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Authors
Jorgenson, Andrew K
Dick, Christopher
Mahutga, Matthew C

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Foreign Investment Dependence and the Environment: An Ecostructural Approach[•]

Andrew K Jorgenson

Department of Sociology

Washington State University

Christopher Dick

Department of Sociology

Washington State University

Matthew Mahutga

Department of Sociology

University of California—Irvine

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[•] Direct all correspondence to Andrew K Jorgenson, Department of Sociology, Washington State University, PO Box 644020, Pullman, WA 99164-4020; P: (509) 335-4010, F: (509) 335-6419; email: jorgenson@mail.wsu.edu. An earlier version of this manuscript was presented at the 2006 Annual Meetings of the American Sociological Association, Montreal, Canada.

Foreign Investment Dependence and the Environment: An Ecostructural Approach

Abstract

Sociologists have long debated the impacts of foreign investment for less-developed countries. However, theorization fails to articulate the potential environmental consequences of foreign investment dependence. Here, an ecostructural theory of investment dependence is proposed and a derived hypothesis is tested. The hypothesis states that less-developed countries dependent on foreign investment in manufacturing exhibit higher levels of per capita noxious gas emissions. These anthropogenic emissions contribute to global warming, climate change, and a variety of human health problems. To test the hypothesis, newly-available panel data for the emission of nitrogen oxides, volatile organic compounds, carbon monoxide, and carbon dioxide gas as well as measures of foreign investment stocks in manufacturing are analyzed in random effects GLS regression models for 39 less-developed countries. Findings confirm the hypothesis, even when controlling for foreign investment rate, domestic investment, the relative size of the manufacturing sector, level of development, and other factors. Overall, the analyses support the ecostructural theory of foreign investment dependence, and underscore the sociological relevance in considering the environmental impacts of the transnational organization of production as well as the overall scale of production.

Foreign Investment Dependence and the Environment: An Ecostructural Approach

Introduction

Sociologists have long investigated the impacts of foreign direct investment. Studies in this literature usually test hypotheses derived from investment dependence theory, which asserts that the accumulated stocks of foreign investment make a receiving country more likely to organize its economy around export-oriented production (e.g. Bornschier and Chase-Dunn 1985). This often makes receiving countries more vulnerable to a variety of global political-economic conditions, leading to the suppression of economic development and increases in domestic income inequality as well as domestic sectoral inequality, urban primacy, and overurbanization (e.g. Bradshaw 1987; Chase-Dunn 1975; Dixon and Boswell 1996; Kentor 2001; London and Smith 1988). However, the theory fails to articulate the potential environmental consequences of being dependent on foreign investment, and more generally, how the relative control of the transnational organization of production unevenly affects the environment around the world, particularly in less-developed countries.

Without doubt, the world-economy has experienced a recent upswing in the globalization of foreign investment, production, and other political-economic factors (e.g. Chase-Dunn, Kawano, and Brewer 2000; Chase-Dunn and Jorgenson 2003; Mahutga 2006). During this upswing, inward foreign investment and the presence of transnational firms in less-developed countries have increased dramatically (e.g. Robinson 2004). Similarly, the world ecological system has experienced an upsurge in the globalization of human-caused environmental problems (Chew 2001; Smith 2001), but the intensity of many different forms of environmental degradation are much more pronounced in less-developed countries than in developed ones (e.g. Bunker and Ciccantell 2005; Jorgenson and Kick 2006). Considering these global patterns in general, and especially the influx of foreign investment and increasing environmental degradation in less-developed countries, the articulation and empirical evaluation of a refined form of investment dependence theory that addresses relevant human/environment relationships is indeed warranted. The health and well being consequences of different forms of environmental degradation, especially the anthropogenic emissions of noxious gases, cannot be overstated (IPCC 2001; National Research Council 1999; World Resources Institute 2004).

In this research, we begin to address the interrelated issues outlined in the preceding discussion. Foremost, we formalize an "ecostructural" theory of foreign investment dependence and derive a testable hypothesis from the theory. The hypothesis is that less-developed countries dependent on foreign investment in manufacturing experience higher per capita levels of different noxious gas emissions. To test the hypothesis, we conduct random effects panel regression analyses of thirty-nine less-developed countries in 1990, 1995, and 2000. We analyze newly-available panel data for carbon dioxide, nitrogen oxides, carbon monoxide, and volatile organic compounds emissions as well as measures of foreign investment in the manufacturing sector. The tested models also include a variety of theoretically relevant controls, including level of development, urbanization, foreign investment rate, domestic investment, and the relative size of the manufacturing sector. Results of the analyses confirm the hypothesis, which validates our reformulated theory of foreign investment dependence. Other findings correspond with prior sociological research, particularly the effects of development and urbanization.

In the next section we briefly review the existing literature on foreign investment dependence. Next, we present our "ecostructural" reformulation of the theory and describe the hypothesis tested in the subsequent analyses. Prior to the analyses, we discuss the environmental and human consequences of the four forms of emissions studied as well as how various activities in the secondary sector contribute to them, and we summarize the theoretical justifications for including particular statistical controls in the tested models. Following the description of the analyses and presentation of findings, we conclude by summarizing the key results of the study and their policy implications.

Foreign Investment Dependence

Foreign investment dependence, the most widely studied form of international dependence in macrocomparative sociology, refers to the extent to which transnational corporations dominate the economy of host countries. Rooted in the longstanding tradition of political-economic sociology (e.g. Amin 1976; Chase-Dunn 1998; Frank 1967), the theory of foreign investment dependence asserts that the accumulated stocks of foreign investment orient a less-developed country toward export-oriented production. Consequentially, they are more vulnerable to global political-economic conditions, and less domestically integrated, often leading to negative consequences for domestic populations (Bornschier and Chase-Dunn 1985). The vast majority of prior research on foreign investment dependence investigates its effects on economic development, income inequality, urban dynamics, and human well being (e.g. Alderson and Nielson 1999; Bornschier, Chase-Dunn, and Rubinson 1978; Chase-Dunn 1975; Dixon and Boswell

1996a, 1996b;; Kentor 1998, 2001; Kentor and Boswell 2003; London and Smith 1988; London and Williams 1990; Wimberly and Bello 1992; c.f. Firebaugh 1992, 1996).

Investment Dependence: An Ecostructural Orientation

Here we apply an "ecostructural" orientation (see Grant, Jones, and Bergesen 2002; Jorgenson 2003) to the theory of foreign investment dependence. By ecostructural we mean the potential environmental implications of collective human activities, particularly in the context of the control, organization, and location of transnational and global production processes. Foreign investment in general and investment dependence in particular deal with aspects of the transnational organization and control of world-economic activities in different productive sectors of the economy. While foreign investment in the primary sector [e.g. agriculture, mining] contributes to "on the ground" forms of environmental degradation, including deforestation, soil erosion, and high pesticide use intensity (Bunker 1984; Bunker and Ciccantell 2005; Jorgenson 2006c, forthcoming), we postulate that the transnational organization of production in the secondary sector [i.e. manufacturing], contributes to a variety of waste and noxious gas emissions in less-developed, investment-dependent countries.

With the influence of global governance institutions, such as the International Monetary Fund, The World Trade Organization, and The World Economic Forum (e.g. Jorgenson and Kick 2006), the polities and domestic elites of many less-developed countries advocate neoliberal agendas that focus on open markets, free trade, and the creation of "attractive" business conditions for foreign investors and transnational corporations (e.g. Hornborg 2001; McMichael 2004; Robinson 2004; Wallerstein 2005). These attractive business conditions, much of which are addressed by prior research on investment dependence, development, and income inequality, include relaxed labor laws and a variety of direct and indirect financial invectives for foreign investors. In an additional effort to attract outside investment, less-developed countries tend to have lower domestic environmental regulations than developed countries (e.g. Clapp 1998; Frey 2003; Redclift and Sage 1998), and are generally less-likely to ratify international environmental treaties (e.g. Roberts 1996; Roberts, Parks, and Vasquez 2004). Because of the perceived threat of capital flight, less-developed countries dependent on foreign investment are also less likely to enforce the domestic environmental regulations that already exist (e.g. Frey 2006). Thus, a large proportion of foreign investment, particularly in less-developed countries, finances ecologically inefficient, highly polluting, and labor-intensive manufacturing facilities and processes outsourced from developed countries (e.g. Jorgenson 2006a, 2006b). Transnationally-controlled production facilities are often located in close proximity to the poorest segments of the domestic populations, which increases their exposure to harmful emissions (Frey 2003). These conditions and their consequences illustrate a transnational form of environmental classism.

Besides production equipment, the transportation vehicles used by foreign-owned manufacturing enterprises in less-developed countries for the movements of goods and labor are more likely to be outdated and energy-inefficient (e.g. Grimes and Kentor 2003). These vehicles are also less likely to include catalytic converters and other devices that suppress the emission of noxious gases. Foreign-owned manufacturing enterprises are more likely to use inexpensive and harmful solvents, glues, paints, building, furnishing, and cleaning supplies that contribute to the emission of volatile organic compounds (World Resources Institute 2005). In a related vein, large-scale power generation facilitates used by transnational corporations and domestic populations in many less-developed countries are considerably less eco-efficient, which increases the generation of waste and emissions (Kentor and Grimes 2006; Roberts et al. 2003).

It is critical to note that our reformulation of investment dependence theory focuses on the relative structure and control of the transnational organization of production and the environmental consequences of dependence on foreign investment in manufacturing. Simply, and of more sociological relevance, the focus here is on the structure and control of the manufacturing sector in the context of foreign investment, not the overall scale of manufacturing production or the actual size of the manufacturing sector in host economies. It is quite possible that less-developed countries with relatively small-scale manufacturing sectors controlled largely by foreign investors and transnational corporations will emit relatively higher intensities of different noxious gases than other countries with similar-sized manufacturing sectors and less foreign control.

Findings for recent cross-national studies suggest that foreign investment is a structural mechanism partly responsible for the emission of carbon dioxide gas (Grimes and Kentor 2003; Shandra et al. 2004; Roberts et al. 2003). However, other forms of noxious gas emissions are generated by manufacturing processes (World Resources Institute 2004) and other human activities[1], and therefore warrant investigation in social scientific research. While there are countless reasons to study carbon dioxide emissions, we consider the exclusion of other forms of emissions as a "scope" limitation. Besides broadening the scope of this research area, investigating the relationship between foreign investment and different forms of noxious gas emissions would provide a more rigorous assessment of our ecostructural theory of foreign investment dependence.

A more serious limitation of prior research on foreign investment and emissions is the use of overall measures of foreign direct investment[2]. This limitation has both methodological and substantive grounds. Methodologically, accumulated stocks of foreign investment in the primary and secondary sectors are only marginally-to-moderately correlated (e.g. OECD 2001; United Nations 1992, 1994, 1996, 2000, 2003). Substantively, our theorization and the related assertions of prior research (e.g. Grimes and Kentor 2003; Kentor and Grimes 2006; Shandra et al. 2004) on foreign investment and noxious gas emissions focus almost explicitly on the potential impacts of manufacturing-related activities [i.e. the secondary sector]. Thus, secondary sector measures of foreign investment are needed to more accurately test propositions about the effects of the transnational organization of manufacturing on greenhouse gas emissions and other air pollutants. This is further underscored by the arguments of other social scientists and international policy makers for the need to evaluate the social and environmental impacts of foreign investment in different sectors (e.g. Bradshaw 1987; Kentor and Boswell 2003; OECD 1999).

In the subsequent analyses, we address the above limitations of scope, measurement, and substance. More importantly, using newly-available panel data for less-developed countries, we test the theoretically-derived hypothesis that foreign investment dependence in manufacturing contributes to the intensity [i.e. per capita] of various forms of noxious gas emissions. Prior to the analyses, we describe the human and environmental consequences of the different outcomes investigated in this study as well as how activities in the manufacturing sector contribute to them. We also briefly discuss the structural factors included as statistical controls in the reported models.

Human Causes and Consequences of the Air Pollutants Investigated in the Analyses

Carbon Dioxide Emissions

Primarily due to volume, carbon dioxide emissions are the largest anthropogenic contributor to global warming and climate change (Houghton et al. 2001; National Research Council 1999; World Resources Institute 2004). It is well known that the principal human cause of carbon dioxide emissions is the burning of fossil fuels, which takes place in a variety of human activities. For example, contributing factors include inefficient and energy-intensive manufacturing machinery as well as transportation vehicles used for the movement of inputs and outputs. The support for fossil fuel consumption requires expensive and expansive infrastructures of wires and roads, pipelines, and the financial resources to pay for the fuel. Not surprisingly, the consumption of fuels largely reflects the international distribution of economic development and geopolitical power (Podobnik 2002; Redclift and Sage 1998; Roberts 2001). Like carbon dioxide emissions, the direct consumption of fossil fuels contributes to the emission of nitrogen oxides, carbon monoxide, and volatile organic compounds. However, other human activities linked to the transnationalization of production in manufacturing also contribute to the generation and emission of these noxious gases.

Nitrogen Oxides Emissions

Nitrogen oxides is the generic term for a group of highly reactive, acidifying gases. Emissions of nitrogen oxides are a principal ingredient in ground-level ozone [i.e. smog], and also a precursor to tropospheric ozone [O3], which is a greenhouse gas that impacts global warming (Harvey 2000; IPCC 2001; World Resources Institute 2004). Industrial production, power generation, and forms of transportation [e.g. trucks, tractors, shipping, and rail] tend to be the largest emitters of nitrogen oxides (Cofala and Syri 1998; Streets and Waldhoff 2000). In particular, nitrogen oxides gas is emitted through fossil fuel combustion at high temperatures and through the burning of biomass (Wang et al. 1998). Biomass burning is relatively common in the secondary sector as a fuel source. Emissions are also generated by the production of cement, coke, lime, and sinter (Cofala and Syri 1998).

Non-Methane Volatile Organic Compounds

Non-methane volatile organic compounds [VOC] is an overarching term for many non-methane hydrocarbons and oxygenated non-methane hydrocarbons [e.g., organic acids, aldehydes, and alcohols] (IPCC 2001). These compounds contribute to several environmental and health problems. First, VOC emissions are a contributor to ground level, or tropospheric, ozone production (IPCC 2001; Bruehlmann et al. 2005). That is, several VOCs, when combined with sunlight and NO_x, create ground-level ozone, which causes health problems for humans (Harvey 2000). VOCs are also catalysts for stratospheric ozone depletion, thus adding to the potential consequences resulting from less ozone in the stratosphere (Hellen et al. 2006). Also, many VOCs are directly toxic or carcinogenic to humans (Bruehlmann et al. 2005; Stokstad 2004). The largest anthropogenic contributor to VOC emissions is the combustion of fossil fuels (IPCC 2001; Harvey 2000). Especially important is the use of fossil fuels in vehicles and manufacturing equipment. There are several other anthropogenic contributors to VOC emissions, including the use of industrial solvents, glues, paints, cleaning, and building supplies (Stokstad 2004; World Resources Institute 2004).

Carbon Monoxide Emissions

Carbon monoxide is a precursor gas of ground-level ozone, and also triggers respiratory problems when it enters the bloodstream by reducing the delivery of oxygen to the body's tissues and organs. Heightened exposure to carbon monoxide can cause impairment of manual dexterity and visual perception (World Resources Institute 2004). Like other air pollutants, carbon monoxide emissions come from both natural and human sources. According to the Intergovernmental Panel on Climate Change [IPCC] (2001), approximately fifty percent of the current emissions of carbon monoxide are anthropogenic. These human-caused emissions primarily come from two general sources: [1] the burning of biomass and [2] fossil fuel combustion (Subak, Raskin, and Von Hippel 1993; Wang et al. 1998). However, by far the largest portion of anthropogenic emissions of carbon monoxide gas comes from the combustion of fossil fuels in manufacturing processes, transportation, and energy production (Harvey 2000). It is well known that the use of catalytic converters reduces the emissions of carbon monoxide from internal combustion engines (e.g. Kaspar, Fornasiero, and Hickey 2003). These converters are most commonly utilized in automobile exhaust systems, but they are also used with generators, forklifts, trains, buses, and manufacturing equipment.

Other Theoretically Relevant Factors Included in the Analyses

Domestic Investment

When assessing the effects of foreign direct investment on any outcome, it is crucial to control for levels of domestic investment (Dixon and Boswell 1996; Firebaugh

1996; Jorgenson 2006a). Moreover, there are particular substantive reasons for asserting that domestic investment might be beneficial for local social conditions and the environment. For example, profits derived from domestic investment are more likely to be reinvested locally, which generally increases economic development and human capital (e.g. Bornschier and Chase-Dunn 1985; Kentor and Boswell 2003). Issues of scale are relevant for environmental outcomes. When foreign direct investment is involved, there is pressure to maximize profits for absentee investors, which tends to favor economies of scale at the expense of the local ecology (Gibson et al. 2000). Conversely, domestic investment stands a better chance of increased local accountability for more environmentally friendly production processes coupled with smaller scales of productive focus (e.g. Evans 2002; Young 1997). Unlike foreign firms, domestically-controlled firms are less likely to downstream or externalize production-based environmental costs (Clapp 2002; Princen 2002).

Economic Development and Urbanization

Level of economic development is the most common factor controlled for in social scientific studies of greenhouse gas emissions and other environmental outcomes (e.g. Burns et al. 1997; Dietz and Rosa 1997; Grimes and Kentor 2003; Hoffman 2004; Jorgenson 2005, 2006c; Roberts and Grimes 1997; Rosa, York, and Dietz 2004; Shandra et al. 2004; York, Rosa, and Dietz 2003). Political-economic perspectives, such as treadmill of production theory (e.g. Schnaiberg and Gould 1994) and world-systems theory (e.g. Chase-Dunn 1998; Roberts and Grimes 2002) argue that developed countries possess sufficient development and economic power to consume higher levels of energy, which increases the generation of waste and emissions. Similarly, urban political-economy scholars argue that energy consumption, which causes the emission of greenhouse gases and other forms of air pollutants, is typically higher and more concentrated in urban areas (Jorgenson 2004; Smith 1996; Rosa et al. 2004). Many forms of production that generate emissions take place in urban regions, and these built environments often require higher levels of energy for the day-to-day activities of dense populaces (Evans 2002; Jorgenson, Rice, and Crowe 2005; Logan and Molotch 1987). Thus, one might expect a nation's level of urbanization to positively affect the per capita emission of various noxious gases.

Size of the Manufacturing and Service Sectors

Since the purpose of this study is to test a hypothesis about the environmental impacts of the transnational organization of manufacturing, controlling for the relative size or intensity of this sector is crucial. Conventional wisdom might suggest that less-developed countries with a relatively larger industrial sector will emit higher total and per capita levels of noxious gas emissions as well as greater intensities of other forms of pollutants. However, prior comparative research yields different findings. For example, while Jorgenson (2006b) finds that the relative size of the manufacturing sector does not affect the growth in a nation's level of organic water pollution intensity, York and Rosa (2006) show that nations with larger industrial-based economies emit higher per capita levels of sulfur dioxide gas.

Neoclassical economic and related perspectives suggest that shifting from manufacturing to a more service-based economy offers a potential solution to reducing the environmental impacts of productive activities (e.g. Grossman and Krueger 1995; OECD 1998, 1999). This shift should reduce the generation and emission of waste since service economies are presumed to be less reliant on the combustion of fossil fuels in economic activities than more industrial economies. Following this line of reasoning, one could posit that countries with more service-based economies will experience lower per capita levels of greenhouse gas emissions and other forms of air pollutants.

Democratization

An aspect shared by ecological modernization theory and political modernization theory holds that democratization encourages environmental responsibility through increased demand for government activism on behalf of the natural environment. Democratization is expected to lead to environmental reforms and greener production processes because it provides conditions in which concerned groups and organizations can influence policy development and behavior. While prior research finds mixed results for the relationship between democratization and environmental outcomes (e.g. Ehrhardt-Martinez et al. 2002; Jorgenson 2006a; Shandra et al. 2004), controlling for the general political climate of nation-states in the subsequent analyses allows for a more rigorous test of our hypothesis.

The Analyses

The Dataset

Our dataset has a balanced panel structure, with the same number of observations over time for each country included in the analyses. In particular, the analyzed dataset consists of 39 less-developed countries with point estimates of all dependent variables for the years 1990, 1995, and 2000. This results in an overall sample of 117. Point estimates for all independent variables are lagged five years relative to the dependent variables. Thus, data for the independent variables are estimates for 1985, 1990, and 1995. This type of short-term lag is very common in quantitative, cross-national research. Appendix A lists all countries included in the analyses.

Random Effects Models

With the recent availability of panel data for all of the outcomes investigated in the current study, we are able to employ estimation methods that deal with potential heterogeneity bias[3] (e.g. Greene 2000; Wooldridge 2002). Random effects and fixed effects models are two approaches designed to correct for the problem of heterogeneity bias (Hannan and Young 1977), and these two approaches have gained popularity in macrosociology in the last two decades (see Halaby 2004). Both methods "simulate" unmeasured time-invariant factors as country-specific intercepts (Nielsen and Alderson 1995:685). The fixed effects model treats the country-specific intercepts as fixed effects to be estimated, equivalent to including dummy variables for N-1 countries. The random effects model treats country-specific intercepts as a random component of the error term (e.g. Frees 2004; Hsiao 2003).

For substantive and methodological reasons, we use STATA [version 9] software to estimate generalized least squares [GLS] random effects models with robust standard errors for all reported analyses (Frees 2004; Hamilton 2006; STATA 2005). Fixed effects models are more likely to deplete the model of sufficient number of degrees of freedom for adequately powerful statistical tests. More specifically, in studies where the time dimension is small, such as two or three time points, a random effects modeling approach is more preferable because fewer degrees of freedom are necessary to account for the subject-specific parameters (Frees 2004:78). Second, when one or more independent variables have relatively low variation across time per case, fixed effects models can suffer from extreme multicollinearity[4] (e.g. Wooldridge 2002). Given that the data analyzed in the current study are macro-level and span across a period of ten years, it is not surprising that some of our independent variables are relatively time-invariant per country. Moreover, fixed effects models cannot include perfectly time-invariant variables of possible relevance, such as world region [e.g. Africa, Latin America], and the estimation algorithm for the fixed effects model can be interpreted substantively as "throwing away" all between-country variation present in the data (Nielsen and Alderson 1995). In sum, since [1] much or most of the useful variation in cross-national research of this sort is between countries, [2] our substantive research questions are framed largely in the context of between country differences, and [3] our panel dataset consists of estimates for three time points, random effects models are more appropriate for the current study than fixed effects models.

In addition to the random effects models, we conducted relevant diagnostics with ordinary least squares regression analyses. Results indicated that the overall sample included in the current study does not contain any overly influential cases, and none of the reported random effects models are unstable due to high multicollinearity[5].

Dependent Variables

Panel data for all dependent variables [estimates for 1990, 1995, and 2000] are obtained from the World Resources Institute CD ROM database (2004) and their online Earthtrends database (earthtrends.wri.org). These data are reported as total emissions in thousand metric tons. Using total population estimates from the World Bank (2000, 2003), we transform all dependent variables into per capita scores. All variables that are logged [ln] in the present study are done so to correct for excessive skewness. We now briefly describe each of the four emissions modeled as dependent variables in the subsequent analyses.

1. *Nitrogen oxides [NO_x] emissions per capita, [ln]*. The World Resources Institute obtains total NO_x emissions in thousand metric tons from the National Institute of Public Health and the Environment, and the Netherlands Organization for Applied Scientific Research.
2. *Non-methane Volatile Organic Compounds [NMVOC] emissions per capita, [ln].* The World Resources Institute gathers measures of NMVOC emissions in thousand metric tons from The Emission Database for Global Atmospheric Research [EDGAR].
3. *Carbon monoxide [CO] emissions per capita, [ln]*. The World Resources Institute obtains the measures of CO emissions in thousand metric tons from Netherlands Organization for Applied Scientific Research and the National Institute of Public Health and the Environment.
4. *Carbon dioxide [CO_2] emissions per capita, [ln]*. The World Resources Institute gathers measures of CO_2 emissions in thousand metric tons from the Carbon Dioxide Information Analysis Center [CDIAC].

Key Independent Variable

- *Accumulated stocks of secondary sector foreign direct investment as percentage of total gross domestic product, [ln]*. This variable is used to test our hypothesis. Foreign direct investment stocks data [point estimates for 1985, 1990, and 1995] are obtained from United Nations' World Investment Directories (1992, 1994, 1996, 2000, 2003) and the Organization for Economic Co-Operation and Development's

International Direct Investment Statistics Yearbook (2001). These data are reported as foreign direct investment stocks in the secondary sector and primarily consist of investment in manufacturing activities. Total GDP data are measured in 1995 US dollars (World Bank 2000). Appendix B lists the productive activities included in the secondary sector measures of foreign direct investment.

Additional Independent Variables Included in the Reported Analyses

Like secondary sector stocks of foreign direct investment, all additional independent variables are measured in 1985, 1990, and 1995 [5 year time lags relative to measures of the dependent variables].

1. *Gross national product per capita, [ln]* quantifies a country's relative level of economic development. These data are taken from the World Bank (2000), and are measured in 1995 US dollars.
2. *Gross domestic investment as percentage of total gross domestic product, [ln]* represents the level of domestic investment in fixed assets plus net changes in inventory levels[6]. We obtain these data from the World Bank (2000).
3. *Secondary sector foreign direct investment rate*, is a ratio of investment flows / investment stocks. Flows refer to the amount of foreign investment that is invested in a host country within a particular year[7]. Using secondary sector investment flows data [point estimates for 1985, 1990, and 1995] that we gather from the same sources as the stocks data, we calculate investment rate measures for all three time periods[8]. Firebaugh (1992:125) argues that "investment rate should be included routinely" in research on foreign investment, and the inclusion of this control has become quite common in cross-national research on the effects of investment dependence on

economic development and income inequality[9] (e.g. Alderson and Nielson 1999; Dixon and Boswell 1996). Including this statistical control leads to a more conservative and accurate analysis of the possible effects of foreign investment dependence [i.e. stocks as percentage of total gross domestic product][10] (Alderson and Nielson 1999; Firebaugh 1996). However, all prior sociological research on foreign investment and environmental outcomes fails to include this statistical control.

4. *Urban population as percentage of total population*, controls for relative levels of urbanization. We gather these data from the World Bank (2000).
5. *Services as percentage of total GDP*, controls for the extent to which a domestic economy is services based. These data are taken from the World Bank (2000).
6. *Manufacturing as percentage of total GDP*, controls for the extent to which a domestic economy is manufacturing based. These data are gathered from the World Bank (2000).
7. *Level of democracy/autocracy*, is an index with a scale from negative 10 to positive 10 measuring the degree to which a nation is either autocratic or democratic. These data are obtained from the World Resources Institute (2004), who gathers the measures from the *Polity IV Project* (www.bsos.umd.edu/cidcm/inscr/polity/polreg). A score of positive 10 indicates a strongly democratic state; a score of negative 10 indicates a strongly autocratic state. A fully democratic government has three essential elements: [1] fully competitive political participation, [2] institutionalized constraints on executive power, and [3] guarantee of civil liberties to all citizens in their daily lives and in political participation. A fully autocratic system severely

restricts or suppresses competitive political participation and the chief executives are chosen by an elite group and exercise power with few institutionalized constraints (World Resources Institute 2004). For ease of interpretation, we refer to this variable as "democratization" in all reported tables and text.

Table 1 provides descriptive statistics and Table 2 presents correlations for all variables included in the reported analyses except the interactions between time and secondary sector stocks of foreign investment as percentage of total GDP. As we discuss below, these interactions are only included in the reported analyses of carbon dioxide emissions per capita.

<Table 1 about here>

<Table 2 about here>

Results and Discussion

Results of the GLS random effects regression analyses are reported in the following series of tables. We present and discuss the findings one outcome at a time, with a particular focus on the effects of secondary sector foreign investment stocks as % of total GDP. We report unstandardized coefficients [flagged for statistical significance], robust standard errors, R^2 between, and R^2 overall. R^2 between quantifies the explained variation between units, and R^2 overall refers to the explained variation overall in the tested model (Hamilton 2006).

With the exception of carbon dioxide emissions, we report results of 7 different models for each dependent variable. Model 1 is treated as a simple baseline, consisting of secondary sector foreign direct investment stocks as % of total GDP, gross national product per capita, and domestic investment as % of total GDP. We add secondary sector foreign direct investment rate as a statistical control in Model 2. Models 3 through 6 include all predictors from Model 2 as well as one additional statistical control. In Model 3, the additional predictor is urban population as % of total population, and services as % of total GDP is the additional control in Model 4. Manufacturing as % of total GDP is the added predictor in Model 5, and we include level of democratization as the additional control in Model 6. Except for carbon dioxide emissions, Model 7 is the most fully saturated model reported for all outcomes investigated in the analyses. Model 7 consists of all predictors included in Models 1-6.

To assess if the effects of foreign investment dependence vary across time, we include slope-dummy interactions (Hamilton 1992:88-92) between time [i.e. 1995, 2000] and secondary sector foreign investment stocks as % GDP in a series of analyses of the 4 forms of emissions[11]. With the exception of carbon dioxide emissions, which we discuss below, all of the effects of the interactions are non-significant. In a second series of analyses, we include temporal dummy variables for 1995 and 2000 as well as region dummy variables for Africa and Latin America. We also include measures of manufacturing value added per capita and manufacturing exports as % of total exports. The effects of these additional controls in most models are non-significant, and more importantly, their inclusion does not alter the effects of secondary sector foreign investment stocks as % of GDP on any of the 4 forms of emissions. Thus, except for the analysis of the slope-dummy interaction variables and carbon dioxide emissions [see Table 6b], we do not report these additional analyses below.

Table 3 presents the analyses of nitrogen oxides [NO_x] emissions. Secondary sector foreign investment stocks positively affects the per capita emission of NO_x gas.

The positive effect is statistically significant across all models, regardless of the couplings of additional statistical controls. This finding, which confirms the tested hypothesis, supports ecostructural investment dependence theory and the notion of transnational firms outsourcing pollution to less-developed countries, particularly through ecologically inefficient manufacturing processes. Many of these productive processes are banned in developed countries where the headquarters of most major transnational firms are located. Unlike prior research on environmental outcomes (e.g. Grimes and Kentor 2003; Jorgenson 2006a, 2006b; Shandra et al. 2004), the positive effect of foreign investment dependence is further validated by the inclusion of both foreign investment rate and domestic investment as statistical controls. The effect of secondary sector foreign investment rate is non-significant in all models. Some evidence is found suggesting that domestic investment, independent of foreign investment dependence, positively affects NO_x emissions. However, the effect is statistically significant in only 3 of the models, and due to data availability limitations, the measure of domestic investment used in this study is for all sectors combined. We return to this finding in the conclusion section.

<Table 3 about here>

Turning to the other statistical controls, level of development and urban population both positively affect per capita NO_x emissions. These two results, which support treadmill of production and world-systems theories (e.g. Roberts and Grimes 2002; Schnaiberg and Gould 1994), are quite consistent with prior comparative research on emissions and other forms of environmental degradation. Manufacturing as % of GDP is negatively associated with NO_x emissions, which contradicts common neoclassical economic assertions (e.g. Grossman and Krueger 1995). However, this finding, combined with the positive effect of foreign investment dependence in the manufacturing sector, underscores the importance in investigating the environmental impacts of the transnational organization of production as well as the relative intensity or size of production in host countries (e.g. Jorgenson 2006a; Robinson 2004). Democratization is positively associated with per capita NO_x emissions. Coupled with the inconsistent results of prior research on democratization and the environment (e.g. Ehrhardt-Martinez et al. 2002; Shandra et al. 2004), the positive effect of democratization on NO_x emissions questions the generalizability of key assertions made by political modernization theory and related perspectives.

The analyses of non-methane volatile organic compound [VOC] emissions are reported in Table 4. Secondary sector foreign investment stocks positively affects per capita VOC emissions, but unlike NO_x emissions, the effect is statistically significant only once foreign investment rate is controlled for. Besides confirming the hypothesis, this finding highlights the importance in controlling for investment rates in research on the effects of foreign investment dependence (e.g. Alderson and Nielson 1999; Firebaugh 1996). Thus, manufacturing facilities controlled by transnational firms and foreign capital are more likely to use fuels, solvents, and chemicals that contribute to the emission of volatile organic compounds (Frey 2006; IPCC 2001; World Resources Institute 2003). Like NO_x emissions, the effect of foreign investment rate on per capita VOC emissions is non-significant. The effect of domestic investment is non-significant as well, which contrasts with prior research on economic outcomes (e.g. Kentor 2001).

<Table 4 about here>

Level of development and urban population both positively affect per capita VOC emissions, while the effect of services as % GDP is negative and statistically significant in the most fully saturated model. Consistent with the findings reported in Table 3, the positive effects or urban population and level of economic development support political-economic theorization and prior research on environmental degradation (e.g. Jorgenson 2003). The negative effect of services supports neoclassical economic assertions about the environmental benefits of shifting to a more service-based economy (OECD 1998). However, while service sector intensity is not the focus of the current study, recent research that includes both developed and less-developed countries shows that service-based economies, which tend to be nested in more-developed countries, externalize their consumption-based environmental costs to lesser-developed countries (Jorgenson and Burns in press; Jorgenson and Rice 2005). Like NO_x emissions, manufacturing as % of GDP is negatively associated with per capita VOC emissions, which again underscores the relevance in assessing the environmental impacts of the social organization and ownership of manufacturing facilities as well as the size of the manufacturing sector in domestic economies.

Table 5 presents the analyses of carbon monoxide [CO] emissions. Results indicate that secondary sector foreign investment stocks positively affects per capita CO emissions, which corresponds with the analyses of NO_x and VOC emissions. Thus, we find additional support for our hypothesis and theorization about the environmental impacts of foreign investment dependence in general, and the outsourcing of environmental costs by transnational corporations involved in secondary sector activities. In the context of CO emissions, transnational firms with facilities in less-developed countries are less likely to invest in catalytic converters and related devices for production and transportation equipment (e.g. Kaspar et al. 2003). Not investing in appropriate devices to reduce emissions is largely motivated by economic factors, and in general, governments of less-developed countries are less likely to enact and enforce regulations that would force firms to use emission suppressing devices. With the potential for capital flight, instituting such polices could be considered as contradictory to the open-market, neoliberal agendas of domestic polities and indigenous elites that benefit from the influx of foreign investment (e.g. Evans 1995; McMichael 2004; Wallerstein 2005). Consistent with the analyses of NO_x and VOC emissions, the effect of foreign investment rate is non-significant. Domestic investment also proves to be a non-significant predictor of per capita CO emissions.

<Table 5 about here>

Turning to the other statistical controls, the effect of level of development is non-significant, and the effect of urban population is positive. While the non-significant effect of per capita GNP sharply contrasts with the analyses reported in Tables 3 and 4, it is not surprising for CO emissions. The use of CO emission suppression devices—particularly catalytic converters—has become commonplace in transportation vehicles and production machinery in more-developed countries. What is more, the relative deindustrialization of many developed countries—or more accurately termed the gradual outsourcing of manufacturing to less-developed countries via transnational firms and foreign capital as well as subcontracting practices—contributes to this finding (e.g. Bonacich and Appelbaum 2000; McMichael 2004).

The analyses of carbon dioxide [CO_2] emissions are presented in the following two tables. Table 6a reports the findings for Models 1 through 7. Prior to discussing the effects of foreign investment dependence, we summarize the effects of the statistical controls. Consistent with most prior sociological research on CO_2 emissions, the effects of level of development and urban population are positive and statistically significant. Services intensity and manufacturing intensity both prove to be non-significant predictors, while level of democratization positively affects per capita CO_2 emissions. The latter finding coupled with the analyses of NO_x emissions and prior research strongly challenges the efficacy of political modernization theoretical assertions. Indeed, future research would do well to more closely examine the particular conditions necessary for higher levels of democracy and civil liberties to suppress different forms of environmental degradation.

<Table 6a about here>

Unlike the analyses of NO_x, VOC, and CO emissions, the direct effect of secondary sector investment stocks on per capita CO_2 emissions is non-significant. While this finding could appear to contrast sharply with prior research on foreign investment and CO_2 emissions, it is important to note that the majority of studies that find a positive effect of *total* foreign investment are typically OLS panel analyses that assess *growth* in emissions rather than analyzing their absolute levels (e.g. Grimes and Kentor 2003). Moreover, it is possible that the effect of foreign investment dependence on levels of per capita emissions varies across time. Above we discuss our investigation elsewhere of possible temporal differences in the effects of foreign investment dependence on all emissions included in this study. While we find no statistically significant differences in the effects of foreign investment dependence on per capita NO_x, VOC, and CO emissions across the three time periods investigated in the current study, analyses of per capita CO_2 emissions do suggest otherwise. Table 6b presents the analysis of CO_2 emissions that includes slope-dummy interactions between time and foreign investment dependence.

<Table 6b about here>

The inclusion of the interaction variables for time and secondary sector foreign investment necessitates a somewhat more complex interpretation of the effects. The coefficient for secondary sector investment stocks as % GDP is the unit change in emissions for each unit increase in stocks of investment for 1990. Note that the effect for 1990 is non-significant. The overall effect for the other two time points [i.e. 1995, 2000] equals the sum of the coefficients for 1990 and the appropriate interaction term. The test of statistical significance for the slope-dummy coefficients determines whether the slope for the particular interaction and the reference category—in this case 1990—differ significantly (Hamilton 1992:89). Results indicate that the slopes of secondary sector investment dependence are statistically significant and increasingly greater in 1995 and 2000 than in 1990. While we report only the most saturated model [i.e. Model 7] with the slope-dummy variables, analyses of Models 1 through 6 with the inclusion of the interaction variables yield very similar findings. Thus, the analysis of the direct effect of investment dependence hides the increasingly positive effect of secondary sector foreign investment stocks on per capita CO_2 emissions. Moreover, when including the interaction variables, the effect of domestic investment becomes non-significant. The effect of foreign investment rate is non-significant in all models of CO_2 emissions, and including the interactions between time and investment dependence does not suppress the positive effects of economic development and urban population.

Thus, foreign investment dependence in manufacturing proves to be a significant predictor of all 4 per capita emissions investigated in this study. However, the relative differences in the overall proportion of variance explained between the 4 outcomes [i.e. R^2 overall values] should be expected. While this research provides robust evidence of the impacts of investment dependence and urban population on all 4 outcomes as well as the positive effect of level of development on all investigated per capita emissions except CO, the overall scale and intensity of these different anthropogenic emissions as well as their chemical properties (IPCC 2001; World Resources Institute 2004) and their political-economic causes are not indistinguishable. This applies to other forms of environmental degradation as well (e.g. Burns, Kick, and Davis 2003; Jorgenson, Rice, and Crowe 2005), which illustrates the need for further nuanced research on how humans degrade the biosphere. The inconsistent effects of other statistical controls in the current analyses further underscore the need for more refined research. As this study shows, political-economic and environmental sociological approaches provide useful analytical signposts for this type of social scientific inquiry. Considering the social and environmental problems associated with increasing emissions and other forms of human-caused environmental degradation, the importance of this research area is highly significant (e.g. Jorgenson and Kick 2006; Smith 2001).

Conclusion

This study advances the macrosociological literature on the potential consequences of the transnational organization of production in the context of inward foreign direct investment. Foremost, we reformulated the longstanding theory of foreign investment dependence to help partially explain how the transnational control of human industrial activities impacts the environment, especially in less-developed countries. To assess the validity of our ecostructural theory of investment dependence, we tested the hypothesis that less-developed countries with higher levels of dependence on foreign investment in the manufacturing sector exhibit higher per capita levels of various noxious gas emissions. With newly-available panel data for 1990, 1995, and 2000, we tested the hypothesis in analyses of nitrogen oxides emissions, volatile organic compound emissions, carbon monoxide emissions, and carbon dioxide emissions. Findings for the random effects regression models of thirty-nine less-developed countries confirm the hypothesis, providing strong support for the theory. With the exception of carbon dioxide emissions, the direct effect of investment dependence is positive and statistically significant in all tested models, net of a variety of statistical controls. Results of the analyses of carbon dioxide emissions suggest that the effect of investment dependence in manufacturing has increased through time. Considering that carbon dioxide emissions are the leading anthropogenic contributor to global warming and climate change (e.g. IPCC 2001; World Resources Institute 2004), this increasing effect is particularly alarming.

Some evidence indicates that domestic investment positively affects the per capita emission of nitrogen oxides gas, but its effect on all other outcomes is non-significant. This set of results, coupled with the robust findings from the analyses of foreign investment dependence, clearly suggest that while domestically-controlled production may not be greatly beneficial for the environment, the impact of transnationally-controlled manufacturing is indeed much more detrimental. However, considering that data availability limitations preclude us from using measures of domestic investment in only the secondary sector, additional comparative research and in-depth case studies are warranted to further untangle these complex interrelationships.

Turning to the statistical controls, level of urbanization is associated with higher per capita levels of all four types of emissions. This finding, which supports urban political-economy theorization (e.g. Smith 1996), is quite consistent with prior research on noxious gas emissions and other forms of environmental degradation (e.g. Jorgenson 2003, 2006a; Jorgenson et al. 2005; Rosa et al. 2004; York et al. 2003). Level of development is positively associated with the per capita emission of nitrogen oxides gas, volatile organic compounds, and carbon dioxide gas. As posited by treadmill of production theory and world-systems theory (e.g. Chase-Dunn 1998; Schnaiberg and Gould 1994), more-developed countries possess the economic power and development that allows them to consume higher levels of energy, which increases the generation of waste and emissions.

The relative size of the manufacturing sector is negatively associated with the per capita emission of all outcomes except carbon dioxide gas. We suggest two tentative interpretations of this finding. First, one long-standing claim of the investment dependence literature is that high levels of foreign control delimit the growth of the host economies by reducing the potential for linkages within the domestic manufacturing sector and their associated spill over effects. Because our investment dependence measure is weakly correlated with the size of the manufacturing sector [.144], it could be that the negative effect of the size of the manufacturing sector is consistent with our argument that less dependent economies emit lower per capita pollutants. Simply, when investigating per capita [i.e. intensity] environmental outcomes in research on forms of dependence, the relative size of sectors may not be as relevant as the extent to which facilities and productive processes are controlled by transnational firms and foreign capital. On the other hand, it could be that these results would be somewhat different if the outcomes investigated were scale rather than intensity measures (e.g. National Research Council 1999). Either way, the effect of manufacturing as % GDP, coupled with the findings for the analyses of investment dependence clearly illustrate the importance and sociological relevance in assessing the environmental impacts of both the level and transnational organization of production. Indeed, future research should investigate the effects of investment dependence in manufacturing relative to the size of the manufacturing sector on the total emission of various noxious gases as well as other environmental outcomes. Finally, level of democratization is positively associated with the per capita emission of carbon dioxide and nitrogen oxides gas, but its effect on carbon monoxide emissions and the emission volatile organic compounds is non-significant. Like other recent studies (e.g. Jorgenson 2006a; Shandra et al. 2004), these results underscore the need for proponents of political modernization theory and other related perspectives to better articulate the conditions in which democratization—relative to other political-economic conditions and processes—can benefit the environment.

The policy implications for our findings are significant. Foreign capital has a built-in incentive to ignore environmental externalities in favor of maximizing profits. Widely promoted assertions about the socially beneficial effects of foreign investment for less-developed countries need to be weighed against ecological concerns related to the scale, intensity, and transnational control of production. More stringent economic penalties for environmentally harmful manufacturing processes could increase the likelihood that firms will upgrade equipment used in production and transport, resulting in decreases of noxious gas emissions and other forms of waste. Thus, implementation of stricter penalties or taxation for the manufacturing sector could force transnational firms to internalize certain contradictions between economy and ecology, and to lessen the distancing and downstreaming of pollution generated by their productive and consumptive activities. Given the potential for capital flight and the global scope of greenhouse gas emissions and other air pollutants, austere forms of regulation would be more effective at the international level. As evidenced by recent activities at World Social Forum meetings and other global civil society venues (e.g. Chase-Dunn et al. 2006; Wallerstein 2005, 2006), the increasing awareness of these problems should quicken the pace towards the development and enforcement of such effective international regulations. Without doubt, the reduction of anthropogenic emissions is one of the most important challenges facing the world today.

References

Alderson, Arthur, and Francois Nielsen. 1999. "Income Inequality, Development, and Dependence: A Reconsideration." *American Sociological Review* 64:606-631.

Amin, Samir. 1976. *Imperialism and Unequal Exchange*. New York, NY: Monthly Review Press.

Bonacich, Edna, and Richard Appelbaum. 2000. *Behind the Label.* Berkeley, CA: University of California Press.

Bornschier, Volker, and Christopher Chase-Dunn. 1985. *Transnational Corporations and Underdevelopment.* New York, NY: Praeger.

Bornschier, Volker, and Christopher Chase-Dunn and Richard Rubinson. 1978. "Cross-National Evidence of the Effects of Foreign Investment and Aid on Economic Growth and Inequality: A Survey of Findings and a Reanalysis." *American Journal of Sociology* 84:651-83.

Bradshaw, York. 1987. "Urbanization and Underdevelopment: A Global Study of Modernization, Urban Bias, and Economic Dependency." *American Sociological Review* 52:224-239.

Bruehlmann, Stefan, Anna-Maria Forss, Dominik Steffen, and Norbert V. Heeb. 2005. "Benzene: A Secondary pollutant formed in the Three Way Catalyst." *Environmental Science and Technology* 39:331-338.

Bunker, Stephen G. 1984. "Modes of Extraction, Unequal Exchange, and the Progressive Underdevelopment of an Extreme Periphery: The Brazilian Amazon." *American Journal of Sociology* 89:1017-1064.

Bunker, Stephen G. and Paul S. Ciccantell. 2005. *Globalization and the Race for Resources.* Baltimore, MD: The Johns Hopkins University Press.

Burns, Thomas, Byron Davis, and Edward Kick. 1997. "Position in the World-System and National Emissions of Greenhouse Gases." *Journal of World-Systems Research* 3:432-466.

Burns, Thomas J, Edward Kick, and Byron Davis. 2003. "Theorizing and Rethinking Linkages between the Natural Environment and the Modern World-System: Deforestation in the Late 20th Century." *Journal of World-Systems Research* 9:357-392

Chase-Dunn, Christopher. 1975. "The Effects of International Economic Dependence on Development and Inequality: A Cross-National Study." *American Sociological Review* 40:720-738.

Chase-Dunn, Christopher. 1998. *Global Formation: Structures of the World-Economy*. Lanham, MD: Rowman & Littlefield.

Chase-Dunn, Christopher, Yukio Kawano, and Benjamin Brewer. 2000. "Trade Globalization since 1795: Waves of Integration in the World-System." *American Sociological Review* 65:77-95.

Chase-Dunn, Christopher, and Andrew K. Jorgenson. 2003. "Regions and Interaction Networks: An Institutional-Materialist Perspective." *International Journal of Comparative Sociology* 44:433-450.

Chase-Dunn, Christopher, Christine Petit, Richard Niemeyer, Robert Hanneman, Rebecca Giem, Erika Gutierrez, and Ellen Reese. 2006. "The Contours and Solidarity and Division among Global Movements." Paper presented at the 2006 Annual Meetings of the American Sociological Association, Montreal, Canada.

Chew, Sing. 2001. *World Ecological Degradation: Accumulation, Urbanization, and Deforestation 3000 B.C. – A.D. 2000.* Walnut Creek, CA: AltaMira Press.

Cofala, Janusz and Sanna Syri. 1998. "Nitrogen Oxides Emissions, Abatement Technologies and Related Costs for Europe in the RAINS Model Database." *Interim Report: International Institute for Applied Systems Analysis.* IR-98-88.

Clapp, Jennifer. 1998. "Foreign Direct Investment in Hazardous Industries in Developing Countries: Rethinking the Debate." *Environmental Politics* 7:92-113.

Clapp, Jennifer. 2002. "The Distancing of Waste: Overconsumption in a Global Economy." Pp. 155-176 in *Confronting Consumption*, edited by Thomas Princen, Michael Maniates, and Ken Conca. Cambridge, MA: MIT Press.

Dietz, Thomas, and Eugene A. Rosa. 1997. "Effects of Population and Affluence on CO_2 Emissions." *Proceedings of the National Academy of Sciences of the U.S.A.* 94:175-179.

Dixon, William, and Terry Boswell. 1996a. "Dependency, Disarticulation, and Denominator Effects: Another Look at Foreign Capital Penetration." *American Journal of Sociology* 102:543-562.

Dixon, William, and Terry Boswell. 1996b. "Differential Productivity, Negative Externalities, and Foreign Capital Dependency: Reply to Firebaugh." *American Journal of Sociology* 102:576-584.

Ehrhardt-Martinez, Karen, Edward M. Crenshaw, and J. Craig Jenkins. 2002. "Deforestation and the Environmental Kuznets Curve: A Cross-National Investigation of Intervening Mechanisms." *Social Science Quarterly* 83:226-243.

Evans, Peter. 1995. *Embedded Autonomy: States and Industrial Transformation.* Princeton, NJ: Princeton University Press.

Evans, Peter. 2002. (ed.) *Livable Cities? Urban Struggles for Livlihood and Sustainability*. Berkeley, CA: University of California Press.

Firebaugh, Glenn. 1992. "Growth Effects of Foreign and Domestic Investment." *American Journal of Sociology* 98:105-130.

Firebaugh, Glenn. 1996. "Does Foreign Capital Harm Poor Nations? New Estimates Based on Dixon and Boswell's Measures of Capital Penetration." *American Journal of Sociology* 102:563-575.

Frank, Andre Gunder. 1967. *Capitalism and Underdevelopment in Latin America*. New York, NY: Monthly Review Press.

Frees, Edward. 2004. *Longitudinal and Panel Data: Analysis and Applications in the Social Sciences*. New York, NY: Cambridge University Press.

Frey, R. Scott. 2003. "The Transfer of Core-Based Hazardous Production Processes to the Export Processing Zones of the periphery; The Maquiladora Centers of Northern Mexico." *Journal of World-Systems Research* 9:317-356.

Frey, R. Scott. 2006. "The Flow of Hazardous Exports in the World-System: The Case of the Maquiladora Centers of Northern Mexico." Pp. 133-150 in *Globalization and the Environment*, edited by Andrew K Jorgenson and Edward Kick. Leiden, The Netherlands: Brill Press.

Gibson, C., E. Ostrom, and T. Ahn. 2000. "The Concept of Scale and the Human Dimensions of Global Change: A Survey." *Ecological Economics* 32:217-239.

Grant, Don Sherman, Andrew J Jones, and Albert J Bergesen. 2002. "Organizational Size and Pollution: The Case of the U.S. Chemical Industry." *American Sociological Review* 67:389-407.

Greene, William. 2000. *Econometric Analysis* (4th edition). Upper Saddle, NJ: Prentice Hall.

Grimes, Peter, and Jeffrey Kentor. 2003. "Exporting the Greenhouse: Foreign Capital Penetration and CO2 Emissions 1980-1996." *Journal of World-Systems Research* 9:261-275.

Grossman, Gene and Alan Krueger. 1995. "Economic Growth and the Environment." *The Quarterly Journal of Economics* 110:353-377.

Halaby, Charles. 2004. "Panel Models in Sociological Research: Theory into Practice." *Annual Review of Sociology* 30:507-544.

Hamilton, Lawrence. 1992. *Regression with Graphics*. Belmont, CA: Duxbury Press.

Hamilton, Lawrence. 2006. *Statistics with STATA*. Belmont, CA: Thomson Higher Education.

Hannan, Michael, and Alice Young. 1977. "Estimation in Panel Models: Results on Pooling Cross Sections and Time Series." Pp. 52-83 in *Sociological Methodology 1977*, edited by D. Heise. San Francisco, CA: Jossey-Bass.

Harvey, L.D. Danny. 2000. *Global Warming: The Hard Science.* Upper Saddle River, NJ: Pearson Education Limited.

Hellen, Heidi, Hannele Hakola, Liisa Pirjola, Tuomas Laurila, and Kati-Henna Pystynen. 2006. "Ambient Air Concentrations, Source Profiles, and Source Apportionment of 71 Different C2-C10 Volatile Organic Compounds in Urban and Residential Areas of Finland." *Environmental Science and Technology* 40: 103-108.

Hoffman, John. 2004. "Social and Environmental Influences on Endangered Species: A Cross-National Study." *Sociological Perspectives* 47:79-107.

Hornborg, Alf. 2001. *The Power of the Machine: Global Inequalities of Economy, Technology, and Environment.* Walnut Creek, CA: AltaMira Press.

Houghton, John, Y. Ding, D.J. Griggs, M. Nohuer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.). 2001. *Climate Change 2001: Working Group I: The Scientific Basis.* Port Chester, NY: Cambridge University Press.

Hsiao, Cheng. 2003. *Analysis of Panel Data* (2nd edition). New York, NY: Cambridge University Press.

Intergovernmental Panel on Climate Change [IPCC]. 2001. *Climate Change 2001: The Scientific Basis*. Cambridge, MA: Cambridge University Press.

Jorgenson, Andrew K. 2003. "Consumption and Environmental Degradation: A Cross-National Analysis of the Ecological Footprint." *Social Problems* 50:374-394.

Jorgenson, Andrew K. 2004. "Uneven Processes and Environmental Degradation in the World-Economy." *Human Ecology Review* 11:103-113.

Jorgenson, Andrew K. 2005. "Unpacking International Power and the Ecological Footprints of Nations: A Quantitative Cross-National Study." *Sociological Perspectives* 48:383-402.

Jorgenson, Andrew K. 2006a. "Global Warming and the Neglected Greenhouse Gas: A Cross-National Study of the Social Causes of Methane Emissions Intensity, 1995." *Social Forces* 84:1777-1796.

Jorgenson, Andrew K. 2006b. "The Transnational Organization of Production and Environmental Degradation: A Cross-National Study of the Effects of Foreign Capital Penetration on Organic Water Pollution Intensity, 1980-1995." *Social Science Quarterly* 87:711-730.

Jorgenson, Andrew K. 2006c (in press). "Unequal Ecological Exchange and Environmental Degradation: A Theoretical Proposition and Cross-National Study of Deforestation, 1990-2000." *Rural Sociology* 71.

Jorgenson, Andrew K. Forthcoming. "Foreign Direct Investment and Pesticide Use Intensity in Less-Developed Countries: A Quantitative Investigation." *Society and Natural Resources*.

Jorgenson, Andrew K. and Thomas Burns. In Press. "The Political-Economic Causes of Change in the Ecological Footprints of Nations, 1991-2001: A Quantitative Investigation." *Social Science Research.*

Jorgenson, Andrew K. and Edward Kick (eds.). 2006. *Globalization and the Environment.* Leiden, The Netherlands: Brill Press.

Jorgenson, Andrew K. and James Rice. 2005. "Structural Dynamics of International Trade and Material Consumption: A Cross-National Study of the Ecological Footprint of Less-Developed Countries." *Journal of World-Systems Research* 11:57-77.

Jorgenson, Andrew, James Rice, and Jessica Crowe. 2005. "Unpacking the Ecological Footprints of Nations." *International Journal of Comparative Sociology* 46:241-260.

Kaspar, J., P. Fornasiero, and N. Hickey. 2003. "Automotive Catalytic Converters: Current Status and Some Perspectives." *Catalysis Today* 77:419-449.

Kentor, Jeffrey. 1998. "The Long Term Effects of Foreign Investment Dependence on Economic Growth 1940-1990." *American Journal of Sociology* 103:1024-1046.

Kentor, Jeffrey. 2001. "The Long Term Effects of Globalization on Income Inequality, Population Growth, and Economic Development." *Social Problems* 48:435-455.

Kentor, Jeffrey, and Terry Boswell. 2003. "Foreign Capital Dependence and Development: A New Direction." *American Sociological Review* 68:301-313.

Kentor, Jeffrey, and Peter Grimes. 2006. "Foreign Investment Dependence and the Environment: A Global Perspective." Pp. 61-78 in *Globalization and the Environment*, edited by Andrew K. Jorgenson and Ed Kick. Netherlands: Brill Academic Press.

Logan, John, and Harvey Molotch. 1987. *Urban Fortunes: The Political Economy of Place.* Berkeley, CA: University of California Press.

London, Bruce, and David Smith. 1988. "Urban Bias, Dependence, and Economic Stagnation in Noncore Nations." *American Sociological Review* 53:454-463.

London, Bruce, and Bruce Williams. 1990. "National Politics, International Dependency, and Basic Needs Provision: A Cross-National Analysis." *Social Forces* 69:565-584.

Mahutga, Matthew. 2006. "The Persistence of Structural Inequality? A Network Analysis of International Trade, 1965-2000." *Social Forces* 84:1863-1889.

McMichael, Philip. 2004. *Development and Social Change: A Global Perspective* (3rd edition). Thousand Oaks, CA: Pine Forge Press.

National Research Council. 1999. *Human Dimensions of Global Environmental Change: Research Pathways for the Next Decade.* Washington, DC: National Academy Press.

Nielsen, Francois, and Arthur Alderson. 1995. "Income Inequality, Development, and Dualism: Results from an Unbalanced Cross-National Panel." *American Sociological Review* 60:674-701.

Organisation for Economic Co-Operation and Development [OECD]. 1998. *Globalization and the Environment: Perspectives from OECD and Dynamic Non-Member Economies.* New York, NY: OECD.

Organisation for Economic Co-Operation and Development [OECD]. 1999. *Foreign Direct Investment and the Environment.* Paris: OECD Publications.

Organisation for Economic Co-Operation and Development [OECD]. 2001. *International Direct Investment Statistics Yearbook 1980-2000.* Paris: OECD Publications.

Podobnik, Bruce. 2002. "Global Energy Inequalities: Exploring the Long-Term Implications." *Journal of World-Systems Research* 8:252-275.

Princen, Thomas. 2002. "Distancing: Consumption and the Severing of Feedback." Pp. 103-132 in *Confronting Consumption,* edited by Thomas Princen, Michael Maniates, and Ken Conca. Cambridge, MA: MIT Press.

Redclift, Michael and Colin Sage. 1998. "Global Environmental Change and Global Inequality: North / South Perspectives." *International Sociology* 13:499-516.

Roberts, J. Timmons. 1996. "Predicting Participation in Environmental Treaties: A World-System Analysis." *Sociological Inquiry* 66:38-57.

Roberts, Timmons. 2001. "Global Inequality and Climate Change." *Society and Natural Resources* 14:501-509.

Roberts, Timmons, and Peter Grimes. 1997. "Carbon Intensity and Economic Development 1962-91: A Brief Exploration of the Environmental Kuznets Curve." *World Development* 25:191-198.

Roberts, Timmons, and Peter Grimes. 2002. "World-System Theory and the Environment: Toward a New Synthesis." Pp. 167-196 in *Sociological Theory and the Environment: Classical Foundations, Contemporary Insights*, edited by Riley Dunlap, Frederick Buttel, Peter Dickens, and August Gijswijt. Lanham, MD: Rowman and Littlefield.

Roberts, Timmons, Peter Grimes, and Jodie Manale. 2003. "Social Roots of Global Environmental Change: A World-Systems Analysis of Carbon Dioxide Emissions." *Journal of World-Systems Research* 9:277-315.

Roberts, Timmons, Bradley Parks, and Alexis Vasquez. 2004. "Who Signs Environmental Treaties and Why? Institutionalism, Structuralism and Participation by 192 Nations in 22 Treaties." *Global Environmental Politics* 4:22-64.

Robinson, William. 2004. *A Theory of Global Capitalism: Production, Class, and State in a Transnational World.* Baltimore, MD: Johns Hopkins University Press.

Rosa, Eugene, Richard York, and Thomas Dietz. 2004. "Tracking the Anthropogenic Drivers of Ecological Impacts." *Ambio* 33:509-512.

Schnaiberg, Allan, and Kenneth Gould. 1994. *Environment and Society: The Enduring Conflict*. New York, NY: St Martin's Press.

Shandra, John, Bruce London, Owen Whooley, and John Williamson. 2004. "International Nongovernmental Organizations and Carbon Dioxide Emissions in the Developing World: A Quantitative, Cross-National Analysis." *Sociological Inquiry* 74:520-545.

Shi, Anqing. 2003. "The Impact of Population Pressure on Global Carbon Dioxide Emissions, 1975-1996: Evidence from Pooled Cross-Country Data." *Ecological Economics* 44:29-42.

Smith, David A. 1996. *Third World Cities in a Global Perspective: The Political Economy of Uneven Urbanization.* Boulder, CO: Westview.

Smith, David A. 2001. “Editor’s Introduction – Globalization and Social Problems.” *Social Problems* 48:429-434.

STATA. 2005. *Longitudinal / Panel Data: Release 9*. College Station, TX: STATA Press.

Stokstad, Erik. 2004. “Factory Study Shows Low Levels of Benzene Reduce Blood Cell Counts.” *Science* 306:1665.

Streets, D.G. and S.T. Waldhoff. 2000. “Present and Future Emissions of Air Pollutants in China: SO_2, NOx, and CO.” *Atmospheric Environment* 34:363-374.

Subak, Susan, Paul Raskin, and David Von Hippel. 1993. “National Greenhouse Gas Accounts: Current Anthropogenic Sources and Sinks.” *Climatic Change* 25:15-58.

United Nations. 1992, 1994, 1996, 2000, 2003. *World Investment Directory* (Volumes 1-8). New York, NY: United Nations.

Wallerstein, Immanuel. 2005. “After Developmentalism and Globalization, What?” *Social Forces* 83:1263-1278.

Wallerstein, Immanuel. 2006. “The Ecology and the Economy: What is Rational?” Pp. 13-22 in *Globalization and the Environment*, edited by Andrew K Jorgenson and Edward Kick. Leiden, The Netherlands: Brill Press.

Wang, Yuhang, Daniel J. Jacob, and Jennifer A. Logan. 1998. “Global Simulation of Tropospheric O3 – NOx – hydrocarbon chemistry: 1. Model Formation.” *Journal of Geophysical Research* 103:10713-10725.

Wimberley, Dale, and Rosario Bello. 1992. “Effects of Foreign Investment, Exports, and Economic Development on Third World Food Consumption.” *Social Forces* 70:895-921.

Wooldridge, Jeffrey. 2002. *Econometric Analysis of Cross Section and Panel Data.* Cambridge, MA: MIT Press.

World Bank. 2000, 2003. *World Development Indicators* (CD-ROM). Washington, D.C.: World Bank.

World Resources Institute. 2004. *Earth Trends, Decisions for the Earth: Balance, Voice, and Power* (Data CD-ROM). Washington, DC: World Resources Institute.

World Resources Institute. 2005. *Earth Trends Data CD-ROM: The Wealth of the Poor*. Washington, DC: World Resources Institute.

York, Richard, and Marcia Gossard. 2004. "Cross-National Meat and Fish Consumption: Exploring the Effects of Modernization and Ecological Context." *Ecological Economics* 48:293-302.

York, Richard, and Eugene Rosa. 2006. "Emissions of Sulfur Dioxide and Nitrogen Oxides in the Modern World-System." In *Globalization and the Environment,* edited by Andrew Jorgenson and Edward Kick. Netherlands: Brill.

York, Richard, Eugene Rosa, and Thomas Dietz. 2003. "A Rift in Modernity? Assessing the Anthropogenic Sources of Global Climate Change with the STIRPAT Model." *The International Journal of Sociology and Social Policy* 23:31-51.

Young, Oran. 1997. *Global Governance: Drawing Insights from the Environmental Experience*. Cambridge, MA: MIT Press.

Endnotes

[1] However, a few sociologists have tentatively investigated the effects of foreign investment on other noxious gas emissions, including methane (Jorgenson 2006a) and sulfur dioxide (York and Rosa 2006).

[2] Jorgenson's (2006a) study includes a preliminary assessment of the effects of sector-level foreign investment on methane emissions per capita. Yet, sector-level investment data for 1967 are used in cross-sectional analyses of per capita emissions for 1995, and investment dependence is not the focus of the study.

[3] Heterogeneity bias in this context refers to the confounding effect of unmeasured time-invariant variables that are omitted from the regression models.

[4] Variables under these conditions will be highly collinear with the country-specific fixed effects (e.g. Greene 2000; Wooldridge 2002).

[5] All VIFs in the preliminary OLS analyses are below 3.0, with the majority having values lower than 2.0.

[6] Ideally, we would prefer measures of domestic investment for different economic sectors. Nevertheless, those types of data were unavailable at the time of this study.

[7] Reporting agencies typically calculate foreign investment stocks by summing investment flows for a fixed length of time—such as 10 or 12 years, and adding a depreciation rate to the summed value.

[8] We thank an anonymous reviewer for encouraging us to include this statistical control in our analyses.

[9] See Firebaugh (1992, 1996), Dixon and Boswell (1996), and Alderson and Nelson (1999) for in-depth discussions and debates about the importance in including investment rate as a statistical control.

[10] Some researchers might argue that the inclusion of this statistical control is now unnecessary since Alderson and Nielson (1999) and Dixon and Boswell (1996) show that controlling for foreign investment rate does not suppress the statistically significant effect of foreign investment dependence on development and domestic income inequality. However, we agree that including foreign investment rate allows for more conservative analyses of the effects of investment dependence, and prior studies on foreign investment and emissions neglect to include investment rate as a statistical control (e.g. Grimes and Kentor 2003; Jorgenson 2006a; Shandra et al. 2004).

[11] For examples of the use of slope-dummy interactions in cross-national research, see Burns, Kick, and Davis (2003), Jorgenson (2004, 2006b), Shi (2003), and York and Gossard (2004).

Appendix A. Countries Included in the Analyses

Argentina
Bangladesh
Benin
Brazil
Cameroon
China
Colombia
Costa Rica
Côte d'Ivoire
Dominican Republic
Ecuador
El Salvador
Ghana
Haiti
Honduras
India
Indonesia
Kenya
Malaysia
Mexico
Morocco
Nepal
Nicaragua
Nigeria
Pakistan
Panama
Paraguay
Peru
Philippines
Portugal
Rwanda
Senegal
Sri Lanka
Thailand
Turkey
Uganda
Venezuela
Vietnam
Zimbabwe

Notes: balanced panel dataset with 3 observations per country; N = 117

Appendix B.

Productive/Industrial Activities Included in the Measures of Secondary Sector Foreign Direct Investment

1. Food and Beverages
2. Tobacco
3. Textiles and Clothing
4. Leather
5. Wood and Wood Products
6. Publishing and Printing
7. Coke
8. Petroleum Products
9. Nuclear Fuel
10. Chemicals and Chemical Products
11. Rubber and Plastic Products
12. Non-Metallic Mineral Products
13. Metal and Metal Products
14. Machinery and Equipment
15. Electrical and Electronic Equipment
16. Precision Instruments
17. Motor Vehicles and other Transport Equipment
18. Other Manufacturing
19. Recycling

(Sources: United Nations 1992, 1994, 1996, 2000, 2003; OECD 2001)

Table 1. Descriptive Statistics (N = 117)

	Mean	S.D.	Min.	Max.
Nitrogen Oxides emissions per capita (ln)	.014	.010	.000	.060
Non-methane Volatile Organic Compounds per capita (ln)	.029	.025	.000	.140
Carbon Monoxide emissions per capita (ln)	.180	.125	.020	.800
Carbon Dioxide emissions per capita (ln)	.727	.515	.050	2.010
FDI in Secondary Sector as % GDP (ln)	1.415	.638	.140	3.530
Gross National Product per capita (ln)	6.812	1.041	5.120	9.250
Domestic Investment as % GDP (ln)	2.974	.348	1.900	3.770
Secondary Sector FDI rate	.172	.157	.000	1.000
Urban Population	41.983	20.155	5.000	88.400
Services as % GDP	48.668	9.777	21.710	73.300
Manufacturing as % GDP	17.909	6.907	4.320	37.460
Democratization	1.427	6.672	-9.000	10.000

Table 2. Correlations (N=117)

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Nitrogen Oxides emissions per capita (ln)	1.											
Non-methane Volatile Organic Compounds per capita (ln)	2.	.763										
Carbon Monoxide emissions per capita (ln)	3.	.770	.800									
Carbon Dioxide emissions per capita (ln)	4.	.542	.495	.141								
FDI in Secondary Sector as % GDP (ln)	5.	.301	.324	.353	.139							
Gross National Product per capita (ln)	6.	.613	.447	.239	.804	.117						
Domestic Investment as % GDP (ln)	7.	.224	.070	-.022	.429	.049	.293					
Secondary Sector FDI rate	8.	.063	.123	.023	.104	-.053	-.020	.162				
Urban Population	9.	.543	.468	.327	.656	.156	.785	.056	-.111			
Services as % GDP	10.	.402	.086	.088	.341	.143	.604	.035	-.093	.520		
Manufacturing as % GDP	11.	.213	.100	-.030	.599	.144	.524	.451	.070	.364	.050	
Democratization	12.	.392	.222	.085	.452	-.161	.533	.220	-.041	.493	.417	.241

Table 3.
Unstandardized Coefficients for the Regression of Nitrogen Oxides Emissions per capita on Secondary Sector Foreign Investment and other Selected Independent Variables: Random Effects Model Estimates for 3 Observations on 39 Less-Developed Countries, 1990-2000

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Secondary Sector FDI stocks as % GDP (ln)	.002* (.001)	.002* (.001)	.002* (.001)	.002* (.001)	.002* (.001)	.003* (.001)	.003* (.001)
GNP per capita (ln)	.005** (.001)	.005** (.001)	.003** (.001)	.004** (.001)	.006** (.001)	.004** (.001)	.004* (.001)
Domestic Investment as % GDP (ln)	.003 (.002)	.003 (.002)	.004* (.002)	.003 (.002)	.004* (.002)	.002 (.002)	.005* (.002)
Secondary Sector FDI Rate		.007 (.006)	.007 (.006)	.007 (.006)	.007 (.006)	.007 (.006)	.008 (.006)
Urban population			.001** (.000)				.001* (.000)
Services as % GDP				.001 (.000)			.000 (.000)
Manufacturing as % GDP					-.001* (.000)		-.001* (.000)
Democratization						.001** (.000)	.001* (.000)
Constant	-.034** (.007)	-.034** (.007)	-.028** (.007)	-.037** (.008)	-.041** (.008)	-.027** (.009)	-.028** (.008)
R^2 Between	.537	.531	.530	.520	.545	.525	.549
R^2 Overall	.407	.413	.425	.413	.443	.429	.470

Notes:
*p<.05 **p<.01 (one-tailed tests)
robust standard errors are in parentheses

Table 4.
Unstandardized Coefficients for the Regression of Non-Methane VOC Emissions per capita on Secondary Sector Foreign Investment and other Selected Independent Variables:
Random Effects Model Estimates for 3 Observations on 39 Less-Developed Countries, 1990-2000

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Secondary Sector FDI stocks as % GDP (ln)	.003 (.002)	.003* (.001)	.004* (.002)	.004* (.002)	.004* (.002)	.004* (.002)	.006** (.002)
GNP per capita (ln)	.010** (.003)	.009** (.003)	.003 (.003)	.010** (.003)	.013** (.004)	.008** (.003)	.010** (.004)
Domestic Investment as % GDP (ln)	.001 (.004)	-.001 (.003)	.000 (.003)	-.002 (.004)	.000 (.004)	-.001 (.004)	.001 (.004)
Secondary Sector FDI Rate		.019 (.016)	.019 (.015)	.020 (.016)	.019 (.015)	.018 (.015)	.021 (.016)
Urban population			.001* (.000)				.001* (.000)
Services as % GDP				-.001 (.001)			-.001** (.000)
Manufacturing as % GDP					-.001** (.000)		-.001** (.000)
Democratization						.001 (.000)	.001 (.001)
Constant	-.042* (.020)	-.041* (.019)	-.018 (.017)	-.039* (.019)	-.049** (.021)	-.029 (.019)	-.019 (.017)
R^2 Between	.273	.303	.344	.335	.327	.286	.492
R^2 Overall	.232	.261	.300	.284	.291	.254	.427

Notes:
*p<.05 **p<.01 (one-tailed tests)
robust standard errors are in parentheses

Table 5.
Unstandardized Coefficients for the Regression of Carbon Monoxide Emissions per capita on Secondary Sector Foreign Investment and other Selected Independent Variables: Random Effects Model Estimates for 3 Observations on 39 Less-Developed Countries, 1990-2000

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Secondary Sector FDI stocks as % GDP (ln)	.025* (.014)	.027* (.014)	.029* (.013)	.028* (.014)	.031* (.014)	.029* (.014)	.036** (.014)
GNP per capita (ln)	.023 (.015)	.022 (.015)	-.017 (.020)	.019 (.017)	.037* (.018)	.015 (.016)	.011 (.026)
Domestic Investment as % GDP (ln)	.003 (.023)	-.003 (.022)	.007 (.023)	-.003 (.022)	.006 (.020)	-.005 (.023)	.013 (.022)
Secondary Sector FDI Rate		.080 (.083)	.081 (.083)	.079 (.084)	.082 (.081)	.078 (.080)	.084 (.081)
Urban population			.002** (.001)				.002* (.001)
Services as % GDP				.001 (.001)			-.001 .001
Manufacturing as % GDP					-.005* (.002)		-.005* (.002)
Democratization						.002 (.002)	.001 (.002)
Constant	-.016 (.095)	-.013 (.010)	.109 (.104)	-.019 (.100)	-.067 (.106)	.036 (.102)	.081 (.102)
R^2 Between	.192	.180	.233	.171	.213	.164	.312
R^2 Overall	.133	.132	.182	.123	.170	.126	.247

Notes:
*p<.05 **p<.01 (one-tailed tests)
robust standard errors are in parentheses

Table 6a.
Unstandardized Coefficients for the Regression of Carbon Dioxide Emissions per capita on Secondary Sector Foreign Investment and other Selected Independent Variables: Random Effects Model Estimates for 3 Observations on 39 Less-Developed Countries, 1990-2000

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Secondary Sector FDI stocks as % GDP (ln)	.008 (.021)	.008 (.022)	.016 (.019)	.008 (.022)	.004 (.022)	.009 (.022)	.010 (.020)
GNP per capita (ln)	.335** (.043)	.337** (.046)	.217** (.054)	.338** (.047)	.323** (.049)	.320** (.046)	.220** (.059)
Domestic Investment as % GDP (ln)	.089* (.489)	.089* (.050)	.083* (.042)	.089* (.051)	.092* (.050)	.072 (.044)	.078* (.040)
Secondary Sector FDI Rate		.008 (.052)	-.013 (.049)	.009 (.053)	.007 (.052)	-.013 (.052)	-.028 (.049)
Urban population			.009** (.002)				.008** (.002)
Services as % GDP				-.001 (.001)			.000 (.002)
Manufacturing as % GDP					.004 (.004)		.005 (.004)
Democratization						.007** (.002)	.004* (.002)
Constant	-1.836** (.269)	-1.852** (.270)	-1.401** (.294)	-1.856** (.268)	-1.823** (.271)	-1.691** (.282)	-1.323** (.278)
R^2 Between	.678	.678	.639	.679	.695	.667	.662
R^2 Overall	.668	.669	.636	.669	.684	.660	.659

Notes:
*p<.05 **p<.01 (one-tailed tests)
robust standard errors are in parentheses

Table 6b.
Unstandardized Coefficicnts for the Regression of Carbon Dioxide Emissions per capita on Interactions between Time and Secondary Sector Foreign Investment:
Random Effects Model Estimates for 3 Observations on 39 Less-Developed Countries, 1990-2000

Secondary Sector FDI stocks as % GDP (ln)	-.032 (.031)
Secondary Sector FDI stocks as % GDP (ln) x 1995	.033** (.014)
Secondary Sector FDI stocks as % GDP (ln) x 2000	.034** (.016)
GNP per capita (ln)	.241** (.054)
Domestic Investment as % GDP (ln)	.060 (.042)
Secondary Sector FDI Rate	-.037 (.053)
Urban population	.005** (.002)
Services as % GDP	-.001 (.001)
Manufacturing as % GDP	.005 (.004)
Democratization	.004 (.003)
Constant	-1.357** (.260)
R^2 Between	.687
R^2 Overall	.683

Notes: *p<.05 **p<.01 (one-tailed tests); robust standard errors in parentheses