch,* 14(1). Retrieved from: http://www.hrw.org/reports/2002/zimbabwe/ZimLand0302.pdf

Jin, F., Lee, K., Kim, Y-K. (2008). Changing Engines of Growth in China: From Exports, FDI and Marketization to Innovation and Exports. *China & World Economy,* 16(2), 31-49.

Karshenas, M. (1990). *Oil, State, and Industrialization in Iran*. New York, NY: Cambridge University Press.

Kingdon, G. & Knight, J. (2005). Unemployment in South Africa, 1995-2003: causes, problems and policies. Global Poverty Research Group. Retrieved from: http://economics.ouls.ox.ac.uk/14073/1/gprg-wps-010.pdf

Klugman, J., Rodriguez, F., & Choi, H.J. (2011). Human Development Research Paper 2011/01: The HDI 2010: New Controversies, Old Critiques. Available at: http://hdr.undp.org/en/reports/global/hdr2011/papers/HDRP_2011_01.pdf

Krueger, A.O. (1997). Trade Policy and Economic Development: How We Learn. *The American Economic* Review, 87(1), 1-22.

Kuznets, P.W. (1988). An East Asian Model of Economic Development: Japan, Taiwan, and South Korea. Economic Development and Cultural Change, 36(3), S11-S43

Kwon, J.K., Kang, J.M. (2011). The East Asian Model of Economic Development. *Asian-Pacific Economic Literature*, 25(2), 116-130.

LaPalombara, J. (1963). *Bureaucracy and political development.* Princeton: Princeton Univ. Press.

Lautier, M. (2008). Export of health services from developing countries: The case of Tunisia. Social Science & Medicine, 67(1), 101-110.

Lee, K. & Mathews, J.A. (2010). From Washington Consensus to BeST Consensus for world development. Asian Pacific Economic Literature, 24(1), 86-103.

Le Quéré C., Raupach, M.R., Canadell, J.G., Marland, Bopp, L., Ciaia, P., …Woodward, F. I. (2009). Trends in the sources and sinks of carbon dioxide. *Nature Geoscience,* 2, 831–836. http://dx.doi.org/10.1038/ngeo689

Leftwhich, A. (1993). Governance, Democracy and Development in the Third World. *Third World Quarterly*, 14(3), 605-624.

Lemoine, F. & Unal-Kesenci, D, (2004). Assembly Trade and Technology Transfer: The Case of China. World Development, 32(5), 829-850. http://dx.doi.org/10.1016/j.worlddev.2004.01.001

Lipset, S.M. (1959). Some Social Requisites of Democracy: Economic Development and Political Legitimacy. *American Political Science Review*, 53, 69–105.

Liu, X. (1997). The relative contributions of foreign technology and domestic inputs to innovation in Chinese manufacturing industries. *Technovation, 17(3), 119-125. http://dx.doi.org/10.1016/S0166-4972(96)00090-9*

Marshall, M.G., Cole, B.R. (2011). Global Report 2011: Conflict, Governance, and State Fragility. Center for Systemic Peace. Available at: http://www.systemicpeace.org/GlobalReport2011.pdf

Marshall, M.G., Jaggers, K., & Gurr, T.R. (2011). Polity IV Project: Dataset Users' Manual. Center for Systemic Peace: Polity IV Project. Available at: http://www.systemicpeace.org/inscr/p4manualv2010.pdf

Martínez, D. M. & Ebenhack, B.W. (2008). Understanding the role of energy consumption in human development through the use of saturation phenomena. *Energy Policy,* 36,1430–1435. http://dx.doi.org/10.1016/j.enpol.2007.12.016

McKinsey Global Institute. (2003). New Horizons: Multinational Company Investment Developing Economies, McKinsey Global Institute, San Francisco

Mechtenberg, A., Borchers, K. Miyingo, E.W., Hormasji, F., Hariharan, A., Makanda, J.V., Musaazi, M.K. (2012). Human power (HP) as a viable electricity portfolio option below 20 W/Capita. *Energy for Sustainable Development*, 16, 125-145. http://dx.doi.org/10.1016/j.esd.2011.12.006

Mikic, M. (2011). Role of trade in development and overview of Asia-Pacific LDCs' performance in trade and investment. In United Nations ESCAP (ed.). Trade beyond Doha: Prospects for Asia-Pacific Least Developed Countries, Studies in Trade and Investment 76. Retrieved from: http://www.unescap.org/tid/publication/tipub2625-chap1.pdf

Moran, D.D., Wackernagel, M., Kitzes, J.A., Goldfinger, S.H., & Boutaud, A. (2008). Measuring sustainable development – nation by nation. *Ecological Economics*, 64 (3), 470–474. http://dx.doi.org/10.1016/j.ecolecon.2007.08.017

Nakano, S., Okamura, A., Sakurai, N., Suzuki, M., Tojo, Y., Yamano, N. (2009). The Measurement of CO_2 Embodiments in International Trade: Evidence from the Harmonised Input-Output and Bilateral Trade Database. OECD Science, Technology and Industry Working Papers, 2009/03, OECD Publishing. http://dx.doi.org/10.1787/227026518048

Nussbaum, M., A. Sen. (1992). *The Quality of Life*, Oxford: Oxford University Press. ISBN 9780198287971Olsen, 2007

Olsen, K.H. (2007). The clean development mechanism's contribution to sustainable development: a review of the literature. Climate Change, 84, 59-73. DOI 10.1007/s10584-007-9267-y

Page, J. (1994).The East Asian Miracle: Four Lessons for Development Policy. In Fischer, S. and Rotemberg, J. (eds). *NBER Macroeconomics Annual 1994*, Volume 9. MIT Press Retrieved from http://papers.nber.org/books/fisc94-1

Park, B. II. (2011). Knowledge transfer capacity of multinational enterprises and technology acquisition in international joint ventures. *International Business Review*, 20(1), 75-87. http://dx.doi.org/10.1016/j.ibusrev.2010.06.002

Parris, T.M. & Kates, R.W. (2003). Characterizing and Measuring Sustainable Development. Annual Review of Environmental Resources, 28, 59-86.

Pasternak, A.D., (2000). Global Energy Futures and Human Development: a framework for analysis. US Department of Energy, Oak Ridge.

Peters, G.P., & Hertwich, E.G., (2008). CO_2 embodied in international trade with implications for global climate policy. *Environmental Science & Technology*, 42 (5), 1401–1407. http://dx.doi.org/10.1021/es072023k

Peters, G. Marland, G., Hertwich, E.G., Saikku, L., Rautiainen, A., Kauppi, P.E. (2009). Trade, transport, and sinks extend the carbon dioxide responsibility of countries: An editorial essay. Climate Change, 97, 379-388. DOI 10.1007/s10584-009-9606-2

Peters, G.P. (2010). Managing carbon leakage. *Carbon Management* 1:35–37.

Peters, G., Minx, J.C., Weber, C., & Edenhofer, O. (2011). Growth in emission transfers via international trade from 1990-2008. *PNAS*, 108(21), 8903-8908. http://dx.doi.org/10.1073/pnas.1006388108
PMid:21518879 PMCid:3102371

Peters, G., Davis, S.J., & Andrew, R. (2012). A synthesis of carbon in international trade. *Biogiosciences*, 9, 3247-3276. http://dx.doi.org/10.5194/bg-9-3247-2012. Data may be downloaded with this link: http://dx.doi.org/10.3334/CDIAC/GCP_V2012

Pourgermani, A. (1988). The political economy of development: A cross-national causality test of development-democracy-growth hypothesis. *Public Choice*, 58, 123-141.

Rodrik, D. (2001). The Global Governance of Trade as if Development Really Mattered. Trade and Human Development Series, UNDP, New York

Rodrik, D., Subramanian, A., & Trebbi, F. (2002). Institutions Rule: The Primacy of Institutions over Geography and Integration in Economic Development. NBER Working Paper No. 9305. http://www.nber.org/papers/w9305

Rodrik, D. (2006). What's So Special about China's Exports? *China & World Economy,* 14(5), 1-19. http://dx.doi.org/10.1111/j.1749-124X.2006.00038.x

Richardson, C. (2004). *The collapse of Zimbabwe in the wake of the 1000-2003 land reforms*. Edwin Mellen Press.

Sachs, J. McArthur, J.W., Schmidt-Traub, G. Kruk, M., Bahadur, C., Faye, M., and McCord, G. (2004). *Ending Africa's Poverty Trap*. Economic Studies Program, The Brookings Institution, vol. 35(1), pages 117-240.

Salarpour, M. (2007) The impact of trade liberalization on the Iranian economy. **A** paper for the ICBM Bangkok

Sanchez T. (2010). *The hidden energy crisis: how policies are failing the world's poor*. Practical action.

Samson, J., Berteaux, D., McGill, B.J., Humphries, M.M. (2011). Geographic disparities and moral hazards in the predicted impacts of climate change on human populations. Global Ecology and Biogeography, 20(4), 532-544.

Schipper, L. & Pelling, M. (2006). Disaster risk, climate change and international development: scope for, and challenges to, integration. Disasters, 30(1). 19-38.

Schott, P.J. (2006) The Relative Sophistication of Chinese Exports. National Bureau of Economic Research, Working Paper 12173. http://www.nber.org/papers/w12173

De Schweinitz, K. (1959). Industrialization, Labor Controls, and Democracy. *Economic Development and Cultural Change*, 7 (4), 385-404.

Sen, A. (1999a). *Commodities and Capabilities*, Oxford: Oxford University Press.

Sen, A. (1999b). *Development as Freedom*, New York: Anchor.

Steinberger, J. & Roberts T. (2010). From constraint to sufficiency: The decoupling of energy and carbon from human needs, 1975-2005. *Ecological Economics*, 425-433. http://dx.doi.org/10.1016/j.ecolecon.2010.09.014

Steinberger, J., Roberts, T. Peters, G. & Baiocchi, G. (2012). Pathways of human development and carbon emissions embodied in trade. *Nature Climate Change*. http://dx.doi.org/10.1038/nclimate1371

Stephenson, J. (2009). AIDS in South Africa. *The Journal of the American Medical Association*, 302(3) doi:10.1001/jama.2009.1013.

Stiglitz, J.E., & Charlton, A. (2005). *Fair trade for all: how trade can promote development*. Oxford University Press

Storm, S. & Naastepad, C.W.M. (2005). Strategic Factors in Economic Development: East Asian Industrialization 1950 - 2003 , *Development and Change.* **36** (6) 1059-1094.

Spierre, S.G., Seager, T.P., Selinger, E. (Accepted) The 2010 Human Development Index: Implications for Sustainable Development and Climate Policy. *Sustainable Development.*

Suarez, C.E. (1995). Energy needs for sustainable human development. In J. Goldemberg, T.B. Johansson (Eds.) *Energy As An Instrument for Socio-Economic Development*. New York United Nations Development Programme.

UNDP (United Nations Development Programme). (2013). Zimbabwe Country Profile: Human Development Indicators. http://hdrstats.undp.org/en/countries/profiles/ZWE.html

United Nations. (2010). Energy for a Sustainable Future: Report and Recommendations, New York. Available at: http://www.un.org/millenniumgoals/pdf/AGECCsummaryreport%5B1%5D.pdf

Vines, A. (2012). The effectiveness of UN and EU sanctions: lessons for the tewenty-first century. International Affairs, 88(4), 867-877.

Wang, Z. & Wei, S.J. (2010). What Accounts for the Rising Sophistication of China's Exports? In Feenstra, R.C. & Wei, S-J (eds.) *China's Growing Role in World Trade.* University of Chicago Press http://www.nber.org/chapters/c10449

Weber, C.L., Matthews, H.S. (2007). Embodied environmental emissions in U.S. international trade, 1997–2004. *Environmental Science & Technology,* 41(14), 4875–4881. http://dx.doi.org/10.1021/es0629110

Weber, C.L., Peters, G.P., Guan, D. and Hubacek, K. (2008) *The contribution of Chinese exports to climate change,* Energy Policy, Volume 36 (9), 3572 - 3577.

Wiebe, K.S., Bruckner, M. Giljum, S., Lutz, C. (2012). Calculating Energy-Related CO_2 Emissions Embodied in International Trade Using Global Input-Output Model. Economic Systems Research, 24(2), 113-139.

Woolcock, M. (1998). Social capital and economic development: Toward a theoretical synthesis and policy framework. Theory and Society, 27(2), 151-208.

World Bank. (2010a). Development and Climate Change. World Bank Publications. Available at: http://web.worldbank.org

World Bank. (2010b). Aid-for-Trade: Case Story. Export Development Project, Tunisia. http://www.oecd.org/aidfortrade/48288694.pdf

World Bank. (2013a). GNI per capita, PPP (current international $). Available at: http://data.worldbank.org/indicator/NY.GNP.PCAP.PP.CD

World Bank. (2013b). Access to electricity (% of population). Available at: http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS

Yang, Y. (2003). China's Integration into the World Economy: Implications for Developing Countries. IMF Working Paper.

Youde, J. (2007). *AIDS, South Africa, and the Politics of Knowledge*. Ashgate Publishing Group.

Chapter 6

A DEVELOPMENT-BASED APPROACH TO GLOBAL CLIMATE POLICY

Susan G. Spierre[1], Thomas P. Seager[2], Evan Selinger[3]

[1] *School of Sustainability, Arizona State University*

[2] *School of Sustainable Engineering and the Built Environment, Arizona State University*

[3] *Department of Philosophy, Rochester Institute of Technology*

Abstract

Defined as an economic problem, the traditional approach to addressing climate change is to reduce the cost of greenhouse gas (GHG) mitigation through market-based mechanisms, which enables an economically efficient allocation of emissions. However, from a human development perspective the market-based approach to emission allocation might not be appropriate, considering the value it places on social well-being. Therefore this research builds on previous empirical work to provide a framework for conceptualizing the relationship between CO_2 and human development. The framework enables a critical examination of policy prescriptions that employ market-based methods for emission allocation in their ability to address human development inequities. Lastly, we offer a novel climate policy proposal aimed at preventing unintended human development consequences that satisfy the following three criteria: 1) places the greatest restrictions on the most developed nations, 2) restrictions placed on underdeveloped nations are based on future human development need, and 3) emissions trading is prohibited between countries of different development levels.

Introduction

As Sunita Narain, director of India's Society for Environmental Communications, pointed out in a recent lecture, "no country has de-linked economic growth from CO_2 emissions". Thus, the relationship between economic growth (e.g., in terms of gross domestic product or gross national income) and CO_2 is understood to be more or less a direct relationship (Figure 15), although the existence of an 'Environmental Kuznets Curve' (the notion that nations reach a turning point in their economic development that enables emission reductions from efficient infrastructure and environmental controls) is still debated (e.g., Steinberger, Roberts, Peters, & Baiocchi,2010; Borhan, Ahmed, & Hitam, 2012; Stern, 2010). Either way, the interdependencies between CO_2 and economic growth are problematic for developing nations, given that efforts to stabilize the climate system will undoubtedly place limits on emissions of carbon dioxide (CO_2), a major GHG contributing to global warming. Defined as an economic problem, the traditional approach to addressing climate change (and other environmental pollution issues) is to reduce the cost of GHG mitigation through market-based mechanisms such as emissions trading or a carbon tax. This enables an economically efficient allocation of emissions, since parties that can make significant reductions inexpensively will, and those that find reductions too expensive will instead pay for their right to emit.

More recent development and policy studies look more broadly at the relationship between CO_2 and *human development,* which encompasses economic and social indicators, such as measures of health and educational attainment. Human development therefore considers more than the distribution of resources, but to also captures some of the common end-states of development progress that resources, like income, can enable

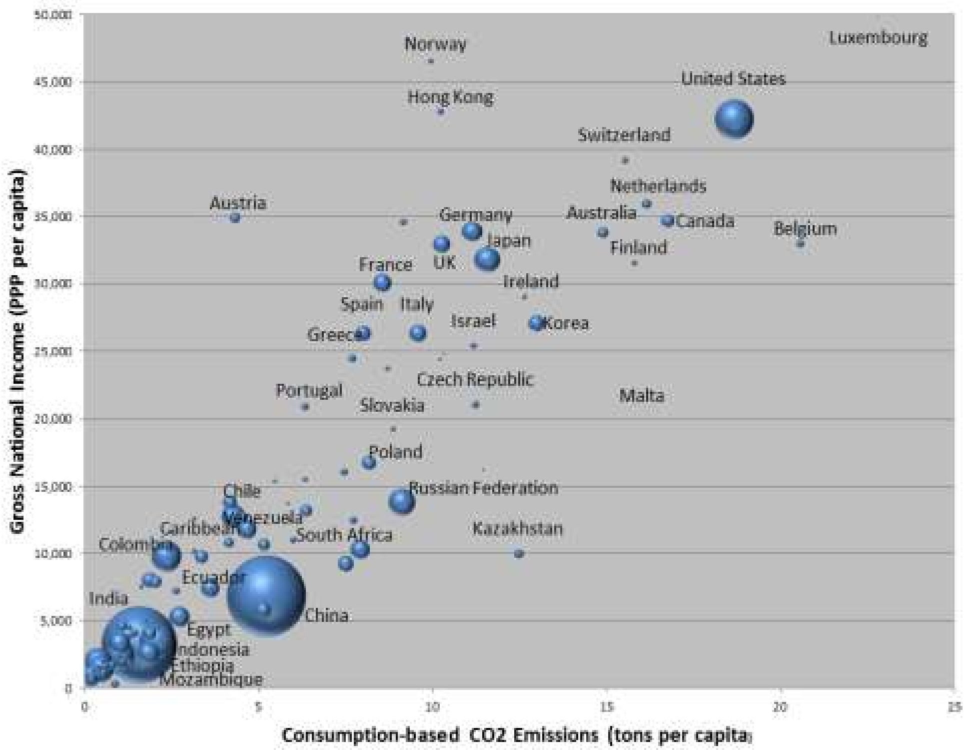


Figure 15. Comparison between consumption-based CO2 emissions (where the emission generated in the production of goods and services get allocated to the consuming nation) and gross national income (GNI) for many nations. CO2 emission data provided Peters et al. (2011), GNI data downloaded from the UNDP.

(Sen 1999a, 1999b; Nussbaum and Sen, 1992). These aspects are critical to consider in the context of climate change policy because energy-related restrictions may inhibit the ability of underdeveloped nations to provide essential energy services to citizens. In fact, 1.6 billion people (almost a third of humanity) have no electricity, and up to a billion more only have access to unreliable electricity networks, and consequently lack essential energy services for schools, health centers and income generation (Birol, 2007; United Nations, 2010). Thus, energy consumption and its resulting emissions are highly correlated with achieved human development (Alam, Bala, Huq, & Matin 1991; Alam, Roychowdhury, Islam, & Huq, 1998; Suarez, 1995; Pasternak, 2000; Goldenberg, Rovere, Coelho, 2004; Dias, Mattos, Balestieri, 2006; Martinez & Ebenhack, 2008; Moran, Wackernagel, Kitzes, Goldfinger & Boutaud, 2008; Sanchez, 2010; Steinberger & Roberts, 2010; Mechtenberg et al., 2012; Steinberger, Roberts, Peters, Baiocchi, 2012; Spierre, Seager, Selinger, in press).

In addition, Spierre et al. (in press) confirm that there are diminishing returns to human development (in terms of the United Nations Human Development Index or HDI) to increasing CO_2 emissions among nations that is independent of the HDI functional form and inherent to the social indicators included in the index (life expectancy and years of schooling) (Figure 16). From a human development perspective, the usual market-based approach to emission allocation might not be appropriate, considering the value it places on social well-being. Moreover, the diminishing returns to HDI from increasing emissions indicates that economic losses from GHG mitigation in developed nations may not be as critical to human development progress as an economic analysis would predict. This questions the viability of economic driven mechanisms to effectively address human development inequities around the world.

Development Equity Concerns

Allocating GHG emissions based on development equity has also been acknowledged across the ethics literature (e.g., Jamieson, 1992; Singer, 2004; Gardiner, 2004; Shue, 1993; Lomborg, 2001; Baer, 2009). In *A Theory of Justice* (1971), John Rawls asserts that inequalities in distribution are justified only if they work to the advantage of, or a minimum do not harm, the worst off. In the context of climate change, the principle suggests that the most vulnerable populations (which are also the least developed nations) should not be expected to pay for costs associated with climate change. It also promotes the notion that the developed countries should take the lead in GHG mitigation because mitigation efforts in underdeveloped countries would unfairly inhibit their development process, a process that was unrestricted to already industrialized nations. This principle is often addressed through mechanisms that transfer resources to developing countries (e.g., Schelling, 1998; Aldy, Orszag, & Stiglitz, 2001; Baumert and Goldberg, 2006).

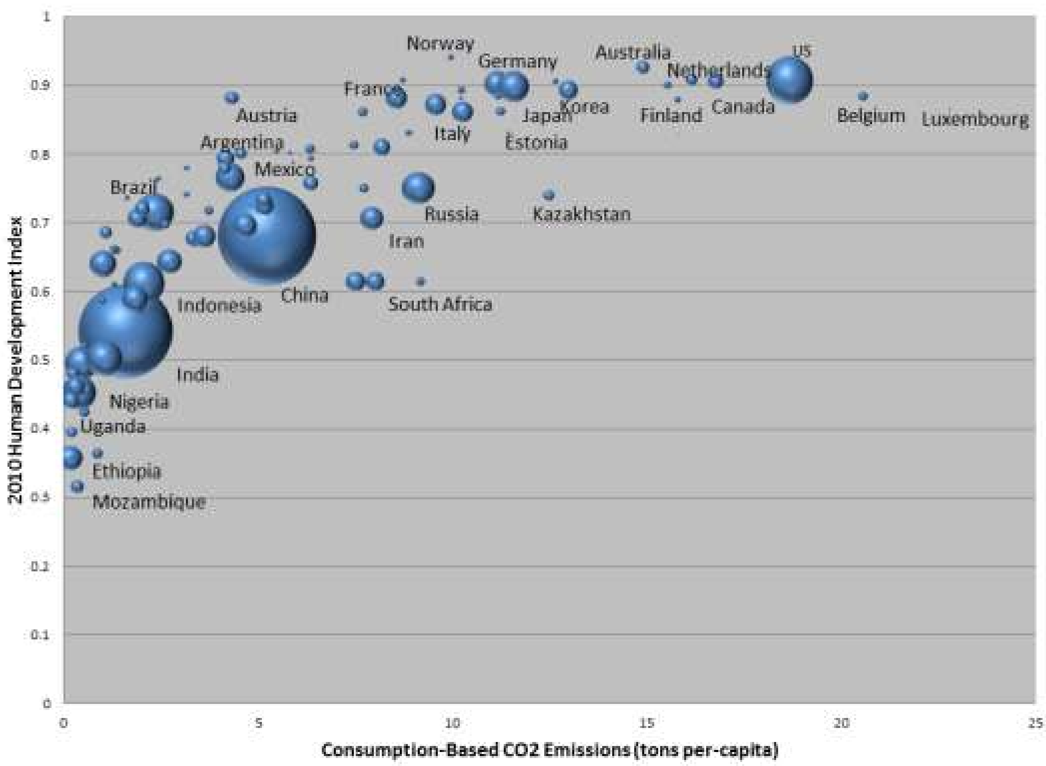


Figure 16. Comparison between consumption-based CO2 emissions and Human Development Index levels for many countries in 2010. CO2 data retrieved from Peters et al. (2011) and HDI levels are from the UNDP.

Not surprisingly, issues of development equity have been a major source of debate in recent international climate policy negotiations, as leaders grapple over the terms of the next climate regime. For example, the Group of Eight (including France, Germany, Italy, Japan, the United Kingdom, the United States, Canada and Russia) call for a 50% reduction in GHG emissions by 2050, but the BASIC negotiating group (Brazil, South Africa, India, and China) call for much larger restrictions, based on principles of historical responsibility and equal entitlement to the atmosphere. Nevertheless, in order to keep global temperatures below a 2ºC increase, it is estimated that developing countries need to reduce CO_2 emissions by 20% below business-as-usual levels by 2020 (Rogelj et al., 2010). When we consider the coupled nature of CO_2 and human development (evident in Figure 16), these CO_2 reductions will likely influence the socio-economic development of developing countries. Still, stabilizing the atmospheric GHG concentration likely depends on policy that includes all major emitters, otherwise developed nations like the U.S. refuse to comply.

Global climate policy is currently led by United Nations Framework Convention on Climate Change (UNFCCC), which does recognize development in its principle of 'common but differentiated responsibilities'. This principle recognizes historical differences in the contributions of developed and developing regions to global environmental problems, and differences in their respective capacities to tackle these problems. This was codified by the Kyoto Protocol, which set binding greenhouse gases emissions reduction targets for major developed countries to collectively reduce emissions on average by 5.2% relative to 1990 during the period of 2008 to 2012. The Protocol includes three flexible mechanisms that help developed nations meet their emission reduction targets. These include permit trading between developed nations, clean development mechanisms (CDMs), and joint implementation (JI). The CDM involves developed countries investing in sustainable development projects that reduce emissions in developing countries, whereas the JI allows developed nations to work with other developed nations towards this effort. Kyoto was recently extended for a second commitment period from 2013 to 2020, which requires GHG emission reductions by at least 18% below 1990 levels by developed nations (UNFCCC, 2013).

The overall consensus is that Kyoto, although an important first step, has been ineffective at addressing climate change and human development challenges. CO_2 emissions from fossil fuel combustion have grown 41% since 1990 and although emissions generated in developed countries have generally stabilized, emissions produced in the exempt developing countries have doubled (Le Quéré et al., 2009). Also, the UNFCCC recognizes development as a priority, yet the major finding of a review article in *Climate Change* finds that the market-based CDM does not significantly contribute to sustainable development in developing countries, since sustainable benefits are not monetized and therefore do not drive investments (Olsen, 2007). Kyoto has also been criticized for its priority of cost-effectiveness, which shifts the focus of negotiations away from ethical issues (Victor, 2001; Brown, 2002; Gardiner, 2004).

As Kyoto approaches expiration, international climate discussions have turned to designing the next climate change policy regime to be implemented in 2020. The plan is known as the Durban Platform for Enhanced Action, with an objective to develop "a protocol, another legal instrument or an agreed outcome with legal force under the Convention and applicable to all Parties" by 2015 and to be fully implemented in 2020 (UNFCCC, 2011). If all major emitters are included in the next climate policy regime, the likelihood of achieving significant mitigation is greatly increased, but it is unclear how development equity concerns will be addressed. Based on existing empirical evidence, we argue that unlimited market based mechanisms, which are focused primarily on economic efficiency, are myopic at addressing current human development inequities. *Therefore this research builds on previous empirical work to provide a framework for conceptualizing the relationship between* CO_2 *and human development. The framework enables us to critically examine policy prescriptions that employ market-based methods for emission allocation in their ability to address human development inequities. Lastly, we offer a novel climate policy proposal aimed at preventing unintended human development consequences.*

Empirical Evidence

Previous empirical work has begun to clarify the relationship between CO2 and human development. As mentioned prior, many studies recognize that per capita CO2 emissions and human development level (in terms of the United Nations Human Development Index or HDI) of nations are highly correlated. Studies also recognize the diminishing returns to HDI as nations transition to higher levels of per capita emissions (Pasternak, 2000; Martinez and Ebenhack, 2008; Mechtenberg; Spierre et al., *in press*). A sensitivity analysis on the 2010 HDI methodology shows that the diminishing returns to HDI from CO2 are inherent to specific development indicators (i.e., life expectancy and years of schooling) and not driven by the functional form of the HDI (Spierre et al., *in press*). In terms of more specific development indicators, a recent study found that high life expectancy can be achieved at a large range of carbon emission levels, whereas income is much more closely linked with carbon (Steinberger, et al., 2012). These findings indicate that reducing per capita income growth, as a result of a decrease in GHG emissions, may not necessarily mean a reduction in social welfare in developed nations.

A few studies have also looked at the comparison of CO_2 emissions and HDI over time. Steinberger & Roberts (2010) found that HDI levels were achieved at decreasing levels of energy and carbon emissions among many nations from 1975 to 2005, suggesting a decoupling of energy and carbon. This finding is supported when individual development pathways are examined, since the saturation-like trend is not consistently detected, especially among highly developed nations (Steinberger et al., 2012; Spierre et al., in press). This suggests that no generalizable model of development exists for all nations. Nevertheless, consistent advances in HDI are found among many of the least developed nations (HDI below 0.5) as emissions increase over time (Spierre et al., *in press*). Thus, policies concerned about development progress should not place emission restrictions on these particular nations.

Elsewhere, we have also studied the CO_2 trade characteristics of underdeveloped nations from 1990 to 2010. We found that many of the underdeveloped countries (with an HDI below 0.8 in 2010) that experienced the greatest gains in HDI from 1990 to 2010 are also nations that have, or are in the process of moving toward, outward oriented trade policies that involve increased domestic capabilities for product manufacture and export. This indicates that the ability to emit CO_2 is at least a co-requisite in the export oriented development strategies of nations that attained the greatest HDI improvements. Thus, CO_2 limitations on underdeveloped nations could inhibit the potential gains from outward oriented trade policies. This is especially true if the CO_2 emission reduction targets for economies in transition are based on current or historical domestic emissions, as was the case in allocating emission rights under Kyoto. That is, if emission limits are placed on developing nations, they ought to consider the future development needs of these nations, which may include the ability to self-sustain export-oriented, and CO_2 generating, processes (Spierre et al., 2013).

A Theoretical Framework

To help clarify the relationship between CO_2 and human development we employ the capabilities approach, which is a theory of basic human entitlements that provides a standard for determining whether people possess the various capabilities necessary for living a genuinely human life (Sen 1999a, 1999b; Nussbaum and Sen, 1992; Nussbaum 2000, 2006). A list of ten suggested human entitlements that societies should provide their citizens are provided by Nussbaum (1997) and is listed in Figure 15. The capabilities approach provides a framework for thinking about development in terms beyond those used in traditional welfare economics, where the focus is not only on the distribution of resources but also on what they enable people to do. For example, Sen (1990) observes that societies typically differ in their capacity to convert income and commodities into valuable human achievements. Figure 17 shows examples of mechanisms needed to transform income, commodities, and rights into actual achievements, such as communication, transportation, education, and health care. For example, a U.S. citizen has the right to life under the Bill of Rights, but to actually attain a life of normal length a person requires access to adequate and affordable health care. The theory of the capabilities approach inspired the creation of the HDI which includes measures of income distribution as well as attained health and education achievements in nations.

Figure 17. Conceptual Framework of the Capabilities Approach applied to the CO_2-Development Relationship.

This research extends the theory behind the capabilities approach to conceptualize the knowledge gained from empirical evidence on the relationship between CO_2 and human development. From a capabilities perspective, energy and CO_2 are co-requisite for transforming resources into achieved human development because they enable modern forms of communication, transportation, education, and health care, among others. As Ezor (2009) points out, “Electricity serves as a catalyst, making other pillars of development—education, modern healthcare, income generating activities, etc.— eye-sight, or physically in the fuel needed to run the car. To phrase it in a more nuanced way, the actual goods and commodities are not as meaningful as the achievements they can enable, if certain conversion capacities are available.

This theory helps to explain our empirical evidence. According to our theory, CO_2 and human development remain highly correlated within the least developed nations of the world, since the emissions generated to build basic infrastructure (such as roads, communication, and energy systems) and provide essential services (e.g., hospitals, schools, banks) directly work to improve human development indicators. At the same time, this framework elucidates the notion that income and resources do not always lead to human development improvements if a society lacks the capacity to transform them into valuable achievements. Additionally, in the case of wealthy individuals, income can be used to purchase luxury goods and services (such as luxury cars, vacations, and hot tubs) that do not lead to improvements in human development indicators. This latter concept explains the diminishing returns to HDI from per capita CO_2 emissions found in empirical studies. Next, we use the established CO_2-development framework as a basis to critique popular market-based policy prescriptions.

A Critical Assessment of Existing Policy Prescriptions

A vast number of authors have written on the topic of distributive justice related to global climate policy. Klinksy and Dowlatabadi (2009) offer a comprehensive list of international climate policy prescriptions, organized by their distribution rules and how they define the climate change problem. Although a complete synthesis of approaches is beyond the scope of this paper, we aim to explain why unlimited market-based approaches are myopic at addressing development equities using a few examples, provided our current understanding of the CO_2-development relationship.

Equal Per Capita Allocation

One popular proposal suggests an approach to climate justice that allocates carbon emissions on an *equal per capita* basis. From this perspective, every person has a right to the same level of GHG emissions, regardless of their nationality. This approach requires scientific agreement on the total allowable amount of GHG emissions, divided by the total world population. Each country, then, would be allowed to emit the sum of their population times the allowable emissions per person. (To account for population increase authors typically suggest that emissions caps would be based on the population to a negotiable baseline year). This is also an approach proposed by the BASIC negotiating group to determine national entitlements to emission rights, but only after cumulative historical emissions are taken into account. This approach is often supplemented with an emissions trading system, whereby countries that require more than their per capita allowance can buy allowances from countries that emit less (e.g., Singer, 2004; Jamieson, 2001; Agarwal & Narain, 1991; BASIC, 2011).

Although popular, this egalitarian approach to initial emission allocation has been criticized. The following criticism of Singer's One World is offered in a NY Review of Books commentary (Skidelsky & Joshi, 2004):

> "Even from a utilitarian perspective, substantial redistribution of wealth and income toward poor countries is subject to a variety of problems. Will poor countries be able to absorb aid productively? Will the aid reach the poor? Will it promote reliant self-development? A particularly stark issue arises from the fact that the world's poor (those living on less than $1 a day) are increasingly to be found in so-called "failed states," many of them in sub-Saharan Africa—states defined not by murderous intent but by lack of competence to secure for their people the basic conditions of life, health, and education. In such states, can poverty be reduced without large-scale intervention, even a takeover of their government and administration? Singer is silent on these practical questions."

In addition, Gardiner (2004, p584) states that, "The per capita proposal does not take into account the fact that emissions may play very different roles in people's lives. In particular, some emissions are used to produce luxury items, whereas others are necessary for most people's survival." In extension, Shue (1993) calls for a greater partitioning of necessary and unnecessary (or luxury) emissions and asserts that the necessary emissions (e.g. subsistence agricultural emissions) be left uncontrolled and protected.

Indeed, empirical evidence indicates that CO_2 does play a larger role in human development increases among nations with relatively low HDI. Also, the first critique calls attention to the capacity of impoverished nations to productively use money received from permit sales. As our empirical and CO_2-development framework suggests, income from selling emission permits is not sufficient for human development improvements. We will come back to these key parts of our argument in a moment.

Greenhouse Development Rights

Another popular approach was more recently presented by Baer, Kartha, Athanasiou, and Kemp-Benedict (2009) called 'Greenhouse Development Rights' (GDRs). GDRs consider an individual's capacity and responsibility through the examination of income distributions within countries. GDRs are based on the principle that the poor should be spared the burdens of the climate transition, regardless of where they live. Baer et al. employ a development threshold; a level of welfare below which people should not be expected to pay for climate mitigation or adaptation. Also, Baer et al. offer two market-based methods of operationalizing GDRs, a global fund via a climate tax or a UNFCCC-style emissions trading scheme, once each nation's contribution is determined via GDRs.

Baer et al.'s focus on the sub-national level stands out among most policy proposals in that it offers a way to consider inequity within nations. This is especially appealing considering concern about the growth of a 'global elite', where the wealthy members in many countries have more in common with each other than with the poor in their particular countries (Robinson and Harris, 2000). Still, applying a principle of individual equity to the national scale for use by the UNFCCC is problematic, as Baer et al. admit, since it ignores recent inaction by many developed nations despite their Kyoto commitments and requires roughly 25% reductions for developing nations today. These reductions that will not only impact the wealthy elite, but would likely mean impediments to human development of the poor, the individuals the proposal aims to protect. Regardless, our main critique of this proposal is the use of an emissions trading scheme to operationalize GDRs internationally.

A Critique of an Unlimited CO_2 Market

From our perspective, these market-based suggestions provided for implementing the GDRs, as well as their use in global climate policy in general, undermine the principle of development equity. Standard neo-classical economic models are based on the assumption that individuals act rationally—i.e., that they want more rather than less of a good, and they choose options that are likely to yield the greatest satisfaction or utility for themselves. In the context of climate policy, this means that emitting parties will elect to reduce pollution in whatever way is least expensive (Becker, 1976). From this view, energy is a mechanism that enables the production of consumer goods and services that will most efficiently maximize global consumption (which according to neoclassical economic theory increases total utility) while complying with the global carbon cap. Yet, both the provided empirical evidence and our theoretical framework suggest that income and commodities may not be sufficient for achieving human development improvement, especially among nations with low HDI that lack the capabilities necessary to transform commodities into achieved human development.

As in the case of the equal per capita and the GDRs proposals, the most common market-based approach to emission allocation attempts to resolve the climate problem by proposing a rigid cap on global GHG emissions, and involves an emissions market that optimizes GHG allocations for greatest profitability. The primary purpose of emissions trading is to reduce the cost for polluters trying to comply with caps, while (secondarily) providing compensation to those that use less than their allowable emissions. This is the method used by the Kyoto Protocol and the European Union Trading System. In effect, cap and trade approaches to climate policy will result in a system where goods are produced most efficiently in technically sophisticated countries and re-distributed to less technologically sophisticated countries through trade.

As such, implementing this type of strategy globally will not necessarily foster human development, and may create additional impediments for underdeveloped nations. That is, countries that sell emission rights, because they are relatively less-efficient at production (or don't participate in production), will have to purchase many of their manufactured products from the more developed nations that bought the emission rights in the first place. This is a 'win-win' scenario for industrialized nations because they do not only have the ability to emit more than their share (they just have to pay for additional rights), but they will also generate profit from the sale of the manufactured goods. Also, underdeveloped nations are unlikely to invest the proceeds of emissions permit sales in effective local human development when they can gain greater risk-adjusted returns in more technologically sophisticated countries. As a result, revenues from permit sales will necessarily be directed towards increasing consumption of goods (and services) that are cost-effective to import, but less likely to result in human development improvements.

Our prediction is supported by an empirical comparison between changes in HDI from 1990 to 2010 and the net official development assistance (ODA) received by many countries (Figure 16). The comparison indicates that the nations receiving the most aid are not the nations experiencing the greatest changes in HDI. Although we are not advocating for ending aid to Africa, or to other nations in need, we are saying that cash (in the form of aid or revenue from emission trading) is not sufficient for advancing human development.

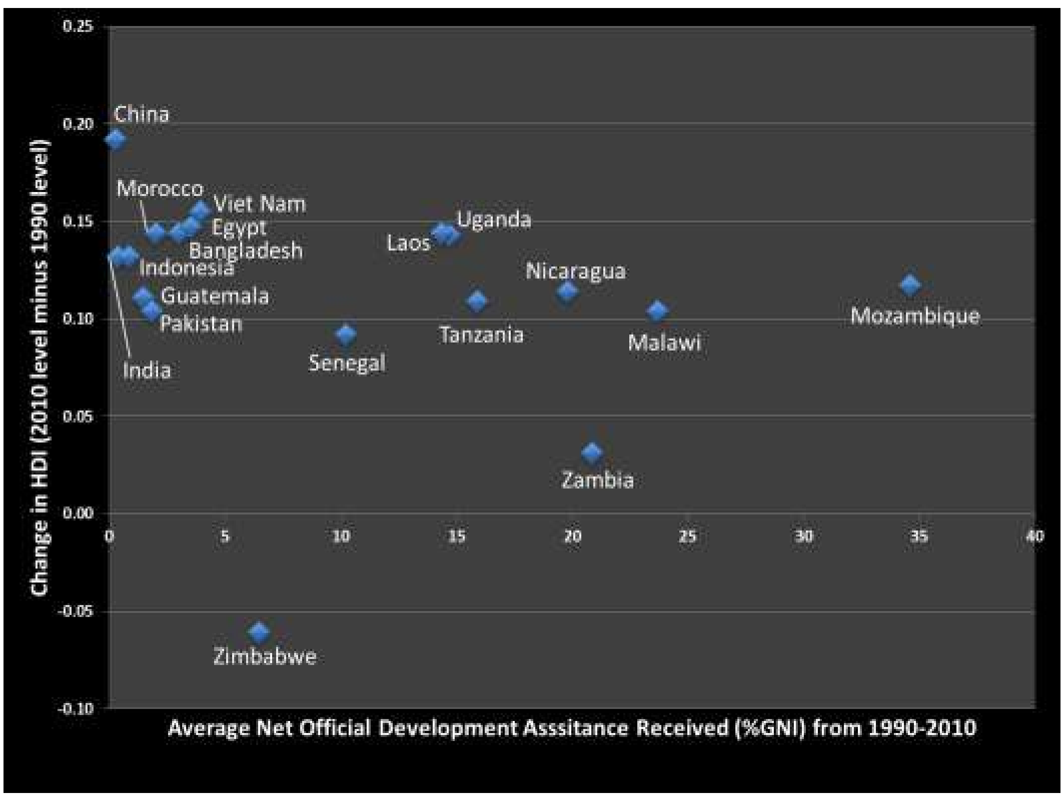


Figure 18. Comparison of Average Net Official Development (ODA) Received and Changes in HDI from 1990 to 2010. ODA data retrieved from The World Bank.

Now, let us extend the capability approach to assess the practicality of improving development through an emissions market using the example of water, an essential resource in a country's development and to an individual's well-being. Historically in developed countries, the establishment of a distribution system to disseminate potable water has proven critical for public health improvements (Nelson, 2001). However, for underdeveloped countries, access to treated water supplies is poor. The World Health Organization (WHO) and UNICEF (2000) estimate that, in the largest cities, those with a household or yard connection range from only 43% in Africa, to 77% in Asia, Latin America and the Caribbean. Moreover, the treatment and distribution of water is expensive, energy intensive, and by necessity a local process (Mintz et al., 2001). If the ability of a developed country to pay for CO_2 emissions exceeds that of the local populace in an underdeveloped country, then it is in the best short-term interest for the underdeveloped country to sell their extra emissions rights to the developed nation. However, there can be nothing gained from this transaction in terms of creating a long-term, sustainable water supply. In other words, the income gained from permit sales will not increase the developing country's *capability* to provide potable water to its citizens. Drawing upon this example and others (e.g., health care services and education), we reason that emissions trading is an insufficient mechanism for enhancing the capabilities of people living in developing countries.

A Moral Assessment

Sandel (2012) helps clarify our objections to an unrestricted market of CO2 permits in a moral sense. He says that there are two kinds of arguments that resonate through debates about what money should and should not buy. The first is the fairness objection, which points to the injustice that can arise when people buy and sell things under conditions of inequality or dire economic necessity. According to the fairness argument, market exchanges may not always be as voluntary as economists suggest and individuals might actually be coerced into selling something by the necessity of their situation. Second is the corruption argument, which is based on the degrading effect of market valuation and exchange of certain goods. In other words, some goods are corrupted if bought and sold. The corruption argument applies under both conditions of equality and inequality. For example, prostitution can be placed under both categories of objections. Some oppose the practice because it is arguably never truly voluntary (fairness objection), others say the prostitution is degrading to women, regardless if they are forced into it or not (corruption argument). Other inalienable goods that are broadly accepted are things like babies and organs, both of which satisfy the fairness and corruption objections.

The sale of CO_2 emission rights falls under both the *fairness* and *corruption* categories that Sandel describes. It satisfies the fairness objection since a poor country would likely choose to sell their emission rights for cash to alleviate extreme poverty in their country, for example. If the situation were different, they may not choose to sell their CO_2 so quickly. That is, the choice to sell emission rights is not a truly free choice if one of the participating countries is desperately poor. Moreover, based on Sandel's description, a CO_2 market between countries of varying development stages may degrade the value of having those rights, which speaks to the corruption objection. That is, if developed nations can simply buy their way out of reducing emissions, it can undermine the sense of shared sacrifice necessary to future global cooperation on the environment.

As Sandel describes it, an emissions market is like letting people pay to pollute and it essentially weakens the stigma attached to harming the environment. The latter argument applies even if the background conditions of equality are met. According to Sandel's criteria, an emissions market may be a candidate for prohibition because it arguable satisfies both objections.

Here, we focus mainly on Sandel's first point. Although we don't disagree with the idea that an emissions market may corrupt (in this case weaken) the sense of environmental sustainability we are striving for, we realize that big emitters will likely not comply if there are not ways to reduce mitigation costs. Moreover, we are primarily concerned with the fairness objection in assessing the ability of market-based policies to address development inequities. We reason that placing a limit on an emissions trading scheme in way that prevents the poorest nations from having to choose between money (which in the short term could help buy basic necessities) and the right to emit (which can be a mechanism for development enhancement over the long-term) is justified on the moral grounds that the right to emit CO_2 is at least a co-requisite for development in the least developed nations who seek development enhancement through outward oriented trade strategies.

Policy Criteria

Considering the current state of policy discussions, existing empirical evidence, established theoretical framework, as well as the arguments against unlimited CO_2 permit markets, we are able to highlight three components of future international climate policy that will least-likely impact international human development progress, including 1) placing the greatest restrictions on the most developed nations, whose human development is least likely to be impacted, 2) restriction placed on underdeveloped nations should be based on future human development need, since CO_2 is at least a co-requisite for achieving human development, and 3) emissions trading should be prohibited between countries of different development levels.

Our Policy Proposal

In extending our claims to climate policy, we are concerned about the limitations placed upon developing countries by emissions trading. Both empirical evidence as well as the examples of the car and water availability in the context of the capability approach demonstrates that the accumulation of financial capital and consumer goods may be insufficient conditions for development. As Sachs et al. (2004) explains, escaping the poverty trap and establishing self-sustained growth in Sub-Sahara Africa will require outside help in building their domestic capabilities (such as infrastructure, institutions and human capital) through increased ODA and trade reforms appropriate for the region before they can benefit from market-based sustained growth. Yet, unlimited cap and trade approaches to climate mitigation allocate CO_2, a mechanism of converting resources into human development, to the most efficient producers rather than those most in need from a development perspective. This is especially troubling given that post-Kyoto policy discussions indicate a transition toward an emissions trading scheme between emitters at all development levels. Still, we recognize the reality of emissions trading in future climate policy for its ability to reduce mitigation costs, since it is the primary concern of big emitters like the U.S. whose inclusion in GHG mitigation schemes is essential.

As a remedy, we propose using a three tiered emissions-market system to obtain sought global GHG reductions (see Figure 19). Tier 1 includes developed nations (e.g., nations with current HDI levels above 0.8) which will have emission reduction targets assigned based on cumulative emission contributions since 1990 (arguably the year in which nations can no longer claim ignorance regarding the climate change problem). Tier 2 includes developing nations (current HDI levels between 0.5 and 0.8) whose emission limitations will be based on future human development need, or emissions estimated to bring each nation to the 0.8 HDI level based on historical development trajectories. Tier 3 includes the least developed nations of the world (current HDI levels below 0.5), whose emission limits will be calculated in the same way as Tier 2. In terms of emission trading, nations will only be permitted to trade within their tier until human development improvements enable a transition to new trading partners within the next tier (although some nations will likely transition around the same time). This proposal addresses all three policy criteria outlined previously, since developed nations in Tier 1 have the greatest emission restrictions, Tier 2 and Tier 3 allow underdeveloped nations some growth for future emissions until they reach high development status, which is about 0.8 HDI according to the UNDP. Also, the tier thresholds allow us to prevent emission trading between nations with large differences in HDI. With the use of a mechanism similar to the CDM, our proposal could be supplemented to incentivize joint ventures with least developed nations that focus on capacity building. We also suggest that consumption-based emission inventories (which allocate generated CO_2 emissions to the consuming nation, see Peters et a., 2011) should be used as a basis for determining limitations and assessing progress. In this way, emission limitations will penalize over-consumption that does not transfer into human development but will in a sense reward production processes that do.

Under our suggested plan, the U.S. would be able to trade emission permits with countries like Canada, Norway, Austria, and Australia (all above the 0.8 HDI level). Likewise, Brazil, India, China and Indonesia would be likely emission trading partners (with HDI levels between 0.5 and 0.8). Also, nations like Uganda, Cambodia, Mozambique and Senegal (all less than 0.5 HDI levels) could transfer emissions between themselves if they were so inclined. This would protect less-developed nations from harmful competition for critical development resources. Although less economically efficient, our analysis indicates that the prohibition is more *developmentally efficient*, since it will result in greater improvements in the human condition, especially in underdeveloped nations.

In prohibiting emissions sales between countries of different development stages, we remove the incentives that restrict development. To comply with CO_2 caps, technologically sophisticated countries will have incentive to locate production in the underdeveloped countries that have the right to emit. As such, wages (and capital investment) will flow to workers in the needy country. A portion of the revenues that would have accrued in the underdeveloped countries will still accrue, but in the form of wages and investment, rather than in the form of carbon sales. In effect, our proposal allows the underdeveloped countries get both development (by participating in the production process) and income.

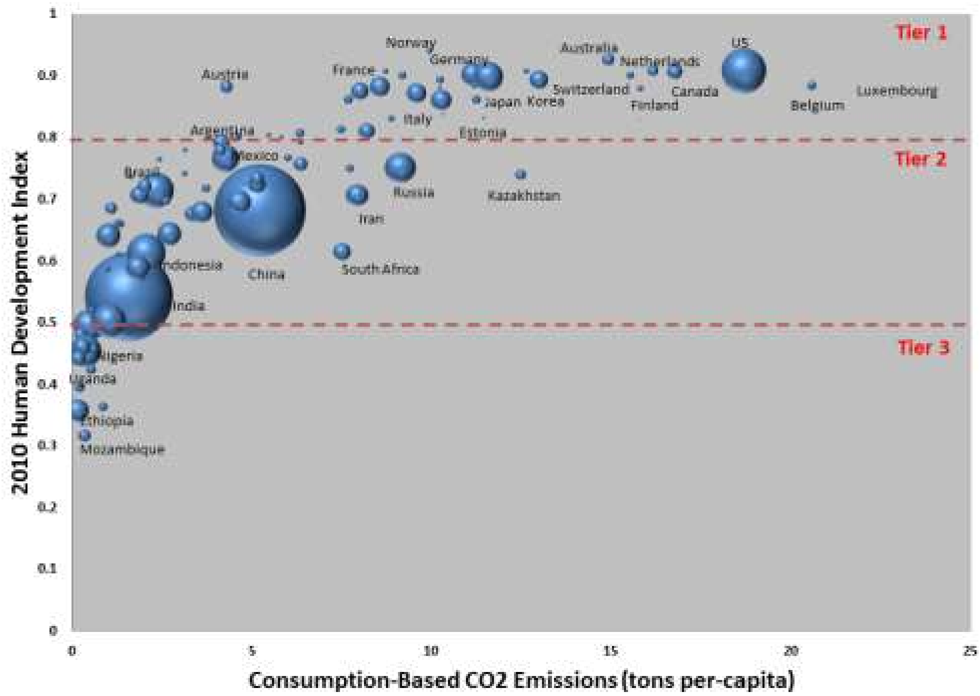


Figure 19. Illustration of our policy proposal, with suggested tier thresholds.

This comes at the expense of the polluting countries, mostly through higher prices that result from lower production efficiencies. However, the developed countries can partially mitigate these higher costs by sharing technology with the underdeveloped countries that can make production more efficient. This would also likely increase the GHG reduction potential of the plan, since it would place greater restrictions on the ability of the developed world to cut-emissions outside its borders, but in a way that does not remove the option all together.

One opposing argument may be that limits to trade based on development equity only applies if enhancing development is the primary goal of every country. Indeed, each nation has their own preferences and primary goals to achieve (e.g., religious goals) that arguably shouldn't be dictated by others in a paternalistic sense. However I do argue that in terms of *climate policy*, because of its inherently global and collective implications, should be focused on development equity. To clarify further, we do not argue that every nation should primarily focus on human development, but that human development should be the primary focus of climate policy, especially in the nations most vulnerable to climate change (which happen to be the least developed nations). Other goals and preferences that trump development goals in a particular country may still be pursued independently of climate policy. Aid from other countries could still be used to promote other ends if a country chooses, for example.

Conclusion

Article 1 of the United Nation's Declaration on the Right to Develop (United Nations, 1986) states, "The right to development is an inalienable human right by virtue of which every human person and all peoples are entitled to participate in, contribute to, and enjoy economic, social, cultural and political development, in which all human rights and fundamental freedoms can be fully realized." This declaration shows the UN's commitment to advance development throughout the world. Nevertheless, development requires access to cheap and reliable energy, which under current technological constraints will inevitably emit GHGs. However, the default mechanism employed by the U.N., and in most other international climate policy prescriptions, is an emissions trading scheme that is meant to efficiently allocate emissions among nations based on economic productivity. With the aid of existing empirical evidence and applied development theory we argue that an unlimited emissions market that includes both developed and developing nations with result in perverse human development consequences.

Alternatively, the proposal we offer differs from the policy arrangements offered by Singer, Jamieson, Baer or Kyoto in that we are criticizing traditional emissions trading schemes that allow big emitters to buy more emission rights from countries emitting much less. We argue that CO_2 policies which fail to display sensitivity to the limits of transfer payments risk inhibiting countries from being able to exercise their right to develop, rather than simply consume. By contrast, when human welfare is evaluated in terms of their capabilities, such as the HDI, the transfer of resources becomes less fungible. In other words, utilizing human development indices within climate mitigation trading schemes introduces parameters (such as life expectancy and education) that cannot be directly transferred like financial resources. Therefore, CO_2 emissions trading among countries of varying stages of development ought to be limited on the basis that the right to emit is at least a co-requisite for human development. Our approach incorporates the appeal of placing primary responsibility of reducing emissions on developed countries, and therefore internalizes the external costs of greenhouse gas emissions, but also focuses on the importance of improved development in countries that are still developing. Specifically, it stresses that growth in poor countries is still essential, and rich countries that are already sufficiently developed will no longer be improved by quantitative growth, but rather by more qualitative growth (e.g., through increased social capital). It is the more qualitative growth among nations that will enable reductions in CO_2 emissions, as the focus of development shifts away from consumption. We assert that this limit on emissions trading will allow production processes to occur in developing countries that will likely lead to more sustainable development pathways over the longer-term.

References

Agarwal, A. & Narain, S. (1991). *Global Warming in an unequal world: a case of environmental colonialism*. New Delhi, Centre for Science and Environment.

Alam, M.S., Bala, B.K., Huq, A.M.Z., Matin, M.A. (1991). A model for the quality-of-life as a function of electrical energy-consumption. *Energy* 16 (4), 739–745.

Alam, M.S., Roychowdhury, A., Islam, K.K., Huq, A.M.Z. (1998). A revisited model for the physical quality of life (PQL) as a function of electrical energy consumption. *Energy* 23 (9), 791–801.

Baer, P., Anthanasiou, T., Kartha, S. and Kemp-Benedict, E. (2009) “Greenhouse Development Rights: A proposal for a fair global climate treaty” *Ethics, Place and Environment*, 12, 3. pp. 267–281

Becker, G. (1976). *The Economic Approach to Human Behavior*. Chicago, IL: University of Chicago Press.

Brown, D. (2002). *American Heat: Ethical Problems with the United States' Response to Global Warming*. Lanham, Md.: Rowman & Littlefield.

Dias, R.A., Mattos, C.R., Balestieri, J.A.P., 2006. The limits of human development and the use of energy and natural resources. Energy Policy 34 (9), 1026–1031.

Ezor, Z. (2009) Power to the People: Rural Electrification in Uganda. Available at: http://digitalcollections.sit.edu

Gardiner, S. (2006) “A Perfect Moral Storm: Climate Change, Intergenerational Ethics and the Problem of Moral Corruption” *Environmental Values*, 15. pp. 397-413.

Gardiner, S. (2004) “Ethics and Global Climate Change” *Ethics*, 114. pp. 555–600

Goldenberg, J., La Rovere, E.L., Coelho, S.T. (2004). Expanding access to electricity in Brazil. *Energy for Sustainable Development*, 8(4), 86-94.

Jamieson, D., (1992). Ethics, public policy and global warming. *Science, Technology and Human Values* 17(2), 139–153.

Jamieson, D. (2001) “Cliamate Change and global Environmental Justice” in C. Miller and P. Edwards (Eds.), Changing the Atmosphere: Expert Knowledge and Environmental Governance,

Klinsky, S. and Dowlatabadi, H. (2009). Conceptualizations of justice in climate policy. Climate Policy. 9, 88-108. doi:10.3763/cpol.2008.0583

Le Quéré, C. Raupach, M.R.m Canadell, J.G., Marland, G., Bopp, L., Ciaia, P., …Woodward, F.I. (2009). Trends in the sources and sinks of carbon dioxide. Nature Geoscience, 2, 831-836. doi: 10.1038/ngeo689.

Lomborg, B. (2001). Global Warming. In *The Sceptical Environmentalist*, by Bjorn Lomborg, 258–324. Cambridge: Cambridge University Press.

Martínez, D. M. & Ebenhack, B.W. (2008). Understanding the role of energy consumption in human development through the use of saturation phenomena. *Energy Policy,* 36,1430–1435. http://dx.doi.org/10.1016/j.enpol.2007.12.016

Mechtenberg, A., Borchers, K. Miyingo, E.W., Hormasji, F., Hariharan, A., Makanda, J.V., Musaazi, M.K. (2012). Human power (HP) as a viable electricity portfolio option below 20 W/Capita. *Energy for Sustainable Development*, 16, 125-145. http://dx.doi.org/10.1016/j.esd.2011.12.006

Mintz, E., Bartram, J., Lochery, P., Wegelin, M. (2001) "Not Just a Drop in the Bucket: Expanding Access to Point-of-Use Water Treatment Systems" *American Journal of Public Health*, 91, 10. pp. 1565-1570

Moran, D.D., Wackernagel, M., Kitzes, J.A., Goldfinger, S.H., & Boutaud, A. (2008). Measuring sustainable development – nation by nation. *Ecological Economics*, 64 (3), 470–474. http://dx.doi.org/10.1016/j.ecolecon.2007.08.017

Nussbaum, M. (1997). Capabilities and Human Rights. *Fordham Law Review*, 273.

Nussbaum, M., Sen, A. (1992) The Quality of Life, Oxford University Press, Oxford.

Nussbaum, M. (2000) Women and Human Development: The Capabilities Approach, Cambridge University Press, Cambridge MA.

Nussbaum, M. (2006) Frontiers of Justice: Disability, Nationality, Species Membership, Harvard University Press, Cambridge MA.

Olmstead, S.M. & Stavins, R.N. (2012). Three Key Elements of the Post-2012 International Climate Policy Architecture, *Review of Environmental Economics and Policy*, 6(1), 65-85.

Pasternak, A.D., (2000). Global Energy Futures and Human Development: a framework for analysis. US Department of Energy, Oak Ridge.

Peters, G., Minx, J., Christopher, J., Weberd, L. and Edenhoferc, O. (2011) "Growth in emission transfers via international trade from 1990 to 2008" PNAS, 108, 21. pp. 8903–8908.

Rawls, J. (1971). *A Theory of Justice*. Harvard : Harvard University Press.

Robinson, W. & Harris, J. (2000). Towards a Global Ruling Class? Globalization and the Transnational Capitalist Class. Science & Society, 64(1), 11-54.

Rogelj J, Nabel J, Chen C, Hare W, Markmann K, et al. (2010) Copenhagen accord pledges are paltry. Nature 464: 1126–1128.

Sachs, J. McArthur, J.W., Schmidt-Traub, G. Kruk, M., Bahadur, C., Faye, M., and McCord, G. (2004). *Ending Africa's Poverty Trap*. Economic Studies Program, The Brookings Institution, vol. 35(1), pages 117-240.

Sanchez T. (2010). *The hidden energy crisis: how policies are failing the world's poor*. Practical action.

Sandel, M.J. (2012). What Money Can't Buy: The Moral Limits of Markets. New York: Farrar, Strauss and Giroux.

Sen, A. K. (1990). Development as Capability Expansion, in Keith Griffin and John Knight (eds), *Human Development and the International Development Strategy for the 1990s*, London: Macmillan,41-58.

Sen, A. (1999a) Commodities and Capabilities, Oxford University Press, Oxford.

Sen, A. (1999b) Development as Freedom, Anchor Books, New York.

Shue, H. (1993) "Subsistence emissions and luxury emissions" *Law & Policy*,15,1. pp. 39-58

Shue, H. (1999) "Global environment and international inequality" *International Affairs*, 75, 3. pp. 531-545

Sethi, N. (2011). Durban Climate talks end, new global climate change regime from 2020." *The Times of India*. Retrieved on 30 September, 2012 at http://articles.timesofindia.indiatimes.com/2011-12-11/developmental-issues/30504463_1_eu-roadmap-climate-talks-climate-change

Singer, P. (2004) *"*One Atmosphere*"* in Chapter 2 of *One World: The Ethics of Globalization*, Yale University Press.

Skidelsky, R. and Joshi V. (2004) "One World?" The New York Review of Books Published 25 March 2004. Available at: http://www.nybooks.com/articles/archives/2004/mar/25/one-world/

Spierre,S.G., Seager, T.P., Selinger, E. (in press). The Diminishing Returns to the 2010 Human Development Index. Sustainable Development. (see Chapter 4 of this work)

Spierre,S.G., Seager, T.P., Selinger, E. (in press). Assessing the Link between CO2 Emission Transfers and Human Development Advancement. (see Chapter 5 of this work)

Steinberger, J. & Roberts T. (2010). From constraint to sufficiency: The decoupling of energy and carbon from human needs, 1975-2005. *Ecological Economics*, 425-433. http://dx.doi.org/10.1016/j.ecolecon.2010.09.014

Steinberger, J., Roberts, T. Peters, G. & Baiocchi, G. (2012). Pathways of human development and carbon emissions embodied in trade. *Nature Climate Change*. http://dx.doi.org/10.1038/nclimate1371

Stern, D. (2010). Between estimates of the emissions-income elasticity. *Ecol. Econ*. 69, 2173-2182 .

Suarez, C.E. (1995). Energy needs for sustainable human development. In J. Goldemberg, T.B. Johansson (Eds.) *Energy As An Instrument for Socio-Economic Development*. New York United Nations Development Programme.

United Nations (1986), Declaration on the Right to Development, Available at: http://www2.ohchr.org/english/law/rtd.htm

United Nations Framework Convention on Climate Change (1998), Kyoto Protocol to the United Nations Framework Convention on Climate Change, available at http://unfccc.int/kyoto_protocol/items/2830.php

United Nations Framework Convention on Climate Change (UNFCCC). (2013). Kyoto Protocol. Available at: http://unfccc.int/kyoto_protocol/items/2830.php

Victor, David. 2001. *The Collapse of the Kyoto Protocol and the Struggle to Slow Global Warming*. Princeton, N.J.: Princeton University Press.

World Health Organization, United Nations Children's Fund (2000), Water Supply and Sanitation Council. Global Water Supply and Sanitation Assessment 2000 Report. New York, NY:UNICEF; 2000.

REFERENCES

Abbink, K., Brandts, J., Herrmann, B, & Orzen, H. (2011) Parochial Altruism in Intergroup Conflicts, *Economic Letters* 117, pp. 45-48.

Agarwal, A. & Narain, S. (1991). *Global Warming in an unequal world: a case of environmental colonialism*. New Delhi, Centre for Science and Environment.

Alam, M.S., Bala, B.K., Huq, A.M.Z., Matin, M.A. (1991). A model for the quality-of-life as a function of electrical energy-consumption. *Energy* 16 (4), 739–745.

Alam, M.S., Roychowdhury, A., Islam, K.K., Huq, A.M.Z. (1998). A revisited model for the physical quality of life (PQL) as a function of electrical energy consumption. *Energy* 23 (9), 791–801.

Alexander R.D. (1987) *The Biology of Moral Systems* (Hawthorne, New York: Aldine de Gruyter).

Alici, A.A. & Sengun, M.S. (2003). Foreign Direct Investment, Exports and Output Growth of Turkey: Causality Analysis. Paper to be Presented at the European Trade Study Group (ETSG) Fifth Annual Conference. Deptember 11-13, 2003, Universidad Carlos III de Madrid

Alkire, S. and Santos, M.E. (2010). Acute Multidimensional Poverty: A New Index for Developing Countries. Oxford Poverty & Human Development Initiative, University of Oxford.

Alley, R.B., Marotzke, J., Nordhaus, W.D., Overpeck, J.T., Peteet, D.M., Pielke Jr., …Wallace, J.M. (2003) Abrupt Climate Change. Science, 299, 2005-2010. DOI: 10.1126/science.1081056

Amid, J. & Hadjikhani, A. (2005). *Trade, Industrialization and the Firm in Iran*. London: I.B. Tauris. ISBN 1850436819

Arora, V. & Ricci, L.A. (2006). Unemployment and the Labor Market. In Nowak, M. & Ricci, L.A. (eds.). *Post-Apartheid South Africa: the First Ten Years. International Monetary Fund. Retreievd from: http://www.imf.org/external/pubs/nft/2006/soafrica/eng/pasoafr/index.htm*

Atkinson, G., Dubourg, R., Hamilton, K., Munasinghe, M., Pearce, D., Young, C.(1997) Measuring Sustainable Development-Macroeconomics and the Environment. Edward Elgar Publishing.

Avolio, B. J., & Luthans, F. (2006) *The high impact leader: Moments matter for accelerating authentic leadership development* (New York: McGraw-Hill).

Axelrod, R., Riolo, R., & Cohen, M. (2002) Beyond Geography: Cooperation with Persistent Links in the Absence of Clustered Neighborhoods, *Personality and Social Psychology Review* 6(4), pp. 341-346.

Azariadis, C. & Drazen, A. (1990). Threshold Externalities in Economic Development. *The Quarterly Journal of Economics*, 105(2), 501-526.

Baer, P., Anthanasiou, T., Kartha, S. and Kemp-Benedict, E. (2009). Greenhouse Development Rights: A proposal for a fair global climate treaty. *Ethics, Place and Environment*, 12 (3), 267–281.

Baster, N. (1972). Measuring Development: The Role and Adequecy of Development Indicators. Totowa, NJ: Frank Cass and Company Limited.

BBC News (2009) "Landmark legislation to help Scotland tackle the threat of climate change has been passed unanimously by MSPs." Retrieved 11 October, 2012 at http://news.bbc.co.uk/2/hi/uk_news/scotland/8115597.stm

BBC News (2012) "Scottish party leaders unite over climate change." *News Scotland*. Retrieved 05 October, 2012 at http://www.bbc.co.uk/news/uk-scotland-17498776

Beck, T. (2002). Financial development and international trade: Is there a link? Journal of International Economics, 57(1), 107-131.

Becker, G. (1976). *The Economic Approach to Human Behavior*. Chicago, IL: University of Chicago Press.

Beg, N., Morlot, J.C., Davidson, O., Afrane-Okesse, Y., Tyani, L., Denton, F., Sokona, Y., Thomas, J.P., La Rovere, E.L., Parikh, J.K., Parijh, K., Rahman, A.A. (2002). Linkages between climate change and sustainable development. Climate Policy,2, 129-144.

Birol, F. (2007). Energy Economics: A Place for Energy Poverty in the Agenda. *The Energy Journal,* 28(3), 1-6. http://dx.doi.org/10.5547/ISSN0195-6574-EJ-Vol28-No3-1

Blasi, A. (1980) Bridging moral cognition and moral action: A critical review of the literature, *Psychological Bulletin*, 88, pp. 1-45.

Bloomberg News (2012). Island Nations Criticize EU Over Climate Deal Extension. Businessweek.com. Retrieved on 10 October, 2012 at http://www.businessweek.com/news/2012-05-10/island-nations-criticize-eu-over-kyoto-climate-deal-extension

Boehm, C. (2012). Moral Origins: The Evolution of Virtue, Altruism, and Shame, (New York: Basic Books).

Borensztein, E., Gregorio, J.D., Lee, J.W. (1998). How does foreign direct investment affect economic growth? *Journal of International Economics*, 45, 115-135.

Borhan, H., Ahmed, E.M., & Hitam, M. (2012). The Impact of CO2 on Economic Growth in Asean 8. Procedia – Social and Behavioral Sciences, 35, 389-397.

Bornstein, G. (2003). Intergroup Conflict: Individual, Group and Collective Interests. Personality and Social Psychology Review 7, pp. 129-145.

Bowles, S., Durlauf, S.N., & Koff, K. (2006). *Poverty Traps*. Princeton, NJ: Princeton University Press.

Brooks, N., Adger, W., Kelly, P. (2005). The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change,* 15, 151–163.

Broome, J. (2008). The Ethics of Climate Change, *Scientific American* 298, pp. 96-102.

Brown, D. (2002). *American Heat: Ethical Problems with the United States' Response to Global Warming*. Lanham, Md.: Rowman & Littlefield.

Brown, D. (2009). The Strong Scottish Moral Leadership On Climate Change Compared To The Absence Of Any Acknowledged Ethical Duty In The US Debate. *ClimateEthics.org*. Accessed 05 October 2012 at http://rockblogs.psu.edu/climate/2009/08/the-strong-scottish-moral-leadership-on-climate-change-compared-to-the-absence-of-any-acknowledged-ethical-duty-in-the-us-debate.html

Brown, D. (2011) "Going Deeper On What Happened In Durban: An Ethical Critique of Durban Outcomes." *Climate Justice Now.* Accessed 05 October, 2012 at http://www.climate-justice-now.org/going-deeper-on-what-happened-in-durban-an-ethical-critique-of-durban-outcomes/

Brown, M. E., & Treviño, L. K. (2006). Ethical leadership: A review and future directions, *Leadership Quarterly* 17, pp. 595-616.

Brown, M.E., Trevino, L.K., & Harrison, D.A. (2005). Ethical Leadership: A Social Learning Perspective for Construct Development and Testing, Organizational Behavior and Human Decisions Processes 97, pp. 117-134.

Bruntland, G. (1987). *Our Common Future: The World Commission on Environment and Development*. Oxford, Oxford University Press.

Bunkley, N. (2008). "Joseph Juran, 103, Pioneer in Quality Control, Dies." *The New York Times*. Retrieved on April 30th, 2012 from http://www.nytimes.com/2008/03/03/business/03juran.html?_r=1

Burns, J.M. (1979). *Leadership* (New York, NY: Harper Perennial).

Caney, S. (2005). Cosmopolitan Justice, Responsibility, and Global Climate Change. Leiden Journal of International Law, 18, 747-775.

Carbon Trust. (2002). International Carbon Flows: Global Flows

Carbon Trust. (2006). The carbon emissions generated in all that we consume.

Chandler, W., Schaeffer, R., Dadi, Z., Shukla, P.R., Tudela, F.,Davidson, O., & Alpan-Atamer, S. (2002). Climate change mitigation in developing countries. Pew Center on Global Climate Change. Available at: http://www.c2es.org/docUploads/dev_mitigation.pdf

Choi, J-K. & Bowles, S. (2007). The Coevolution of Parochial Altruism and War, Science 318, pp. 636-640.

CiuUa, J. (2004). Ethics and Leadership Effectiveness, in: Antonakis, J., Cianciolo, A.T. & Sternberg, R.J. (Eds.) *The Nature of Leadership*, (Sage, Thousand Oaks/ London/New Dehli), pp. 302-327.

Coase, R. (1960). The Problem of Social Cost, *Journal of Law and Economics* 3(1), pp. 1-44.

Davies, A., & Quinlivan, G. (2006). A Panel Data Analysis of the Impact of Trade on Human Development. The Journal of Socio-Economics, 35(5), 868-867.

Davis, S. & Caldeira, K. (2010). Consumption-based accounting of CO_2 emissions. *PNAS*, 107 (12) 5687-5692.

Davis, S.J., Peters, G.P., Caldeira, K. (2011). The supply chain of CO_2 emissions. *PNAS.* www.pnas.org/cgi/doi/10.1073/pnas.1107409108

De Schweinitz, K. (1959). Industrialization, Labor Controls, and Democracy. *Economic Development and Cultural Change*, 7 (4), 385-404.

Dias, R.A., Mattos, C.R., Balestieri, J.A.P., 2006. The limits of human development and the use of energy and natural resources. Energy Policy 34 (9), 1026–1031.

Eaton, J. & Kortum, S. (1997). Engines of growth: Domestic and foreign sources of innovation. *Japan and the World Economy*, 19(2). 235-259. http://dx.doi.org.ezproxy1.lib.asu.edu/10.1016/S0922-1425(97)00011-X

EIA (Energy Information Administration). (2013) Independent Statistics & Analysis. http://www.eia.gov/countries/data.cfm

Environment Canada (2011). Canada's Closing Statement at COP17. Retrieved on 15 October, 2012 at http://www.ec.gc.ca/default.asp?lang=En&n=FFE36B6D-1&news=39FCDB85-A69C-4B71-AC5E-8D14140AADD7

ESCAP (2009). Asia-Pacific Trade and Investment Report 2009: Trade-led Recovery and Beyond. *United Nations publication*. ISBN: 978-92-1-120586-2

Esfahani, H.S. & Pesaran, M.H. (2008) Iranian Economy in the Twentieth Century: A Global Perspective. Cambridge Working Papers in Economics, number 0815. Retrieved from: http://www.dspace.cam.ac.uk/bitstream/1810/229367/2/0815.pdf

Ezor, Z. (2009) Power to the People: Rural Electrification in Uganda. Available at: http://digitalcollections.sit.edu

Feenstra, R.C. & Kee, H.L. (2007). Trade Liberalization and Export Variety: A Comparison of Mexico and China. *The World Economy*, 30(1), 5-21.

Freeman, N.J. & Hew, D. (2002) Introductory Overview: Rethinking the East Asian Development Model. ASEAN Economic Bulletin, 19(1), 1-5. http://www.jstor.org/stable/25773705

Gardiner, S. (2004) "Ethics and Global Climate Change" *Ethics*, 114. pp. 555–600

Gardiner, S. (2006). A Perfect Moral Storm: Climate Change, Intergenerational Ethics and the Problem of Moral Corruption. *Environmental Values*, 15:397-413.

Goldenberg, J., La Rovere, E.L., Coelho, S.T. (2004). Expanding access to electricity in Brazil. *Energy for Sustainable Development*, 8(4), 86-94.

Gowdy, J.M. (2008). Behavioral economics and climate change policy, *Journal of Economic Behavior & Organization* 68, pp. 632-644.

Greenwald, B. & Stiglitz, J.E. (2006). Helping Infant Economies Grow: Foundations of Trade Policies for Developing Countries. American Economic Review, 96(2), 141-146. http://www.jstor.org/stable/10.2307/30034630

Group of Eight (G8). (2009). Chair's Summary. L'Aquila, 10 July 2009. Available at: http://www.g8italia2009.it/static/G8_Allegato/Chair_Summary%2c1.pdf

Gu, J., Humphrey, J. and Messner, D. (2007). Global Governance and Developing Countries: The Implications of the Rise of China. Bonn, Germany: The German Development Institute. ISBN: 978-3-88985-356-1

Gwarthney, J. Lawson, R. & Hall, J. (2012). Economic Freedom of the World: 2012 Annual Report. Fraser Institute. http://www.freetheworld.com/2012/EFW2012-complete.pdf

Haggard, S. (2004). Institutions and Growth in East Asia. *Studies in Comparative International Development*, 38(4), 53-81.

Hannah, S. T., Avolio, B. J., & May, D. R. (in press). Moral Maturation and moral conation: A capacity approach to explaining moral thought and action. *Academy of Management Review*

Hannah, S. T., Lester, P. B., & Vogelgesang, G. (2005) Moral leadership: Explicating the moral component of authentic leadership, in: Gardner, W. L., Avolio, B. J. & Walumbwa, B. J. (Eds.) *Authentic leadership and practice: Origins, effects, and development*, (Amsterdam: Elsevier), pp. 43-82.

Hannah, S.T., Avolio, B. J., Walumbwa, F.O. (in press). Relationship between Authentic Leadership, Moral Courage, Ethical and Pro-social Behaviors.

Happy Planet Index. (2012). The Happy Planet Index: 2012 Report: a global index of sustainable well-being. http://www.happyplanetindex.org/assets/happy-planet-index-report.pdf

Hardin, G. (1968). The Tragedy of the Commons, *Science* 162 (3859), pp. 1243–1248.

Higgott, R.A., Underhill, G.R.D., Bieler, A. (2000). Non-state Actors and Authoeriy in the Global System. New York, NY: Routledge.

Hirst, P. & Thompson, G. (1996). Globalization in Question: The international Economy and the Possibilities of Governance, Cambridge: Polity Press.

Hofmann, D.J., Butler, J.H., & Tans, P.P (2009). A new look at atmospheric carbon dioxide. *Atmospheric Environment*, 43(12), 2084-2086.

Holman Fenwick Willan (2012) "The UNFCCC's Durban platform explained." Retrieved 10 October, 2012 at http://www.hfw.com/publications/client-briefings/the-unfcccs-durban-platform-explained

Howells, J.R.L. (2001). Tacit Knowledge, Innovation and Economic Geography. Urban Studies, 39 (5-6), 871-884.

Hume, D. (1992). *A Treatise of Human Nature*, (Buffalo, NY: Prometheus Books).

Huntington, S.P. & Nelson, J.M. (1976*). No easy choice: Political participation in developing countries*. Cambridge, MA: Harvard University Press.

Hurd, D. (1990). Promoting good government. Crossbow, Autumn, 4-5.

International Institute for Sustainable Development (2011). Summary of the Durban Climate Change Conference: 28 November-11 December 2011. Retrieved on 07 October, 2012 at http://www.iisd.ca/vol12/enb12534e.html

International Monetary Fund (IMF), Organization for Economic Cooperation and Development (OECD), United Nations, World Bank Group. (2000). *2000 A Better World for All: Progress Toward the International Development Goals.* Washington, DC: Communications Development.

IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jamieson, D. (2005). Adaptation, Mitigation, and Justice. *Advances in the Economics of Environmental Resources* 5: 217–248.

Jamieson, D. (2001). Climate Change and global Environmental Justice, in: Miller, C. and Edwards, P. (Eds.), *Changing the Atmosphere: Expert Knowledge and Environmental Governance*, (Cambridge, Mass.: MIT Press), pp. 287-307.

Jamieson, D. (1992). Ethics, public policy and global warming. *Science, Technology and Human Values* 17(2), 139–153.

Jin, F., Lee, K., Kim, Y-K. (2008). Changing Engines of Growth in China: From Exports, FDI and Marketization to Innovation and Exports. *China & World Economy,* 16(2), 31-49.

Karshenas, M. (1990). *Oil, State, and Industrialization in Iran*. New York, NY: Cambridge University Press.

Kaufmann, D., Kraay, A., Mastruzzi, M. (2009) Governance Matters VIII: Aggregate and Individual Governance Indicators, 1996-2008. World Bank Policy Working Paper No. 4978. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1424591

King, M.E. (1999). *Mahatma Gandhi and Martin Luther King Jr: The Power of Nonviolent Action*, (UNESCO Publishing)

Kingdon, G. & Knight, J. (2005). Unemployment in South Africa, 1995-2003: causes, problems and policies. Global Poverty Research Group. Retrieved from: http://economics.ouls.ox.ac.uk/14073/1/gprg-wps-010.pdf

Klinsky, S. and Dowlatabadi, H. (2009). Conceptualizations of justice in climate policy. Climate Policy. 9, 88-108. doi:10.3763/cpol.2008.0583

Klugman, J., Rodriguez, F., & Choi, H.J. (2011). Human Development Research Paper 2011/01: The HDI 2010: New Controversies, Old Critiques. Available at: http://hdr.undp.org/en/reports/global/hdr2011/papers/HDRP_2011_01.pdf

Krueger, A.O. (1997). Trade Policy and Economic Development: How We Learn. *The American Economic* Review, 87(1), 1-22.

Kuznets, P.W. (1988). An East Asian Model of Economic Development: Japan, Taiwan, and South Korea. Economic Development and Cultural Change, 36(3), S11-S43

Kwon, J.K., Kang, J.M. (2011). The East Asian Model of Economic Development. *Asian-Pacific Economic Literature*, 25(2), 116-130.

LaPalombara, J. (1963). *Bureaucracy and political development.* Princeton: Princeton Univ. Press.

Lautier, M. (2008). Export of health services from developing countries: The case of Tunisia. Social Science & Medicine, 67(1), 101-110.

Le Quéré C., Raupach, M.R., Canadell, J.G., Marland, Bopp, L., Ciaia, P., …Woodward, F. I. (2009). Trends in the sources and sinks of carbon dioxide. *Nature Geoscience,* 2, 831–836. http://dx.doi.org/10.1038/ngeo689

Lee, K. & Mathews, J.A. (2010). From Washington Consensus to BeST Consensus for world development. Asian Pacific Economic Literature, 24(1), 86-103.

Leftwhich, A. (1993). Governance, Democracy and Development in the Third World. *Third World Quarterly*, 14(3), 605-624.

Lemoine, F. & Unal-Kesenci, D, (2004). Assembly Trade and Technology Transfer: The Case of China. World Development, 32(5), 829-850. http://dx.doi.org/10.1016/j.worlddev.2004.01.001

Lenzen M (2001) Errors in Conventional and Input-Output-based Life-Cycle Inventories.*Journal of Industrial Ecology* 4:127-148.

Lenzen, M., Wood, R., & Wiedmann, T. (2010). Uncertainty analysis for Multi-Region Input- Output Models—A case study of the UK's carbon footprint. *Econ Syst Res* 22:43–63.

Lester, P. B., Vogelgesang, G., Hannah, S. T., & Kimmey, T. (2009). Developing courage in followers: Theoretical and applied perspectives, in Pury, C. Lopez, S. (Eds.), *The psychology of courage: Modern research on an ancient virtue*, (Washington, DC: American Psychological Association).

Lezra, E. (1972). *Ethical oil: the case for Canada's oil sands,* (Toronto, Ontarion: McClelland & Stewart Ltd.)

Lipset, S.M. (1959). Some Social Requisites of Democracy: Economic Development and Political Legitimacy. *American Political Science Review*, 53, 69–105.

Liu, X. (1997). The relative contributions of foreign technology and domestic inputs to innovation in Chinese manufacturing industries. *Technovation, 17(3), 119-125. http://dx.doi.org/10.1016/S0166-4972(96)00090-9*

Lomborg, B. (2001). Global Warming. In *The Sceptical Environmentalist*, by Bjorn Lomborg, 258–324. Cambridge: Cambridge University Press.

Lucas, R. (1988). On the Mechanics of Economic Development, Journal of Monetary Economics, XXI 30-42.

Lutsey, N. & Sperling, D. (2008). America's bottom-up climate change mitigation policy. *Energy Policy,* 26, 673-685.

Marowitz, E.M. & Shariff A.F. (2012). Climate Change and Moral Judgement, *Nature Climate Change* 2, pp. 243–247.

Marshall, M.G., Cole, B.R. (2011). Global Report 2011: Conflict, Governance, and State Fragility. Center for Systemic Peace. Available at: http://www.systemicpeace.org/GlobalReport2011.pdf

Marshall, M.G., Jaggers, K., & Gurr, T.R. (2011). Polity IV Project: Dataset Users' Manual. Center for Systemic Peace: Polity IV Project. Available at: http://www.systemicpeace.org/inscr/p4manualv2010.pdf

Martínez, D. M. & Ebenhack, B.W. (2008). Understanding the role of energy consumption in human development through the use of saturation phenomena. *Energy Policy,* 36,1430–1435. http://dx.doi.org/10.1016/j.enpol.2007.12.016

Matondi, P.B. (2002). Fast Track Land Reform in Zimbabwe. *Human Rights Watch,* 14(1). Retrieved from: http://www.hrw.org/reports/2002/zimbabwe/ZimLand0302.pdf

Mayer, D.M., Kuenzi, M., Greenbaum, R., Bardes, M., & Salvador, R. (2009). How Low Does Ethical Leadership Flow? Test of the Trickle-Down Model, Organizational Behavior and Human Decisions Processes 108, pp. 1-13.\

McKinsey Global Institute. (2003). New Horizons: Multinational Company Investment Developing Economies, McKinsey Global Institute, San Francisco

Mechtenberg, A., Borchers, K. Miyingo, E.W., Hormasji, F., Hariharan, A., Makanda, J.V., Musaazi, M.K. (2012). Human power (HP) as a viable electricity portfolio option below 20 W/Capita. *Energy for Sustainable Development*, 16, 125-145. http://dx.doi.org/10.1016/j.esd.2011.12.006

Mikic, M. (2011). Role of trade in development and overview of Asia-Pacific LDCs' performance in trade and investment. In United Nations ESCAP (ed.). Trade beyond Doha: Prospects for Asia-Pacific Least Developed Countries, Studies in

Trade and Investment 76. Retrieved from: http://www.unescap.org/tid/publication/tipub2625-chap1.pdf

Milinski, M., Semmann, D., & Krambeck, H.J. (2002). Reputation Helps Solve the 'Tragedy of the Commons, *Nature* 415, pp. 424-426.

Mintz, E., Bartram, J., Lochery, P., Wegelin, M. (2001) "Not Just a Drop in the Bucket: Expanding Access to Point-of-Use Water Treatment Systems" *American Journal of Public Health*, 91, 10. pp. 1565-1570

Moran, D.D., Wackernagel, M., Kitzes, J.A., Goldfinger, S.H., & Boutaud, A. (2008). Measuring sustainable development – nation by nation. *Ecological Economics*, 64 (3), 470–474. http://dx.doi.org/10.1016/j.ecolecon.2007.08.017

Nakano, S., Okamura, A., Sakurai, N., Suzuki, M., Tojo, Y., Yamano, N. (2009). The Measurement of CO_2 Embodiments in International Trade: Evidence from the Harmonised Input-Output and Bilateral Trade Database. OECD Science, Technology and Industry Working Papers, 2009/03, OECD Publishing. http://dx.doi.org/10.1787/227026518048

Neumayer, E. (2000). In Defense of Historical Accountability for Greenhouse Gas Emissions, *Ecological Economics*, 33, 185–92.

Nordhaus, W.D. (2007). The challenge of global warming: economic models and environmental policy, July 24, 2007, Yale. Available at: http://nordhaus.econ.yale.edu/dice_mss_072407_all.pdf

Nowak, M.A. (2006). Five Rules for the Evolution of Cooperation. Science 314, pp. 1560-1563.

Nowak, M.A. (2012). Evolving Cooperation, *Journal of Theoretical Biology* 299, pp. 1-8.

Nussbaum, M. (2000). Women and Human Development: The Capabilities Approach, Cambridge University Press, Cambridge MA.

Nussbaum, M. (1997). Capabilities and Human Rights. *Fordham Law Review*, 273.

Nussbaum, M. (2006). Frontiers of Justice: Disability, Nationality, Species Membership, Harvard University Press, Cambridge MA.

Nussbaum, M., A. Sen. (1992). *The Quality of Life*, Oxford: Oxford University Press. ISBN 9780198287971Olsen, 2007

Ohmae, K. (1990). The Borderless World: Power and Strategy in the Interlinked Economy, London: Collins.

Olmstead, S.M. & Stavins, R.N. (2012). Three Key Elements of the Post-2012 International Climate Policy Architecture, *Review of Environmental Economics and Policy*, 6(1), 65-85.

Olsen, K.H. (2007). The clean development mechanism's contribution to sustainable development: a review of the literature. *Climate Change*, 84, 59-73. DOI 10.1007/s10584-007-9267-y

Ostrom, E. (2010). Analyzing Collective Action, *Agricultural Economics* 41 (s1), pp.155-166.

Ostrom, E., J. Burger, R.B. Field, R.B. Norgaard, and D. Policansky. (1999). Revisting the Commons, *Science* 284 (5412), pp. 278-282.

Page, J. (1994).The East Asian Miracle: Four Lessons for Development Policy. In Fischer, S. and Rotemberg, J. (eds). *NBER Macroeconomics Annual 1994*, Volume 9. MIT Press Retrieved from http://papers.nber.org/books/fisc94-1

Park, B. II. (2011). Knowledge transfer capacity of multinational enterprises and technology acquisition in international joint ventures. *International Business Review*, 20(1), 75-87. http://dx.doi.org/10.1016/j.ibusrev.2010.06.002

Parkinson, G. (2011). "Oz to push for more ambitious emissions targets on international stage." *Crikey*. Retrieved on 08 October, 2012 at http://www.crikey.com

Parris, T.M. & Kates, R.W. (2003). Characterizing and Measuring Sustainable Development. Annual Review of Environmental Resources, 28, 59-86.

Pasternak, A.D., (2000). Global Energy Futures and Human Development: a framework for analysis. US Department of Energy, Oak Ridge.

Patt, A., Tadross, M., Nussbaumer, P., Asante, K., Metzger, M., Rafael, J., …Brundrit, G. (2010). Estimating least-developed countries vulnerability to climate-related extreme events over the next 50 years. Proc Nat Acad Sci USA, doi: 10.1073/pnas.0910253107: 1–5.

Pauly, L. and Reich, S. (1997). National structures and the multinational corporate behavior: enduring differences in the age of globalization. *International Organization*, 51(1), 1-30.

Peters, G. Marland, G., Hertwich, E.G., Saikku, L., Rautiainen, A., Kauppi, P.E. (2009). Trade, transport, and sinks extend the carbon dioxide responsibility of countries: An editorial essay. Climate Change, 97, 379-388. DOI 10.1007/s10584-009-9606-2

Peters, G., Davis, S.J., & Andrew, R. (2012). A synthesis of carbon in international trade. *Biogiosciences*, 9, 3247-3276. http://dx.doi.org/10.5194/bg-9-3247-2012. Data may be downloaded with this link: http://dx.doi.org/10.3334/CDIAC/GCP_V2012

Peters, G., Minx, J.C., Weber, C., & Edenhofer, O. (2011). Growth in emission transfers via international trade from 1990-2008. *PNAS*, 108(21), 8903-8908. http://dx.doi.org/10.1073/pnas.1006388108. PMid:21518879 PMCid:3102371

Peters, G.P. (2010). Managing carbon leakage. *Carbon Management* 1:35–37.

Peters, G.P., & Hertwich, E.G., (2008). CO_2 embodied in international trade with implications for global climate policy. *Environmental Science & Technology*, 42 (5), 1401–1407. http://dx.doi.org/10.1021/es072023k

Pourgermani, A. (1988). The political economy of development: A cross-national causality test of development-democracy-growth hypothesis. *Public Choice*, 58, 123-141.

Prescott-Allen, R.. 2001. Compendium of Environmental Sustainability Indicator Collections: The Wellbeing of Nations. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://sedac.ciesin.columbia.edu/data/set/cesic-wellbeing-of-nations. Accessed 30 March, 2013.

Putnam, R.D. (1995). Bowling alone: America’s declining social capital. *Journal of Democracy,* 6(1), 65–70.

Ravallion, M. (2011). On Multidimensional Indices of Poverty. World Bank Policy Research Working Paper, 5580. Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1774427

Rawls, J. (1971). *A Theory of Justice*. Harvard : Harvard University Press.

Resick, C.J., Hanges, P.J., Dickson, M.W., Mitchelson, J.K. (2006). A Cross-Cultural Examination of the Endorsement of Ethical Leadership, *Journal of Business Ethics* 63, pp. 345-359.

Rest, J. R. (1986). *Moral development: Advances in research and theory*, (New York: Praeger).

Rest, J., Narvaez, D., Bebeau, M. J., & Thoma, S. J. (1999). *Postconventional moral thinking: A neo-Kohlbergian Approach*., (Mahway, NJ: Erlbaum).

Richardson, C. (2004). *The collapse of Zimbabwe in the wake of the 1000-2003 land reforms*. Edwin Mellen Press..

Robinson, W. & Harris, J. (2000). Towards a Global Ruling Class? Globalization and the Transnational Capitalist Class. *Science & Society*, 64(1), 11-54.

Rodrik, D. (2001). The Global Governance of Trade as if Development Really Mattered. Trade and Human Development Series, UNDP, New York

Rodrik, D. (2006). What's So Special about China's Exports? *China & World Economy,* 14(5), 1-19. http://dx.doi.org/10.1111/j.1749-124X.2006.00038.x

Rodrik, D., Subramanian, A., & Trebbi, F. (2002). Institutions Rule: The Primacy of Institutions over Geography and Integration in Economic Development. NBER Working Paper No. 9305. http://www.nber.org/papers/w9305

Rogelj, J., Nabel, J., Chen, C., Hare, W., Markmann, K., et al. (2010). Copenhagen accord pledges are paltry. *Nature* 464: 1126–1128.

Sachs, J. McArthur, J.W., Schmidt-Traub, G. Kruk, M., Bahadur, C., Faye, M., and McCord, G. (2004). *Ending Africa's Poverty Trap*. Economic Studies Program, The Brookings Institution, vol. 35(1), pages 117-240.

Sadowski, J., Seager, T.P., Selinger, E., Spierre, S.G., and Whyte, K. (2012a). An Experiential, Game-Theoretic Pedagogy for Sustainability Ethics. *Science and Engineering Ethics*, (Accepted).

Sadowski, J., Seager, T.P., Selinger, E., Spierre, S.G., Martin, E.A., & Berardy, A. (2012b). Collective Action, Evolution, and Intergroup Cooperation*, Human Ecology* (Under review).

Salarpour, M. (2007). The impact of trade liberalization on the Iranian economy. **A** paper for the ICBM Bangkok

Sally, D. (1995). Conversation and cooperation in social dilemmas: A meta-analysis of experiments from 1958–1992. *Rationality and Society* 7, pp. 58–92.

Sally, D. (2001). On Sympathy and Games, *Journal of Economic Behavior & Organization* 44(1), pp. 1-30.

Samson, J., Berteaux, D., McGill, B.J., Humphries, M.M. (2011). Geographic disparities and moral hazards in the predicted impacts of climate change on human populations. Global Ecology and Biogeography, 20(4), 532-544.

Sanchez T. (2010). *The hidden energy crisis: how policies are failing the world's poor*. Practical action.

Sandel, M.J. (2012). What Money Can't Buy: The Moral Limits of Markets. New York: Farrar, Strauss and Giroux.

Schipper, L. & Pelling, M. (2006). Disaster risk, climate change and international development: scope for, and challenges to, integration. *Disasters*, 30(1). 19-38.

Schott, P.J. (2006). The Relative Sophistication of Chinese Exports. National Bureau of Economic Research, Working Paper 12173. http://www.nber.org/papers/w12173

Seager, T.P., Selinger, E., & Spierre, S.G. (2011). Determining Moral Responsibility for CO2 Emissions: A Reply to Nolt, *Ethics, Policy & Environment* 14(1), pp. 39-42.

Seager, T.P., Selinger, E., Whiddon, D., Schwartz, D., Spierre, S.G., & Berardy, A. (2010). Debunking the fallacy of the individual decision-maker: An experiential pedagogy of sustainability ethics. *Proceedings of the 2010 IEEE International Symposium on Sustainable Systems and Technology*, Arlington, VA.

Sen, A. (1999a). *Commodities and Capabilities*, Oxford: Oxford University Press.

Sen, A. (1999b). *Development as Freedom*, New York: Anchor.

Sen, A. K. (1990). Development as Capability Expansion, in Keith Griffin and John Knight (eds), *Human Development and the International Development Strategy for the 1990s*, London: Macmillan,41-58.

Sethi, N. (2011). Durban Climate talks end, new global climate change regime from 2020." *The Times of India*. Retrieved on 30 September, 2012 at http://articles.timesofindia.indiatimes.com/2011-12-11/developmental-issues/30504463_1_eu-roadmap-climate-talks-climate-change

Shue, H. (1993). Subsistence emissions and luxury emissions. *Law & Policy*,15(1), 39-58.

Shue, H. (1999). Global environment and international inequality. *International Affairs*, 75, 3. pp. 531-545

Singer, P. (2004). One Atmosphere, in: *One World: The Ethics of Globalization*. Yale University Press.

Skidelsky, R. and Joshi, V. (2004). One World? The New York Review of Books Published 25 March 2004. Available at: http://www.nybooks.com/articles/archives/2004/mar/25/one-world/

Smith, W. (2012). Kerry: On Eve of Rio+20, An Honest Assessment of Climate Change Challenge." Retrieved on 16 October, 2012 at http://www.usclimatenetwork.org/resource-database/kerry-on-eve-of-rio-20-an-honest-assessment-of-climate-change-challenge

Solow, R. (1956). A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics*, LXX 65-94.

Spierre, S.G., Seager, T.P. & Selinger, E. (2010). Determining an Equitable Allocation of Global Carbon Dioxide Emissions. *Proceedings of the 2010 IEEE International Symposium on Sustainable Systems and Technology*, Arlington, VA

Spierre,S.G., Seager, T.P., Selinger, E. (in press). Assessing the Link between CO2 Emission Transfers and Human Development Advancement. (see Chapter 5 of this work)

Spierre,S.G., Seager, T.P., Selinger, E. (in press). The Diminishing Returns to the 2010 Human Development Index. Sustainable Development. (see Chapter 4 of this work)

Steinberger, J. & Roberts, T. (2010). From constraint to sufficiency: The decoupling of energy and carbon from human needs, 1975-2005. *Ecological Economics*, 425-433. http://dx.doi.org/10.1016/j.ecolecon.2010.09.014

Steinberger, J., Roberts, T. Peters, G. & Baiocchi, G. (2012). Pathways of human development and carbon emissions embodied in trade. *Nature Climate Change*. http://dx.doi.org/10.1038/nclimate1371

Stephenson, J. (2009). AIDS in South Africa. *The Journal of the American Medical Association*, 302(3) doi:10.1001/jama.2009.1013.

Stern, N. (2007). *The Economics of Climate Change: the Stern Review*. Cambridge: Cambridge University Press.

Stern, D. (2010). Between estimates of the emissions-income elasticity. *Ecol. Econ*. 69, 2173-2182 .

Stiglitz, J.E., & Charlton, A. (2005). *Fair trade for all: how trade can promote development*. Oxford University Press

Storm, S. & Naastepad, C.W.M. (2005). Strategic Factors in Economic Development: East Asian Industrialization 1950 - 2003 , *Development and Change.* **36** (6) 1059-1094.

Strange, S. (1996). The Retreat of the State, Cambridge: Cambridge University Press.

Suarez, C.E. (1995). Energy needs for sustainable human development. In J. Goldemberg, T.B. Johansson (Eds.) *Energy As An Instrument for Socio-Economic Development*. New York United Nations Development Programme.

Tao, H. (2012) “To be a global moral leader. How can Norway change the world in a changing world?” Retrieved on 15 October, 2012 at http://www.regjeringen.no/nb/dep/ud/kampanjer/refleks/innspill/miljo_klima/tao.html?id=495584

Thoma, S. J. (1984). Do moral education programs facilitate moral judgment? A meta-analysis of studies using the Defining Issues Test. *Moral Education Forum* 9, pp. 20−25.

Tol R (2009) The Economic Effects of Climate Change. *Journal of Economic Perspectives*, 23 (2): 29–51.

Traxler, M. (2002). Fair Chore Division for Climate Change. *Social Theory and Practice,* 28, 101–34.

Trivers, R.L. (1971). *The Evolution of Reciprocal Altruism*, *The Quarterly Review of Biology* 46 (1), pp. 35-57.

United Nations Development Programme. (UNDP). (2002). Human Development Report 2002. New York: Oxford University Press.

United Nations Development Programme (UNDP). (2013). Zimbabwe Country Profile: Human Development Indicators. http://hdrstats.undp.org/en/countries/profiles/ZWE.html

United Nations (1986), Declaration on the Right to Development, Available at: http://www2.ohchr.org/english/law/rtd.htm

United Nations Environment Programme (UNEP). (2008). Clean Development Mechanism Projects Booming Around the World 2008" Retrieved 12 October, 2012 at: http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=555&ArticleID=6026&l=en

United Nations Framework Convention on Climate Change (1998), Kyoto Protocol to the United Nations Framework Convention on Climate Change, available at http://unfccc.int/kyoto_protocol/items/2830.php

United Nations Framework Convention on Climate Change (2012). Durban Climate Change Conference- November/December 2011. Retrieved on 19, October, 2012 at http://unfccc.int/meetings/durban_nov_2011/meeting/6245.php

United Nations Framework Convention on Climate Change (UNFCCC). (2013). Kyoto Protocol. Available at: http://unfccc.int/kyoto_protocol/items/2830.php

United Nations. (1987). United Nations Report of the World Commission on Environment and Development, Our Common Future: Brundtland Report, Available at http://www.worldinbalance.net/intagreements/1987-brundtland.php

United Nations. (2010). Energy for a Sustainable Future: Report and Recommendations, New York. Available at: http://www.un.org/millenniumgoals/pdf/AGECCsummaryreport%5B1%5D.pdf

Vermuri, A. and Costanza, R. (2005) "The role of human, social, built, and natural capital in explaining life satisfaction at the country level: Toward a National Well-Being Index (NWI)" *Ecological Economics*, 58. pp. 119-133

Victor, David. 2001. *The Collapse of the Kyoto Protocol and the Struggle to Slow Global Warming*. Princeton, N.J.: Princeton University Press.

Vines, A. (2012). The effectiveness of UN and EU sanctions: lessons for the tewenty-first century. International Affairs, 88(4), 867-877.

Walker, L. J. (1985). Sex differences in the development of moral reasoning: A critical review. *Child Development* 55, pp. 677−691.

Walker, L. J., & Henning, K. H. (2004). Differing conceptions of moral exemplarity: Just, brave, and caring. *Journal of Personality and Social Psychology* 86, pp. 629-647.

Walumbwa, F. O., Avolio, B. J., Gardner, W. L., Wernsing, T. S., & Peterson, S. J. (2008). Authentic leadership: Development and analysis of a multidimensional theory-based measure. *Journal of Management* 34, pp. 89-126.

Wang, E. (2012). Gore: Climate change a 'moral issue'. *The Chronicle*. Retrieved 17 October, 2012 at http://www.dukechronicle.com/article/gore-climate-change-moral-issue

Wang, Z. & Wei, S.J. (2010). What Accounts for the Rising Sophistication of China's Exports? In Feenstra, R.C. & Wei, S-J (eds.) *China's Growing Role in World Trade.* University of Chicago Press http://www.nber.org/chapters/c10449

Weber, C.L., Matthews, H.S. (2007). Embodied environmental emissions in U.S. international trade, 1997–2004. *Environmental Science & Technology,* 41(14), 4875–4881. http://dx.doi.org/10.1021/es0629110

Weber, C.L., Peters, G.P., Guan, D. and Hubacek, K. (2008) *The contribution of Chinese exports to climate change,* Energy Policy, Volume 36 (9), 3572 - 3577.

Wiebe, K.S., Bruckner, M. Giljum, S., Lutz, C. (2012). Calculating Energy-Related CO_2 Emissions Embodied in International Trade Using Global Input-Output Model. Economic Systems Research, 24(2), 113-139.

Williams ED, Weber CL, & Hawkins TR (2009) Hybrid Framework for Managing Uncertainty in Life Cycle Inventories. Journal of Industrial Ecology 13:928-944.

Woolcock, M. (1998). Social capital and economic development: toward a theoretical synthesis and policy framework. *Theory* and *Society,* 27(2),151–208.

World Bank. (2010a). Development and Climate Change. World Bank Publications. Available at: http://web.worldbank.org

World Bank. (2010b). Aid-for-Trade: Case Story. Export Development Project, Tunisia. http://www.oecd.org/aidfortrade/48288694.pdf

World Bank. (2013). Country Policy and Institutional Assessment. World Bank Data. http://data.worldbank.org/data-catalog/CPIA

World Bank. (2013a). GNI per capita, PPP (current international $). Available at: http://data.worldbank.org/indicator/NY.GNP.PCAP.PP.CD

World Bank. (2013b). Access to electricity (% of population). Available at: http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS

World Health Organization, United Nations Children's Fund (2000), Water Supply and Sanitation Council. Global Water Supply and Sanitation Assessment 2000 Report. New York, NY:UNICEF; 2000.

Yang, Y. (2003). China's Integration into the World Economy: Implications for Developing Countries. IMF Working Paper.

York, G. (2012). "Low profile in Durban relegates Canada to margins of climate debate 2012." *The Globe and Mail.* Retrieved on 17 October, 2012 at http://m.theglobeandmail.com/news/politics/low-profile-in-durban-relegates-canada-to-margins-of-climate-debate/article2262549/?service=mobile

Youde, J. (2007). *AIDS, South Africa, and the Politics of Knowledge*. Ashgate Publishing Group.

Appendix A

MORAL LEADERSHIP AND CLIMATE JUSTICE

Susan G. Spierre[1], Jathan Sadowski[2], Thomas P. Seager[3], Evan Selinger[4]

[1]PhD Candidate in the School of Sustainability at Arizona State University

[2]Graduate Student at Arizona State University

[3]Associate Professor in the School of Sustainable Engineering and the Built Environment at Arizona State University

[4]Associate Professor of Philosophy and Graduate Program Faculty in the Golisano Institute for Sustainability, both at Rochester Institute of Technology

Abstract

International climate meetings are typified by frustration over diverse mitigation outlooks. This is not surprising: climate change is a collective action problem; domestic mitigation efforts yield global benefits. To explore overlooked models of cooperation, we've created, run, and studied a non-cooperative game that examines how students at multiple universities manage common-pool resources. Contrary to theoretical predictions, we observe widespread cooperative behavior. This success is due to the moral suasion of ethical leaders, and we argue the importance of our findings extends beyond the classroom. It clarifies which countries can exert ethical leadership to facilitate enhanced global cooperation for significant mitigation.

Challenges of Addressing Climate Change

In late December, 2011 government officials and other representatives gathered for the United Nations Framework Convention on Climate Change (UNFCCC) in Durban, South Africa. It was the 17th Conference of the Parties (COP 17) since 1994, when the convention entered into force. According to the United Nations (UN) the notable outcomes of the meeting include the establishment of a second commitment period under the Kyoto Protocol, an outline to negotiate a new legal and universal emission reduction agreement by 2015 that would come into force in 2020, and the operationalization of the Green Climate Fund for climate adaptation (UNFCCC 2012; IISD 2011). However, this seemingly successful list of Durban's climate achievements masks the complicated turmoil and frustrations expressed by participants during the conference.

Political and economic impediments to cooperation are the more familiar narrative of international climate talks, and Durban was no exception. Many of the details surrounding the listed outcomes have been a source of continuing controversy between nations. For example, the decision on exactly when the second commitment period of Kyoto will end was not decided (HFW 2012). The Alliance of Small Island States pushed for a shorter, five-year commitment period to prevent inaction by the developed world. The European Union (EU) opted for an eight year period, claiming that they have already set domestic targets for 2020. At the same time, the low-lying nations sought deeper emissions cuts to contain temperature gains and resulting sea-level rises (Bloomberg News 2012). In addition, arguments ensued between the EU and major developing countries, lead by China and India, over the terms of Kyoto's predecessor. The EU pushed for a globally binding agreement that would include mitigation commitments for major developing economies. India and China however demanded an approach that considers the development needs of poorer nations (Sethi 2012). Also, funding for the Green Climate Fund (GCF) was not secured; at Durban only pledges were made. There is always the risk that countries may not fulfill their commitments, just as Canada threatened to withhold contributions to the GCF unless all major polluters committed to binding carbon reductions (Environment Canada, 2011). Canada, Russia and Japan joined the US, who has never ratified the Kyoto Protocol, in not signing up for new emission targets under the second Kyoto commitment period. Consequently, real cooperation among the world's biggest emitters on a global mitigation framework remains a fantasy.

The collective action problem vexing climate policy is by now familiar (e.g., Seager et al., 2011; Gardiner, 2004, 2006; Ostrom, 2010). Greenhouse gases (GHG) mix globally in the atmosphere and their accumulation has global impacts on the Earth's climate. Efforts to abate emissions by a single country impose local costs while yielding globally shared benefits. Each country therefore faces incentives to free ride—to let others bear the costs of limiting emissions while enjoying the global benefit. Moreover, the uneven development and varying historical responsibility for emissions creates a strong ethical debate about who should bear the cost of mitigation efforts (Jamieson, 1999; Brown, 2011; Gardiner, 2004, 2006; Broome, 2008; Singer,2004; Spierre et al. 2010), Alas, successfully implementing a system of global compliance requires collective, social decision making that is unprecedented among people with radically different values and radically different needs (Gowdy, 2008).

To make matters worse, foundational theories of human behavior provide scant insight into successful strategies for resolution of collective action problems. Neoclassical economic theory predicts tragedy when rational decision-makers maximize personal utility without enforcement by a third-party. Evolutionary biology tells us that cooperation is possible, but only likely when boundaries define an in-group and an excluded out-group, a.k.a. evolutionary tribalism or parochial altruism (Abbink et al., 2011; Bornstein, 2003; Choi & Bowles, 2007; Sadowski et al., 2012b). The implication is that global problems of collective action like climate change, which include all individuals without exception, are insolvable.

In practice, however, individuals have been found to exhibit behavior that is inconsistent with foundational theory. For example, Elinor Ostrom (1999) provides examples of sustainably managed common-pool resources at the local scale without privatization or institutional regulation (e.g., community owned irrigation systems in Nepal). Moreover, David Sally (2001) points out that unlike the independent decision-makers modeled in game theory (e.g., the prisoner's dilemma) humans have the innate quality of sympathy generated through social interaction, which guides strategy formulation. The effect of sympathy on game-play can result in unpredicted behaviors of players, especially among friends, face to face interaction, and those players identified as having interpersonal similarities (Sally, 2001). Furthermore, reciprocity has been proposed as a solution to the problem of moral compliance, the problem of how moral norms are often in contradiction to incentives to deviate. The idea is that people living in close-knit groups form complex reciprocal relationships which result in linkages of people indirectly helping other people (Alexander, 1987; Boehm, 2012; Hume, 1992; Nowak, 2006, 2012; Trivers, 1971).

Thus, contrary to many foundational theories, alternative models of cooperation may be available through the study of real human behavior in social settings. To identify potential strategies for collective action that may have been heretofore overlooked, we modeled a Tragedy of the Commons problem[1] as a non-cooperative game, called *the Pisces Game,* to investigate how students at multiple universities organize and make decisions about common-pool resources, in this case a fishery. Contrary to the usual narrative of international negotiations and the predictions of foundational theories, we observed cooperative—even altruistic—behaviors among students from different groups during game-play.

Testing Cooperation

We organized two game experiments using *the Pisces Game*. The first was played by Arizona State University (ASU) and Rochester Institute of Technology (RIT) students. The second was played by three different classes, one from ASU and two from Mesa Community College (MCC). In both treatments, students were encouraged to communicate face to face in class and to use information communication technologies (ICT) outside of class and with students attending the partner university. For example, an online discussion board was established on the National Science Foundation funded website EthicsCORE (www.nationalethicscenter.org) for students to collaborate. The following is a short description of the game.

In the Pisces Game, all participants are assigned to a group based on their zodiac sign. Each group represents a fishing village and all the fishing villages depend on a common lake for sustenance. The villages take turns catching fish out of the common lake and make decisions about what they want to do with the fish they catch. They have five options:

[1] Garrett Hardin first described this social dilemma in "The Tragedy of the Commons", published in *Science* in 1968, which predicts that individuals acting in their own self-interest will destroy common pool resources in the absence of regulation, privatization or population constraints (Hardin, 1968)

1. *Consume* fish, where one fish consumed equals one point towards their grade. Each student must consume a minimum number fish per round for sustenance or they are eliminated from the game.
2. *Invest* fish into building a private pond for storage and growth of a private stock of fish separate from the lake. The capacity of the pond is a function of the cumulative total of fish invested, and subject to economies of scale[2].
3. *Stock* their private pond with fish from the common lake.
4. *Harvest* fish from their private pond for consumption or gifting (see #5).
5. *Give* fish caught from the lake or harvested from the pond to other groups.

At the end of each full round of play, i.e. once every group has turn, reproduction occurs in both the common lake and the entire private ponds. The game proceeds for eight full rounds or until all of the groups can no longer eat the subsistence requirement of fish each round.

The game is designed to create real tensions among participants by placing personal interests at odds with collective goals. Participants are incentivized to act selfishly because real grade points are allotted based upon their game performance; the more fish a player consumes, the better their grade. It is possible for students to achieve an “A+” in the game, but only if they are willing to consume so many fish that they impoverish other players (Sadowski et al., 2012a; Seager et al., 2010). There are also multiple ways for collective cooperation to occur; we have observed two particular common strategies among students during past game tests. First, each group can curb

[2] In microeconomic terms, ‘Economies of scale’ refers to the reductions in unit cost as the size of the facility and the inputs increase. In the Pisces Game, the private pond capacity grows slowly with initial investments, but the size of the pond increases rapidly after significant investments are made.

consumption to allow growth of fish—either in the common lake on in ponds—to ensure that all groups have equal, long-term access to resources. For these particular experiments, the game was calibrated so that a minimal consumption and individual investment strategy could lead to a grade of about a “C+” for every player. Second, groups could strategically invest as much as possible in just a few private ponds in select villages, thereby capturing economies of scale. The villages that tended these collective ponds would distribute the harvested fish to every group during the last round of the game, enabling consumption and a grade of about a “B+” or “A-“ for each group. One challenge in the game was discovering these strategies, as they were not revealed to the students by the instructors.

Both strategies could be discovered, but difficult to implement for multiple reasons.   Players would not only have to overcome their tribalistic attitudes towards other groups (predicted by evolutionary biology theory, see Sadowski et al. 2012b), but also work through the transaction costs (Coase, 1960) involved in coordinating one of these cooperative plans. Ostrom (2010) offers a comprehensive list of likely determinants of collective action and how they are posited to affect results from wider literature. In general, as both the number and diversity of participants increase, the likelihood of achieving collective action has been found to decrease. Also, the amount of trust and the reputation of participants from former actions play a critical role in how individuals behave in a group setting. Ostrom also explains that face-to-face interaction is the preferred medium to increase the likelihood of cooperation.

The first game treatment had 48 students between ASU and RIT that were from a wide-range of degree programs and included both undergraduates and graduate students.

The second had a total of 118 students in three undergraduate engineering classes at ASU and MCC. During game-play it was likely that if one or more of the groups deviated from collective plan their reputation would be tarnished and the other groups would be unlikely to trust them for the remainder of the game (Milinski et al., 2002). And, although our students were able to communicate face to face with their classmates during parts of the game, communication across universities and outside of class occurred through digital ICT.

To determine the extent to which students cooperate during game-play, we observe the students' deliberation, and review their public statements of intent. These are compared to actual decisions and behaviors during the game, individual final game grades, and overall group outcome. For example, if the groups' interactions suggested the desire for an egalitarian outcome, but their actual decisions resulted in inequality, we would presume the group was not mutually cooperative. Indeed, studies show that ethical judgments are only weakly related to actual ethical behaviors (Rest et al., 1999; Hannah et al., in press). At the end of each treatment we moderated class discussions and, if necessary, spoke to individual players so as to better understand the students' motivations during the game. Next, we will briefly describe the two game experiments.

Treatment 1: ASU & RIT

In the first treatment, gameplay was asynchronous; the classes met on different days and at different times. The ASU class played the first four rounds (first generation), then RIT inherited the model from ASU (second generation) to finish the remaining four rounds. In this treatment each village was required to consume a minimum of four fish per village to sustain themselves until the next round and all players belonging to one zodiac sign received the same grade at the end of eight rounds, regardless of the university in which they were enrolled. Thus, all zodiac villages were required to make collective decisions, but only those players at one university (at a time) had the authority to decide. The ASU play happened in one three-hour class period, with no prior experience with the game model. RIT play followed two days later, and players at both Universities were permitted to communicate via EthicsCORE during the time between game play decisions. This means RIT players had more time to experiment and benefit from the ASU players' experience, but were also more constrained in their options (by inheriting the choices the ASU players had already made, without the RIT players' knowledge).

The ASU students decided to cooperate and do their best to supply RIT with the means to achieve an equitable grade outcome. They reasoned that the just strategy would be to ensure that everyone had a chance to earn the same grade. Unfortunately, because the ASU students had limited time and failed to understand the mechanics of the game right away, they left their RIT counterparts with a relatively depleted fishery. The second generation was less than pleased with their inheritance of fish. One student in particular questioned the lack of planning on the part of ASU that resulted in "a far from optimal first half" that couldn't be fixed. ASU responded that the RIT players were being insensitive to the limited time and experience they had with the game.

Meanwhile, it was discovered that there was a zodiac sign represented at RIT that was not present at ASU. RIT discussed a plan that would capitalize on this discovery and "punish" ASU for their earlier mistakes. The strategy was to give all their points to this 'extra' group in the last round and then redistribute the points back to the RIT players after the game. In this way no points would be left for ASU students. There was rampant disagreement amongst the RIT groups on how to proceed with the game. Some groups wanted to remain amiable and cooperative, while others opted to earn a high grades, even if that meant harming everybody else. ASU acted quickly to try to persuade RIT to act cooperatively via ICT and save their grades from RIT's revenge. Luckily, one player at RIT devised and disseminated a strategy that could be implemented by the second generation that would salvage the game and earn everyone a decent grade. No one publicly contested the plan and the second generation of RIT students seemed ready to implement it during class.

However, during class one group at RIT unexpectedly deviated from the collective plan and over consumed fish. The dissenters argued that the master plan was too technical for them to verify and therefore required blind obedience by the less mathematically savvy members of the class[3]. Arguments and accusations overwhelmed the class, so much so that the class was dismissed early to allow players to calm down. Heated discussions however continued online between the RIT students, unbeknownst to ASU. The cooperative players contested the behavior by the dissenting group and began thinking about ways to retaliate. Instead, another group (who had the second highest stock of fish, second to the dissenters) altruistically decided to donate all their fish to the dissenting group. They reasoned that this act would reveal their true moral fiber because they would have to decide between giving away their fish to uphold their stated principle of democracy, or be exposed for acting selfishly by keeping the fish for themselves. The decision by the dissenters would make or break the outcome of the game and ultimately

[3] Later on, the dissenting group admitted that they deviated from the plan because they thought that the cooperative solution was 'boring' and instead they wanted to make the game more interesting.

be the difference between successful cooperation and moral failure (not to mention good or bad grades for most players).

In the end, the dissenters committed to the greater ethical principle that the class sought and distributed the fish equally among all groups. But the drama wasn't over; when ASU found out about what happened, and despite the positive outcome, complained that their grades were put on the line by RIT without their consent. RIT responded by producing a video message to ASU, explaining their actions and why ASU was not included in the discussions. All groups avoided disaster and ended up achieving group cooperation—even in the face of an unusual conflict.

Treatment 2: ASU & MCC

In the second treatment, game-play took place on a single day over two class periods. The first class at MCC (first generation) met earlier in the day and played the first four rounds of the game. A few hours later the second class at MCC and the ASU class (second generation) met simultaneously and inherited the model from the first generation of players. The size of the lake was recalibrated to anticipate an explosion of players during the second generation, so the comparatively smaller first generation could potentially consume as many fish as they could in without exhausting the lake during their four rounds of play (although this would risk impoverishing the later classes). Since the second generation classes at ASU and MCC were scheduled to meet at the same time, they were required to discuss and make decisions in real time via chat windows on EthicsCORE. In this treatment, we required consumption of four fish per player. Thus, larger villages were disadvantaged compared to smaller groups. Also, students were graded individually in this treatment and earned points for the fish they personally consumed.

A similar dynamic to Treatment 1 occurred during this game. The first generation at MCC devised a long-term cooperative plan based on limiting consumption and investment in collective ponds for capturing economies of scale. Their plan was to sacrifice their own grades (down to an 80%) by limiting their consumption, so as to ensure that the second generation could earn “A” grades. This strategy was remarkable given that the first generation had no interaction with the second generation and would in no way benefit from this choice to behave altruistically towards the other classes. Unfortunately, a clerical error in the way that they reported their final round of decisions resulted in a catastrophic destruction of fish (by stocking the private ponds beyond their capacity). The second generation of students at ASU and MCC discovered the error in the middle of their first round of play, after several villages had already entered consumption decisions predicated on a false impression of how many fish remained in the lake. The accidental destruction of the fish meant that grade expectations of the second generation were significantly reduced. Instructor’s let the error stand, reasoning that population surveys are imperfect, ecological models are often incorrect, and that decisions must be made today under the constraints imposed by mistaken decisions in the past.

This unforeseen incident caused the second generation to blame their ‘ancestors’ and reconsidered their initial cooperative intentions. Several students at ASU closed their laptop computers, as if to disengage from the game. However, the tone and location of leadership changed in response to the new challenge—particularly at ASU. One student argued that the point of the lesson was not to test the students’ ability to manipulate the model correctly, but to test their moral aptitude, and that giving up now would be to fail the moral challenge. He asked the technical leaders in the class to reopen their laptops and find a new optimal solution, given the new constraints. Despite an increase in the conflict, both classes in the second generation successfully coordinated decisions at each village to achieve an egalitarian outcome.

The uniform cooperation amongst every group from both universities came as a surprise. There were strong incentives for the groups to compete with each other over the scarce resources. Yet, the players demonstrated collective action and, per their intended plan, allocated grade points among players in an equitable fashion.

Cooperation through Moral Leadership

In our observations, we noticed an important factor for achieving collective action. The devised strategies and group decisions were often centered around a few active individuals who took on the role of *ethical leaders*. They were players that emerged as outgoing and trustworthy individuals that voluntarily advised and directed their own group's actions as well as influenced other groups to follow suit. They encouraged collective deliberation to determine what ends the group should work towards. They gained authority with others through their significant contributions to decisions that resulted in the cooperative ends being realized. Moreover, they employed altruistic and moral arguments for the outcomes and behaviors they sought from the group. In particular, these leaders were crucial during the online discussions amongst the groups.

Social cognitive theory (SCT) helps to explain why and how ethical leaders influence their followers. SCT is based on the idea that individuals learn by observing and emulating attractive and credible models of values, attitudes and behaviors (Hannah et al., in press; Brown &Trevino 2006; Brown et al. 2005; Mayer et al. 2009). Ethical leaders are likely sources of guidance because their appeal and credibility as role models draw attention to their modeled behavior. They are characterized as honest, caring, and principled individuals who make fair and balanced decisions. They also frequently communicate with their followers about ethics, and set clear ethical standards (Brown & Trevino, 2006; Avolio & Luthans, 2006; Walumbwa et al., 2008). Drawing from SCT, social learning through observing moral exemplars will enhance observers' moral cognitions and also their moral courage, the ability to sacrifice or risk one's individual interests in order to uphold personal moral principles (Lester et al., 2009; Walker & Henning, 2004). When leaders signal that followers should stand up and act in line with their values, thus showing moral courage, and the leader consistently demonstrates similar behavior, followers are more likely to emulate moral courage (Hannah et al. 2005). It could be that the more introvert and/or ethically inexperienced members of the class looked to the emerging ethical leaders in the game for guidance on how to navigate the unfamiliar problem they confronted in the game. Because the guidance originated with the morally minded students, they may have inspired the cooperative actions and outcomes observed among groups.

To investigate this postulation in our game experiments, we plotted the number of online responses contributed by each student for both treatments, shown in Figure 1. Both plots show that most of the contributions to the group were made by just a few active individuals. The sloping trend line on each graph is a power law equation fitted to the data for each treatment. Notice the high R^2 values for both sets of data (0.9512 and 0.88), which indicates that the power function represents the experimental data quite well. The observed power-law relationship of contributions is indicative of student leadership, at least in terms of participating in online discussions. This relationship is consistent with the Pareto Principle, in which "80% of the consequences typically stem from 20% of the causes" (Bunkley, 2008). In this case the consequence was group cooperation, and the cause could be the *moral persuasion* of ethical leaders in the group.

As instructors, we were able to examine the context of the posts and link the most active online contributors to particular students in our classes. Indeed, those students who posted the most on the discussion boards were the very leaders that coordinated the actions of others in the game. For example, the player that contributed the most online in the first treatment was a major influence on how RIT proceeded with the game after ASU played the first four rounds.

This active player argued for a utilitarian strategy that, in his opinion, was hindered greatly by the actions of ASU. He emphasized the need for ASU to realize the implications of their behavior on others. He also was the first to push for an egalitarian outcome that would result in the same but highest grade possible for everyone; he spent hours devising a step-by-step plan that his generation could follow. This student leader however was unwilling to sacrifice moral principles to achieve higher grades for everyone; when RIT was encouraged by ASU to misrepresent the number of zodiac signs in the RIT class to maximize everyone's grade, he responded by discussing the moral implications of acting in such a way. He wrote the following on EthicsCORE, "In an effort to gain trust of most people, my basic plan has been transparency and democracy. The whole class seemed uncomfortable with lying so democratically it would have failed and any lying spits in the face of transparency. If we are willing to lie about teams this game, who knows what that will lead to next game." From the beginning, this player was an ethical leader, whose strong vocal communication influenced the ultimate game outcome.[4]

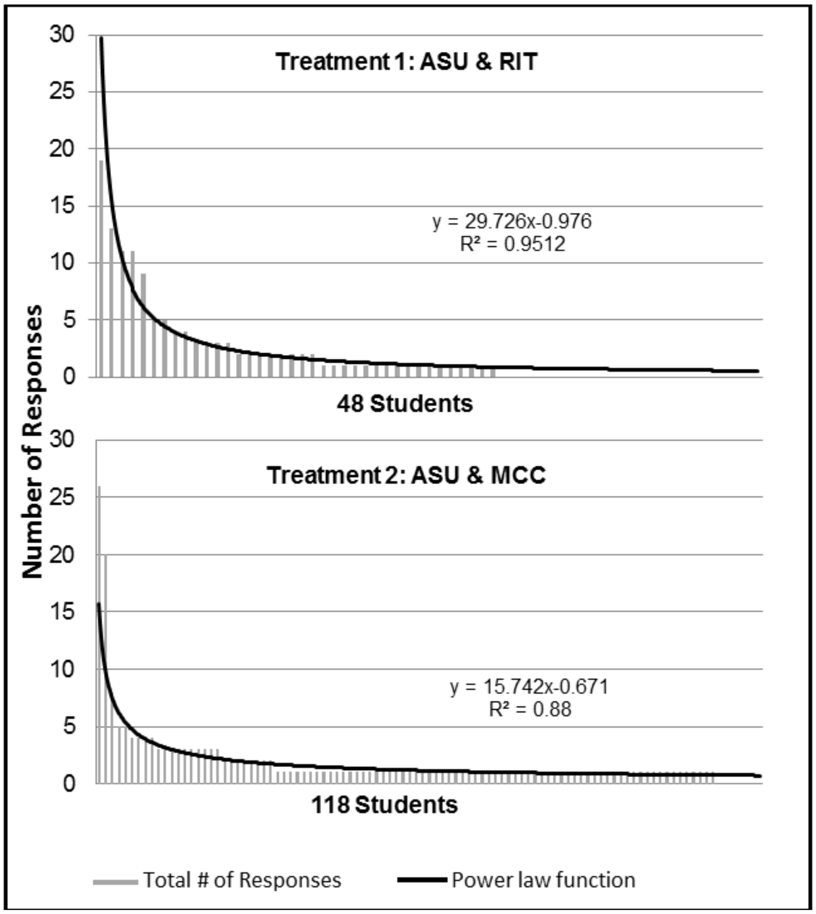


Figure 20. The numbers of online responses contributed by each student are plotted for both Treatment 1 (top) and Treatment 2 (bottom). A power law trendline is fitted to the data on both plots. We found that most of the contributions to the group's online communication were made by a few relatively active individuals.

[4] When the active player's plan was subverted during game-play, his ethical leadership was called into question. The dissenters claimed that the student's plan was technocratic and that he was instilling an ethos of group think. This points out the risk that ethical leaders take when they display acts of moral courage; they are subject to being misinterpreted by those around them. We reason that the group who subverted his plan was incorrect in their accusations. The problem of group-think or technocracy wasn't really present, given the student's public display of a solution and how he offered step-by-step instructions for each group to follow. Also, the deviant group admitted later-on that the initial reason that they resisted cooperation was to "make the game more interesting".

In general, the online contributions by the most active players seemed to greatly influence the strategies that lead to the cooperative solutions in both treatments. That is, they influenced the disparate groups to cooperate with each other instead of taking the free-rider approach to the problem or resorting to economic rationality or evolutionary tribalism. Furthermore, in the case of multi-university play, influence exerted by these leaders involved communicating through digital ICT, rather than face-to-face appeals. This is significant given the emphasis placed on face to face communication in achieving positive outcomes in collective action experiments (Ostrom, 2010; Sally, 1995). The implication is that the difficulty of achieving cooperation over geographical distances may be alleviated through electronic communication (Axelrod et al., 2002). Digital ICT may be a tool that can help to reduce the transaction costs of international collaboration and perhaps aid the achievement of collective action.

It could also be that the relative role or position of the ethical leader in the game is significant in the moral persuasion of followers. The student described above, who was very influential in coordinating the actions during the ASU and RIT game was in the Gemini group, which is the third sign in the zodiac calendar. This means that the student not only argued for cooperation on the moral grounds of fairness, but also sacrificed the potential opportunity he had to take advantage of his relative position in the game. Had the student been a member of one of the later groups, the plea for equity may not have been as influential and could have been perceived as a selfish act. This is because the later groups in the zodiac calendar (i.e., Aquarius and Pisces) are the last groups to fish from the common lake in each round; they have a disadvantage in terms of the number of fish available to catch when/if the common lake becomes depleted. Even if these disadvantaged players provide sound moral arguments for a particular strategy, they also have personal incentives to argue for egalitarian outcomes that may offer them a higher grade than they could achieve independently. Therefore, only the students with a relative advantage can exhibit true acts of moral courage, because they are personally taking a risk for a greater moral principle.

Moral Leadership and Society

Before proceeding further, it is important to make the distinction between ethical leadership and positional leadership. Holding a formal leadership position or position of power does not necessarily mean that a person exercises true leadership. People in leadership positions may exercise force or authority using only their position and the resources and power that come with it. For example, Ciulla (2004) discusses “the Hitler problem”, the idea of considering Hitler as a great leader because of his profound influence over history. However, any definition of leadership that includes moral considerations would not consider Hitler a leader at all (Ciulla, 2004). According to Burns (1978), true leadership “induces followers to act in accord with the values and the motivations of both leaders and followers and where they raise one another to higher levels of morality.” It is the latter type of ethical leadership we observed making a difference in games and are interested in exploring further. The implication is that this type of leadership may induce cooperative actions for the greater good among groups with competing interests, even among leaders at the international scale.

To consider the potential implications at the global scale, we need to first think about how differences in culture may impact peoples’ perceptions of what makes an ethical leader. Fortunately, Resick et al. (2006) studied qualities of ethical leadership across more than fifty nations. Using data from the global leadership and organizational effectiveness (GLOBE) project Resick and colleagues measured four dimensions of ethical leadership: character/integrity, altruism, collective motivation and encouragement. They found that these four dimensions were universally supported, but the degree to which each component was endorsed varied across cultures. Furthermore, studies show little to no relationship between leader demographics (i.e., sex, race, gender) and ethical leadership (Brown & Trevino, 2006; Walker, 1985; Rest 1986; Thoma, 1984). This is good news for the prospect of using ethical leadership to influence positive collective action at the larger scale because there seems to be a general consensus on the qualities that an ethical leader should possess that is unbiased towards a person's nationality or inborn characteristics.

Perhaps one of the most well-known examples of effective moral leadership at the international scale is Mahatma Gandhi. Gandhi led the struggle for independence of India against British colonialism, against the caste system, and to oppose the maltreatment of women. With a commitment to nonviolent action and truth, Gandhi sought justice, human rights, and democracy. He was truly an ethical leader because he emphasized how the moral courage needed to uphold non-violence as a tool of protest was much greater than the one needed to strike back in a violent way. His broader influence resulted from African American leaders who traveled to India to learn from Gandhi about how to create power without the urge for revenge. Eventually, Gandhi's insights influenced Martin Luther King, Jr. and motivated his approach to non-violent activism for racial equality. Furthermore, the techniques of Gandhi and King have been employed successfully by people in recent popular movements including the Poles, East German, Czechs and

Slovaks, the Burmese, Palestinians, Guatemalans, and Thais (King 1999). But, do we have a modern day ethical leader like Gandhi, not motivated by personal interests but by the greater good, available to act as a moral exemplar for the leaders of the 195 member countries in the UNFCCC?

Ethical Leadership in the UNFCCC

Unlike the exemplar leadership Gandhi and King, leadership at representative international meetings is much more complicated than the personal moral standards and/or commitments of the individual delegate. Each representative embodies the values and principles, as well as the judgments resulting from historical decisions, of their respective nation or organization. Thus, ethical leaders that embody such characteristics like integrity, transparency, and altruism at the climate negotiations yet represent historically uncooperative and untrustworthy parties will likely not emerge as the influential agent of collective action. In the context of international climate policy, potential ethical leaders may be representatives of nations that are respected by both developed and developing nations for things like justice, equality, and human rights. Particularly for climate change negotiations, an ethical leader would be committed to showing national moral courage by fulfilling their nation's obligations to others (in terms of mitigation and/or financial support) despite what other nations do and at the risk of domestic interests.

Considering the outcomes of past climate negotiations, ethical leadership is improbable to emerge from the likes of the United States, Russia, Canada, or Japan. These nations have been resolute in their unwillingness to commit to GHG emission reduction unless other major world economies do so as well (HFW, 2012). The reason for this position, they say, is that reductions in emissions will not be politically feasible (i.e., in the U.S. it is unlikely to get ratified by Congress) if those reductions place the nation at an economic disadvantage. This is considered to be an immoral act because these countries are approaching negotiations as if their national self-interests trump their global responsibilities to protect people around the world and the natural resources on which life depends (Brown, 2011). In fact, it is a contradiction to moral courage, which in this context refers to one's willingness to risk domestic interests in order to fulfill obligations to others.

One might argue that countries like the United States may not be acting immorally if they reason that they do not have any moral obligation to others in the context of anthropogenic climate change. Markowitz & Shariff (2012) found evidence from behavioral and brain science that individuals may not be well inclined to identify climate change as an important moral imperative because it fails to generate strong moral intuitions in the same way that other moral imperatives do. However, some American leaders have publicly admitted responsibility. Former Vice President Al Gore, who was awarded a Nobel Peace Prize in 2007 for his book *An Inconvenient Truth*, has emphasized that reversing the effects of climate change is a moral imperative and that ignoring the problem will imperil future generations. In a 2010 speech he said, "Make no mistake, this is not just a political issue, not just a market issue, not just a national security issue, not just a jobs issue; It is a moral issue" (Wang 2010). Also, Senator John Kerry, Chairman of the Foreign Relations Committee said the following in a senate floor speech this past June,

> *"The plain fact is that there isn't a nation on the planet that has escaped the steady onslaught of climate change. When the desert is creeping into*

East Africa, and ever more scarce resources push farmers and herders into deadly conflict, then that is a matter of shared security for all of us. When the people of the Maldives are forced to abandon a place they've called home for hundreds of years—it's a stain on our collective conscience, and a moral challenge to each of us. When our own grandchildren risk growing up a world we can't recognize and don't want to, in the long shadow of a global failure to cooperate, then—clearly, urgently, profoundly—we all need to do better" (Smith 2012).

The realization by some national leaders that climate change is an ethical issue, yet persistent in-action in addressing responsibility substantiates the perception of immorality.

Much like the US, Canada openly opposes the second commitment period of Kyoto because it exempts the major developing economies of the world from emission reduction targets. A nation that was applauded for its ethical stance in the 1980's when it fought the apartheid system has now been accused of abandoning its moral leadership in Durban. Canada has tried to promote the oil sands as the 'ethical oil'[5] option in the past, but critics say that it cannot make the argument by being silent. Canadian representation kept a low profile at the conference, and stuck to its position of opposing Kyoto. Whereas other countries offered video messages and had pavilions in the Durban Exhibition Center, Canada did not even have a small booth on display. Because of the country's no effort diplomacy, many countries have stopped perceiving Canada as a negotiating partner (York 2012). In this way, Canada has become a bystander in the current climate negotiations; in terms of showing moral courage or ethical leadership in the UNFCCC, Canada would be more accurately described as morally disengaged.

[5] In a book entitled 'Ethical Oil: The Case for Canada's Oil Sands', Ezra Levant makes the case for exploiting Canada's oil sands in terms of four criteria: the environment, conflict, economic and social justice, and freedom of oppression. He says that in these terms, the Canadian petroleum industry is much more ethical that other crude producers like Saudi Arabia, Libya, Nigeria and Venezuela (Lezra 2010).

We also can look at the quality of ethical leadership for other major players in the climate negotiations. The EU, backed by the small island states, came to Durban with a plan to convince the developing nations, mainly the major economies like India and China, to agree to a forward-looking approach that would place legally binding emission targets on all countries, regardless of historical responsibility. The small-island states backed the EU because their priority is to attain deeper emission cuts to contain the temperature increases, thus sea-level rise, that is already inundating their coasts. The island alliance understandably called for a shorter, five-year second commitment period to Kyoto given their preference for more urgent reductions, but the EU opted for an eight year period that more conveniently aligned with already determined domestic targets. The position of the EU, although arguing for a system that would likely result in more significant reductions overall, is perceived as inequitable by the developing countries because it would place less responsibility on the industrialized nations compared to a situation that determines obligations based on historical emissions. Moreover, the EU's argument for a more extended commitment to Kyoto than desired by the islands, questions the moral integrity of the European countries further.

India's Union environment minister, Jayanthi Natarajun, has been admired for "standing up" to the developed world, using ethical arguments to justify the nation's position. India demanded that the principle of equity -- in terms of historical responsibility and human development considerations– remain intact in the new climate regime. Other developing countries supported India, including China and countries like Pakistan, Philippines and Egypt. They demanded a more equitable mitigation system that would secure development space for the poorer nations, even under their increased obligations under the post-Kyoto climate regime. China's minister, Xie Zhenhua, stood up in support of India's position saying, "What qualifies you to tell us what to do? We are taking action. We want to see your actions" (Sethi, 2011). Indeed, both China and India have ratified the Kyoto Protocol, and although are exempt from binding emission limits, they are the largest sources of Clean Development Mechanism (CDM) credits[6] (UNEP 2012). Also, both nations have reduced their emissions growth rates significantly over the past few decades (C2ES, 2002).

It is reported that after many hours of negotiations in Durban, the chair was forced to adjourn the meeting and requested that the EU and India find a compromise. Other countries like China and the U.S. huddled around India's representatives to determine a statement that would offer the world cooperation towards a new climate regime, but using language that did not lock in any of the countries to future commitments they weren't prepared to make. The countries decided "to launch a process to develop a protocol, another legal instrument or an agreed outcome with legal force" (HFW 2012). Although the specific details of how the new climate regime will address both sides of the issue, it is said that India showed great leadership by bringing considerations of equity back into the discussion and gained respect from many developing countries in the G77+China group for remaining committed to their position (Sethi, 2011). But can we consider India an ethical leader in the UNFCCC negotiations?

Many accounts of the happenings at Durban applaud India for its role in keeping equity a priority in the next climate regime. However, India's Jayanthi Natarajun did not

[6] The CDM grants emission credits for verified reductions in developing countries, which can be used by developed countries toward meeting their Kyoto targets. This provides lower-cost emission reductions for developed countries and generates investment in clean development in developing countries.

exercise moral courage as it has been defined here. Although India is arguing for a mitigation system that focuses on equity, its representatives are not risking national interests. A system based on historical responsibility and/or development needs will certainly benefit the interests of India, China and other developing nations. Their position argues for more responsibility for climate change placed on the developed world, which would likely result in less stringent emission caps and/or mechanisms that would aid the developing countries reach their targets without sacrificing development. Even though the developing nations are making a sound ethical argument, they are not displaying true moral courage because they are not risking their nation's interests for greater moral principles. We suggest that the ethical leaders among the delegates at the UNFCCC must emerge from developed nations that are willing to risk potential economic losses for the collective goal of mitigation and equity.

A few researchers have informally alluded to the potential role of smaller developed nations as exemplars of climate justice. For example, Norway is proposed as a nation that is not known for its economic or military power but is recognized internationally as a nation with known for its good reputation, respect, culture, justice, and not to mention relative wealth due to its economy based on producing oil and natural gas. Norway is also broadly respected for its reputation in environmental protection, poverty alleviation and public health (Tao, 2012). In fact, it was the Prime Minister of Norway, Gro Harlem Brundtland, who led the 1987 World Commission on Environment and Development report entitled "Our Common Future", which notably defined the concept of *sustainable development*[7] for the world (United Nations, 1987). In Durban, Norway allied with Australia and put forth a proposal that would place binding mitigation commitments on the developed world, saying that they should be "held accountable" to the emissions outcome of their targets; but developing nations would "only be bound to implement their actions, not the specific emissions outcome" (Parkinson, 2011). If countries like Norway, who risk significant economic losses to its oil and natural gas economy, altruistically support binding emission reduction proposals with considerations of equity, other developed nations with analogous risks may be persuaded to follow suit.

Another glimmer of ethical leadership may be found among Scotland's leaders. Scotland passed a tough climate change law recently that requires a 42% cut in GHG emissions by 2020, rising to 80% by 2050 (BBC News, 2009). When the legislation passed, the Cabinet Secretary for Finance and Sustainable Growth told the Parliamentarians that passing the law was justified because climate change impacts all people and that they had a duty to make the commitment (Brown, 2009). Donald Brown of ClimateEthics.org reported statements by several Parliamentarians in support of the legislation. For example, Steward Stevenson, Minister for Transport, Infrastructure, and Climate Change, said:

> *"The bill is not an economic bill, although it will have economic effects. It is not legislation to gather dust on the shelves of hundreds of lawyers; it is a moral step we take that will be important for the world. ... part of what we are doing is making a moral case on behalf of nations that will be more adversely affected by climate change than Scotland will be, such as those in sub-Saharan Africa, in particular. There is a moral as well as a practical imperative to what we are doing."* (Brown, 2009)

[7] The term 'sustainable development' was used by the Brundtland Commission which coined what has become the most often-quoted definition of sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations 1987).

Unfortunately, Norway and Scotland and other small countries that might be able to facilitate cooperation through modeled ethical leadership are not specifically mentioned, nor are their leaders acknowledged, in most accounts of the Durban meetings. If they are speaking up, they are being overshadowed by countries and alliances like the EU, India, China, and the US.

Implications for International Cooperation

Recounting the debates between the key international players in Durban (i.e., US, EU, China, and India) provides little hope of ever designing an effective yet equitable international mitigation system. In particular the EU's position is perceived to be in contradiction to the demands of India, China, and other developing nations. However, when we look at nations that are concerned with designing a system centered on issues of responsibility, equity and justice, the resolution of the problem seems consistent. Specifically, the arguments by India, China and other developing countries (that equity remains the basis for Kyoto's predecessor) are the same justifications that both leaders of Norway and Scotland argue for. Specifically, there is a general consensus between the morally minded nations that call for emission reduction targets by all nations (except maybe the least developed nations of the world) while including considerations of different levels of obligations based on historical contribution and current capacities of nations. When viewed from this perspective there doesn't seem to be such a strong North/South divide. Instead the debate seems to be between those who acknowledge climate change as a moral issue (and seek to actively address it) and others who approach the problem in terms of economic and/or political feasibility.

An analogy can be made between the role that ethical leaders played in achieving cooperation in our game experiments and the potential role that exemplary ethical leadership by countries like Norway and Scotland could play in influencing collective action between nations. In order to influence the outcome of negotiations, the leaders of Scotland and Norway (and other potential ethical leaders that are committed to mitigation, despite risking their domestic interests) must employ moral courage and emerge from their current alliances as exemplars of ethical action. This will mean taking a much more active role and strong stand at upcoming conferences that may persuade other nations through their nation's exemplary actions. If we are lucky, displays of moral courage by these smaller developed nations will begin to bridge the gap between emitters at all development levels.

References

Abbink, K., Brandts, J., Herrmann, B, & Orzen, H. (2011) Parochial Altruism in Intergroup Conflicts, *Economic Letters* 117, pp. 45-48.

Alexander R.D. (1987) *The Biology of Moral Systems* (Hawthorne, New York: Aldine de Gruyter).

Avolio, B. J., & Luthans, F. (2006) *The high impact leader: Moments matter for accelerating authentic leadership development* (New York: McGraw-Hill).

Axelrod, R., Riolo, R., & Cohen, M. (2002) Beyond Geography: Cooperation with Persistent Links in the Absence of Clustered Neighborhoods, *Personality and Social Psychology Review* 6(4), pp. 341-346.

BBC News (2009) "Landmark legislation to help Scotland tackle the threat of climate change has been passed unanimously by MSPs." Retrieved 11 October, 2012 at http://news.bbc.co.uk/2/hi/uk_news/scotland/8115597.stm

BBC News (2012) "Scottish party leaders unite over climate change." *News Scotland*. Retrieved 05 October, 2012 at http://www.bbc.co.uk/news/uk-scotland-17498776

Blasi, A. (1980) Bridging moral cognition and moral action: A critical review of the literature, *Psychological Bulletin*, 88, pp. 1-45.

Bloomberg News (2012). Island Nations Criticize EU Over Climate Deal Extension. Businessweek.com. Retrieved on 10 October, 2012 at http://www.businessweek.com/news/2012-05-10/island-nations-criticize-eu-over-kyoto-climate-deal-extension

Boehm, C. (2012). Moral Origins: The Evolution of Virtue, Altruism, and Shame, (New York: Basic Books).

Bornstein, G. (2003). Intergroup Conflict: Individual, Group and Collective Interests. Personality and Social Psychology Review 7, pp. 129-145.

Borhan, H., Ahmed, E.M., & Hitam, M. (2012). The Impact of CO2 on Economic Growth in Asean 8. Procedia – Social and Behavioral Sciences, 35, 389-397.

Broome, J. (2008). The Ethics of Climate Change, *Scientific American* 298, pp. 96-102.

Brown, D. (2009). The Strong Scottish Moral Leadership On Climate Change Compared To The Absence Of Any Acknowledged Ethical Duty In The US Debate. *ClimateEthics.org*. Accessed 05 October 2012 at http://rockblogs.psu.edu/climate/2009/08/the-strong-scottish-moral-leadership-on-climate-change-compared-to-the-absence-of-any-acknowledged-ethical-duty-in-the-us-debate.html

Brown, D. (2011) "Going Deeper On What Happened In Durban: An Ethical Critique of Durban Outcomes." *Climate Justice Now.* Accessed 05 October, 2012 at http://www.climate-justice-now.org/going-deeper-on-what-happened-in-durban-an-ethical-critique-of-durban-outcomes/

Brown, M. E., & Treviño, L. K. (2006). Ethical leadership: A review and future directions, *Leadership Quarterly* 17, pp. 595-616.

Brown, M.E., Trevino, L.K., & Harrison, D.A. (2005). Ethical Leadership: A Social Learning Perspective for Construct Development and Testing, Organizational Behavior and Human Decisions Processes 97, pp. 117-134.

Bunkley, N. (2008). "Joseph Juran, 103, Pioneer in Quality Control, Dies." *The New York Times*. Retrieved on April 30th, 2012 from http://www.nytimes.com/2008/03/03/business/03juran.html?_r=1

Burns, J.M. (1979). *Leadership* (New York, NY: Harper Perennial).

Chandler, W., Schaeffer, R., Dadi, Z., Shukla, P.R., Tudela, F.,Davidson, O., & Alpan-Atamer, S. (2002). Climate change mitigation in developing countries. Pew Center on Global Climate Change. Available at: http://www.c2es.org/docUploads/dev_mitigation.pdf

Choi, J-K. & Bowles, S. (2007). The Coevolution of Parochial Altruism and War, Science 318, pp. 636-640.

CiuUa, J. (2004). Ethics and Leadership Effectiveness, in: Antonakis, J., Cianciolo, A.T. & Sternberg, R.J. (Eds.) *The Nature of Leadership*, (Sage, Thousand Oaks/ London/New Dehli), pp. 302-327.

Coase, R. (1960). The Problem of Social Cost, *Journal of Law and Economics* 3(1), pp. 1-44.

Environment Canada (2011). Canada's Closing Statement at COP17. Retrieved on 15 October, 2012 at http://www.ec.gc.ca/default.asp?lang=En&n=FFE36B6D-1&news=39FCDB85-A69C-4B71-AC5E-8D14140AADD7

Gardiner, S. (2004) Ethics and Global Climate Change, *Ethics* 114, pp. 555–600.

Gardiner, S. (2006). A Perfect Moral Storm: Climate Change, Intergenerational Ethics and the Problem of Moral Corruption, *Environmental Values* 15, pp. 397-413.

Gowdy, J.M. (2008). Behavioral economics and climate change policy, *Journal of Economic Behavior & Organization* 68, pp. 632-644.

Hannah, S. T., Avolio, B. J., & May, D. R. (in press). Moral Maturation and moral conation: A capacity approach to explaining moral thought and action. *Academy of Management Review*

Hannah, S.T., Avolio, B. J., Walumbwa, F.O. (in press). Relationship between Authentic Leadership, Moral Courage, Ethical and Pro-social Behaviors.

Hannah, S. T., Lester, P. B., & Vogelgesang, G. (2005) Moral leadership: Explicating the moral component of authentic leadership, in: Gardner, W. L., Avolio, B. J. & Walumbwa, B. J. (Eds.) *Authentic leadership and practice: Origins, effects, and development*, (Amsterdam: Elsevier), pp. 43-82.

Hardin, G. (1968). The Tragedy of the Commons, *Science* 162 (3859), pp. 1243–1248.

Holman Fenwick Willan (2012) "The UNFCCC's Durban platform explained." Retrieved 10 October, 2012 at http://www.hfw.com/publications/client-briefings/the-unfcccs-durban-platform-explained

Hume, D. (1992). *A Treatise of Human Nature*, (Buffalo, NY: Prometheus Books).

International Institute for Sustainable Development (2011). Summary of the Durban Climate Change Conference: 28 November-11 December 2011. Retrieved on 07 October, 2012 at http://www.iisd.ca/vol12/enb12534e.html

Jamieson, D. (2001). Climate Change and global Environmental Justice, in: Miller, C. and Edwards, P. (Eds.), *Changing the Atmosphere: Expert Knowledge and Environmental Governance*, (Cambridge, Mass.: MIT Press), pp. 287-307.

King, M.E. (1999). *Mahatma Gandhi and Martin Luther King Jr: The Power of Nonviolent Action*, (UNESCO Publishing)

Lester, P. B., Vogelgesang, G., Hannah, S. T., & Kimmey, T. (2009). Developing courage in followers: Theoretical and applied perspectives, in Pury, C. Lopez, S. (Eds.), *The psychology of courage: Modern research on an ancient virtue*, (Washington, DC: American Psychological Association).

Lezra, E. (1972). *Ethical oil: the case for Canada's oil sands,* (Toronto, Ontarion: McClelland & Stewart Ltd.)

Marowitz, E.M. & Shariff A.F. (2012). Climate Change and Moral Judgement, *Nature Climate Change* 2, pp. 243–247.

Mayer, D.M., Kuenzi, M., Greenbaum, R., Bardes, M., & Salvador, R. (2009). How Low Does Ethical Leadership Flow? Test of the Trickle-Down Model, Organizational Behavior and Human Decisions Processes 108, pp. 1-13.\

Milinski, M., Semmann, D., & Krambeck, H.J. (2002). Reputation Helps Solve the 'Tragedy of the Commons, *Nature* 415, pp. 424-426.

Nowak, M.A. (2006). Five Rules for the Evolution of Cooperation. Science 314, pp. 1560-1563.

Nowak, M.A. (2012). Evolving Cooperation, *Journal of Theoretical Biology* 299, pp. 1-8.

Ostrom, E. (2010). Analyzing Collective Action, *Agricultural Economics* 41 (s1), pp.155-166.

Ostrom, E., J. Burger, R.B. Field, R.B. Norgaard, and D. Policansky. (1999). Revisting the Commons, *Science* 284 (5412), pp. 278-282.

Parkinson, G. (2011). "Oz to push for more ambitious emissions targets on international stage." *Crikey*. Retrieved on 08 October, 2012 at http://www.crikey.com.au/2011/09/21/oz-to-push-for-more-ambitious-emissions-targets-on-international-stage/?wpmp_switcher=mobile&wpmp_tp=1

Resick, C.J., Hanges, P.J., Dickson, M.W., Mitchelson, J.K. (2006). A Cross-Cultural Examination of the Endorsement of Ethical Leadership, *Journal of Business Ethics* 63, pp. 345-359.

Rest, J., Narvaez, D., Bebeau, M. J., & Thoma, S. J. (1999). *Postconventional moral thinking: A neo-Kohlbergian Approach*., (Mahway, NJ: Erlbaum).

Rest, J. R. (1986). *Moral development: Advances in research and theory*, (New York: Praeger).

Sadowski, J., Seager, T.P., Selinger, E., Spierre, S.G., and Whyte, K. (2012a). An Experiential, Game-Theoretic Pedagogy for Sustainability Ethics. *Science and Engineering Ethics*, (Accepted).

Sadowski, J., Seager, T.P., Selinger, E., Spierre, S.G., Martin, E.A., & Berardy, A. (2012b). Collective Action, Evolution, and Intergroup Cooperation*, Human Ecology* (Under review).

Sally, D. (2001). On Sympathy and Games, *Journal of Economic Behavior & Organization* 44(1), pp. 1-30.

Sally, D. (1995). Conversation and cooperation in social dilemmas: A meta-analysis of experiments from 1958–1992. *Rationality and Society* 7, pp. 58–92.

Seager, T.P., Selinger, E., Whiddon, D., Schwartz, D., Spierre, S.G., & Berardy, A. (2010). Debunking the fallacy of the individual decision-maker: An experiential pedagogy of sustainability ethics. *Proceedings of the 2010 IEEE International Symposium on Sustainable Systems and Technology*, Arlington, VA.

Seager, T.P., Selinger, E., & Spierre, S.G. (2011). Determining Moral Responsibility for CO2 Emissions: A Reply to Nolt, *Ethics, Policy & Environment* 14(1), pp. 39-42.

Sethi, N. (2011). Durban Climate talks end, new global climate change regime from 2020." *The Times of India*. Retrieved on 30 September, 2012 at http://articles.timesofindia.indiatimes.com/2011-12-11/developmental-issues/30504463_1_eu-roadmap-climate-talks-climate-change

Singer, P. (2004). One Atmosphere, in: One World: The Ethics of Globalization. Yale University Press.

Smith, W. (2012). Kerry: On Eve of Rio+20, An Honest Assessment of Climate Change Challenge." Retrieved on 16 October, 2012 at http://www.usclimatenetwork.org/resource-database/kerry-on-eve-of-rio-20-an-honest-assessment-of-climate-change-challenge

Spierre, S.G., Seager, T.P. & Selinger, E. (2010). Determining an Equitable Allocation of Global Carbon Dioxide Emissions. *Proceedings of the 2010 IEEE International Symposium on Sustainable Systems and Technology*, Arlington, VA

Tao, H. (2012) “To be a global moral leader. How can Norway change the world in a changing world?” Retrieved on 15 October, 2012 at http://www.regjeringen.no/nb/dep/ud/kampanjer/refleks/innspill/miljo_klima/tao.html?id=495584

Thoma, S. J. (1984). Do moral education programs facilitate moral judgment? A meta-analysis of studies using the Defining Issues Test. *Moral Education Forum* 9, pp. 20−25.

Trivers, R.L. (1971). *The Evolution of Reciprocal Altruism*, *The Quarterly Review of Biology* 46 (1), pp. 35-57.

United Nations Environment Programme (2008). Clean Development Mechanism Projects Booming Around the World 2008” Retrieved 12 October, 2012 at http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=555&ArticleID=6026&l=en

United Nations Framework Convention on Climate Change (2012). Durban Climate Change Conference- November/December 2011. Retrieved on 19, October, 2012 at http://unfccc.int/meetings/durban_nov_2011/meeting/6245.php

United Nations. (1987). United Nations Report of the World Commission on Environment and Development, Our Common Future: Brundtland Report, Available at http://www.worldinbalance.net/intagreements/1987-brundtland.php

Walker, L. J. (1985). Sex differences in the development of moral reasoning: A critical review. *Child Development* 55, pp. 677−691.

Walker, L. J., & Henning, K. H. (2004). Differing conceptions of moral exemplarity: Just, brave, and caring. *Journal of Personality and Social Psychology* 86, pp. 629-647.

Walumbwa, F. O., Avolio, B. J., Gardner, W. L., Wernsing, T. S., & Peterson, S. J. (2008). Authentic leadership: Development and analysis of a multidimensional theory-based measure. *Journal of Management* 34, pp. 89-126.

Wang, E. (2012). Gore: Climate change a ‘moral issue’. *The Chronicle*. Retrieved 17 October, 2012 at http://www.dukechronicle.com/article/gore-climate-change-moral-issue

York, G. (2012). “Low profile in Durban relegates Canada to margins of climate debate 2012.” *The Globe and Mail.* Retrieved on 17 October, 2012 at http://m.theglobeandmail.com/news/politics/low-profile-in-durban-relegates-canada-to-margins-of-climate-debae/article2262549/?service=mobile