CAPITAL MOVEMENTS AND ENVIRONMENTAL HARMS

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ABSTRACT

The authors engage appropriate macrosociological theorization and employ quantitative comparative methods to assess the extent to which various forms of environmental degradation in less-developed countries are tied to inward foreign direct investment in the primary and secondary sectors. Analyzed outcomes include carbon dioxide emissions, industrial organic water pollution, and deforestation. Such forms of environmental harms are known to partially shape migration processes as well as other social dynamics. Results of longitudinal analyses indicate that all three forms of environmental degradation are positively associated with sector-level inward foreign direct investment, which provides broad support for the engaged theoretical orientation.

INTRODUCTION

In this short article we employ quantitative comparative methods to investigate the extent to which world-economic integration in the mode of foreign investment dependence contributes to various types of environmental degradation in less-developed countries. As we briefly discuss in the next section, different forms of environmental harms are known to partially shape migration processes as well as other social conditions. These sorts of interrelationships underscore the importance in considering the structural determinants of environmental degradation. Following the discussion of environment / migration relationships, we summarize the theoretical articulations and related empirical works concerning the potential environmental impacts of foreign investment dependence. Next, we describe the methods, variables and their sources, and samples employed to conduct the analyses, which are followed by the presentation and discussion of the findings. We conclude by summarizing the noteworthy results of the study, and we close by making a call for other social scientists to consider similar topics in future research.

ISSN 1076-156X

ENVIRONMENTAL HARMS AND THE MOVEMENT OF PEOPLE

Many social scientists link migration to environmental degradation (e.g. Bates 2002; Hugo 1996). One of the most prolific researchers in this area is Norman Myers (e.g. 1997), who claims that 'environmental refugees' – who are displaced due to some form of environmental problem which disallows them from gaining a secure livelihood from their land – already outnumber 'traditional' refugees. It is also likely that their numbers will grow in coming years due to increased environmental degradation and climate change. Like Myers (1997), other scholars (e.g. Chase-Dunn and Hall 1997; Diamond 2005) claim that many forms of environmental degradation are major contributors to migration, particularly in less-developed countries. For example, climate change, which largely results from anthropogenic carbon dioxide emissions, is noted to have quite complex effects on patterns of natural disasters (IPCC 2007). The social and environmental costs of climate change have already been felt by the populations of many less-developed countries, especially those in coastal areas and on smaller islands in tropical regions (e.g. Roberts and Parks 2007). The consequences of these disasters often include temporary and permanent migration.

Myers (1997) argues that water shortages are another environmentally-related reason why people migrate. Taking this point a bit further, highly polluted water is also greatly problematic for human well-being. Although less sudden and noticeable than out-migration that occurs after a natural disaster, water pollution may have a noticeable impact on migration processes. Deforestation is an additional form of environmental degradation that is frequently tied to migration (e.g. Amacher et al. 1998). Deforested land – particularly in the tropics – is less able to hold nutrients in the soil, which impacts crop yields. For a variety of reasons, reduced soil fertility can lead to a persistent need to be mobile. Further, as much of the best land is taken up by corporate – and often transnational – interests, small landholders are commonly pushed on to more marginal lands. Thus, there are indeed ways in which forms of environmental degradation can impact the movement of human populations. While other selections in this collection address the causes or consequences of migration, we investigate how world-economic integration in the form of foreign investment dependence contributes to particular environmental harms that are known to partially shape migration patterns as well as other social processes and structural conditions.

FOREIGN DIRECT INVESTMENT AND THE ENVIRONMENT

Throughout the contemporary history of macrosociology, a great deal of theoretical and empirical attention is paid to the potential impacts of foreign investment. The most broadly known and debated orientation in this area of scholarship is the theory of foreign investment dependence (e.g. Bornschier and Chase-Dunn 1985; Chase-Dunn 1975). This longstanding theory generally asserts that the accumulated stocks of foreign investment make a less-developed country more vulnerable to different transnational and global political-economic conditions, which often leads to a variety of negative consequences for domestic populations. The vast majority of prior research that tests hypotheses derived from this theory investigates the effects of foreign investment dependence on domestic income inequality, economic development, food security, and other social outcomes (e.g. Alderson and Nielsen 1999; Dixon and Boswell 1996; Jenkins

and Scanlan 2001; London and Smith 1988). Building on this area of scholarship, a growing number of environmental sociologists have begun to theorize about and investigate the extent to which foreign investment dependence impacts the environment in less-developed countries (e.g. Dick and Jorgenson 2010; Grimes and Kentor 2003; Jorgenson 2007, 2008; Jorgenson, Dick, and Mahutga 2007; Jorgenson and Kuykendall 2008).

During recent decades, many less-developed countries experienced a deepening of foreign debt, which resulted in austerity measures developed by global governance and finance institutions (McMichael 2004). These austerity measures, such as structural adjustment programs, often encourage the governments of indebted countries to create more favorable domestic conditions for foreign investors and transnational corporations as a way to stimulate economic development to assist in repayment of debt while increasing the level of well-being for domestic populations. Less-developed countries have attempted to facilitate and maintain more appealing business conditions using several different strategies, including relaxed labor laws and tax reductions as well as exemptions to environmental regulations designed to protect the natural environment from activities in different sectors of the economy (e.g. Clapp and Dauvergne 2005). In many cases, the real or perceived threat of capital flight could be viewed as an additional incentive for less-developed countries to offer regulatory concessions to foreign-headquartered firms and foreign capital (Wallerstein 2005). Further, prior research shows that many less-developed countries are less likely to ratify international environmental treaties, many of which deal explicitly with extractive and productive activities that are of direct relevance for transnational corporations (Roberts and Parks 2007). At least partly resulting from these unfolding political-economic processes, the relative presence of foreign investment stocks for all economic sectors combined within less-developed countries increased substantially during recent decades (Jorgenson 2007). This increase for less-developed countries is much more pronounced than the overall recent upsurge in the structural globalization of foreign investment for the world-economy as a whole (Chase-Dunn and Jorgenson 2007).

With these emergent political-institutional dynamics in mind, we argue that a large proportion of foreign investment in less-developed countries finances highly polluting and ecologically inefficient manufacturing processes and facilities, much of which are outsourced from developed countries. Transnational firms benefit economically from this form of environmental cost shifting, since different ecologically inefficient and highly polluting manufacturing processes often include more outdated and inexpensive machinery and materials. This also allows transnational firms to distance themselves in the public eye from the environmental and related human well being costs of their productive activities (Princen 2002). Besides lessening the likelihood of transnational firms being subject to increased regulations, restrictions, and fines by domestic political institutions in the countries of their headquarters, the buying habits of consumers within more-developed countries are less likely to be influenced since they are often less aware of the environmental impacts associated with the production of the commodities they consume. Moreover, partly resulting from a lack of tax revenues and cuts in public spending, the power generation techniques within many less-developed countries tend to be fossil fuel dependent and considerably less eco-efficient. Many of these types of facilities generate at least some of the electricity used by transnationally-owned manufacturing centers.

In addition to production equipment and power generation techniques, the transportation vehicles owned and used by foreign-owned manufacturing enterprises in less-developed countries for the movement of inputs, outputs, and labor are more likely to be outdated and energy-

inefficient (Jorgenson 2007). Also, the "on-the-ground" transportation infrastructure of many less-developed countries tends to be more poorly maintained than in developed countries. For example, roadways are less likely to be paved on a regular basis, and rail systems are more likely to be spotty in different areas, and these problematic conditions can lead to the increased use of fossil fuels for the transportation of raw materials, manufactured goods, and labor (Grimes and Kentor 2003). These sorts of processes, conditions, and structural relationships contribute to higher overall levels of greenhouse gas emissions and air pollutants as well as emission per unit of production, which is a common measure of relative eco-efficiency.

We also posit that the use of organic materials in manufacturing processes controlled by foreign capital often results in higher levels of industrial organic water pollutants. Many of these organic materials are highly toxic and capable of remaining in the environment for extended periods of time (Eckenfelder 2000). More specifically, organic water pollution can result from a variety of secondary sector activities, including the environmentally unfriendly processing of industrial chemicals, pulp and paper manufacturing, food processing, textile production, and steelmaking (e.g. World Resources Institute 2005), and they have severe consequences for aquatic ecosystems and human well-being. In fact, a recent panel study of less-developed countries links higher infant mortality rates to elevated industrial water pollution levels, net of other relevant factors (Jorgenson 2009).

In a related vein, we argue that foreign investment in the primary sector commonly finances forestry projects, agricultural activities, and extractive operations that contribute to deforestation in less-developed countries. Many less-developed countries, especially those with relatively larger forest areas, are prime locations for logging operations (e.g. Kick et al. 1996), and indebted countries are often encouraged to utilize their natural resources, including forested areas, as a form of comparative advantage to attract foreign capital (McMichael 2004). What is more, as agriculture enterprises are integrated into the world-economy, especially those owned by transnational firms, the scale and intensity of their production tend to increase substantially (e.g. Harper and Le Beau 2003; Jorgenson and Kuykendall 2008). To increase production and agricultural output, forest areas are cleared through the slashing and burning of biomass as well as the use of tractors and other types of machinery (Jorgenson 2008). Forest areas are also cleared for livestock ranching for export markets, many of which are controlled by foreign capital (Burns et al. 1994). The extraction of minerals and other raw materials are the starting points for a large proportion of global production systems, and transnational firms are key actors in these primary sector activities (Bunker 1984). Mining activities are often carried out in a series of stages [e.g. prospecting, exploration, the development of facility infrastructure and transportation systems, direct extraction, transported to other locations], each of which involves possible environmental impacts that are detrimental to forested areas (Rudel 2005).

In the subsequent analyses, we examine the extent to which secondary sector foreign investment dependence contributes to total carbon dioxide emissions, total industrial organic water pollution, and carbon dioxide emissions per unit of production in less-developed countries. We also examine the relationship between deforestation and primary sector foreign investment dependence in less-developed countries.

THE ANALYSES

Methods

To investigate the extent to which secondary sector foreign direct investment contributes to (1) total carbon dioxide emission, (2) carbon dioxide emissions per unit of production, and (3) total industrial organic water pollution, we use Stata version 9 software to estimate fixed effects (FE) panel models. In all FE models we include a correction for first-order autocorrelation (i.e. AR[1] correction). Not correcting for autocorrelation can often lead to biased standard error estimates.

In the comparative social sciences, FE panel regression is one of the most commonly used methods designed to correct for the problem of heterogeneity bias (Halaby 2004). Heterogeneity bias in this context refers to the confounding effect of unmeasured time-invariant variables that are omitted from the regression models. To correct for heterogeneity bias, FE models control for omitted variables that are time invariant but that do vary across cases. This is done by estimating unit-specific intercepts, which are the fixed-effects for each case. With Stata the fixed effects are estimated with the within estimator, which involves a mean deviation algorithm for the dependent variable and each time-varying independent variable. FE models are quite appropriate for this type of cross-national panel research because time invariant unmeasured factors such as natural resource endowments and geographic region could affect environmental outcomes. The FE approach also provides a stringent assessment of the relationship between foreign investment and the dependent variables, given that their associations are estimated net of unmeasured between-country effects. Overall, this modeling approach is quite robust against missing control variables and more closely approximates experimental conditions. The basic linear FE model is as follows:

$$y_{it} = \mu_t + \beta x_{it} + \gamma z_i + \alpha_i + \varepsilon_{it}$$

Subscript *i* represents each unit of analysis (i.e., country), subscript *t* represents the time period, y_{it} is the dependent variable for each country at each time period, μ_t is an intercept that may be different for each time period, and β and γ are vectors for coefficients. Predictor variables that vary over time are represented by the vector x_{it}, time-invariant predictor variables are represented by the vector z_i, α_i represents the combined effect on y of all unobserved variables that are constant over time, and ε_{it} represents purely random variation at each time point. Since α_i is perfectly collinear with z_i, the conventional FE model will not produce coefficient estimates for the time-invariant predictors.

For the analyses of primary sector foreign investment and deforestation, we employ ordinary least squares [OLS] regression, which is the most commonly used method in cross-national analyses of forest degradation. Adequate panel data for natural forest cover that would allow for the use of FE or other related models are currently unavailable.

Dependent Variables

1. Total carbon dioxide emissions represent the mass of carbon dioxide produced during the combustion of solid, liquid, and gaseous fuels, as well as from gas flaring and the manufacture of cement. These data, which are measured in thousand metric tons and logged [ln] to correct for excessive skewness, are gathered from the World Resources Institute (2005). All other logged [ln] variables in the current study are done so for analogous reasons.

2. Carbon dioxide emissions per unit of GDP [ln] measures the quantity of carbon dioxide released into the atmosphere for each million dollars of Gross Domestic Product (GDP) in a country or region. These data, which we use as measures of relative eco-efficiency, are obtained from the World Resources Institute (2005) and measured as metric tons of emissions per million constant 1995 United States dollars.
3. Total water pollution [ln] consists of industrial organic water pollutant emissions per day. They are measured in kilograms and by biochemical oxygen demand, which refers to the amount of oxygen that bacteria in water will consume in breaking down waste. In particular, these data include water pollutants from manufacturing activities as defined by the two-digit divisions of the International Standard Industrial Classification revision. Overall, this consists of organic water pollutants from the manufacturing of primary metals, paper and pulp, chemicals, food and beverages, stone, ceramics, glass, textiles, wood, and manufactured goods included in the two divisions of classification labeled as "other" manufactured goods (divisions 38 and 39). These data are gathered from the World Resources Institute (2005).
4. The final dependent variable for the current study is percent change in natural forest area, 1990-2005 [i.e. "deforestation"]. Forest area data used in the calculation of this dependent variable are taken from the World Resources Institute (2005), who obtains them from the *Global Forest Resource Assessment* of the Food and Agricultural Organization. Positive values correspond with deforestation, and negative values correspond with increased levels of natural forest area, sometimes referred to as aforestation or reforestation. We use the available point estimates of natural forest areas measured in hectares for 1990 and 2005 to calculate the percent change scores. These are the most recent estimates available on a comparative cross-national basis. Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds, are considered forests. Natural forest areas consist of native forest species only, with the possible exception of small areas of natural regeneration or assisted natural regeneration. Areas established through planting or seeding are categorized as forest plantations instead of natural forests and are excluded from these measurements. Moreover, natural forest areas do not include land under agricultural or urban land use [e.g. fruit plantations, agroforestry systems, gardens, urban parks].

Independent Variables for the Carbon Dioxide Emissions and Water Pollution Analyses

- Accumulated stocks of secondary sector foreign direct investment as percentage of total GDP [ln] is used to investigate the relationship between foreign investment in manufacturing and the first three outcomes. The foreign direct investment stocks data are obtained from the Organization for Economic Co-Operation and Development's *International Direct Investment Statistics Yearbook* (2001) and the United Nations' *World Investment Directories* (1992, 1994, 1996, 2000, 2003). These data consist of investment in food and beverages, tobacco, textiles and clothing, leather, wood and wood products, publishing and printing, coke, petroleum products, nuclear fuel, chemicals and chemical products, rubber and plastic products, non-metallic mineral products, metal and metal products, machinery and equipment, electrical and electronic equipment, precision instruments, motor vehicles and other transport equipment, other manufacturing, and recycling (United Nations 1992, 1994,

1996, 2000, 2003; OECD 2001). Total GDP data are measured in 2000 US dollars, and gathered from the World Bank (2007).

- Total population is measured in thousands and logged [ln]. These data are obtained from the World Bank (2007). The measures of total population are based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. Refugees not permanently settled in the country of asylum are generally considered to be part of the population of their country of origin. Controlling for total population in analyses of scale outcomes [e.g. total emissions] is both commonplace and commonsensical. Larger populations tend to have greater cumulative impacts on the environment. We also include total population as a statistical control in the analyses of emissions per unit of production, which allows for a more rigorous statistical investigation of the relationship between relative eco-efficiency and secondary sector foreign investment.
- GDP per capita [ln] is included as a control for level of economic development. These data, which we gather from the World Bank (2007), are measured in 2000 US dollars. Political-economic approaches, such as treadmill of production theory (e.g. Schnaiberg and Gould 1994), argue that level of development is a key structural driver of greenhouse gas emissions and other forms of waste, including industrial water pollution. Turning to emissions per unit of production, world-systems scholars, such as Roberts, Grimes, and Manale (2003), assert that middle-developed or semiperipheral countries tend to have enough fossil fuel dependent technologies to compete on the world market but not enough technologically advanced infrastructure to do so efficiently. Lesser-developed or peripheral countries tend to consist of relatively less fossil fuel based technologies and capital-intensive production. Thus, when excluding the most-developed countries, one would expect emissions per unit of GDP to be positively associated with level of development.
- Gross domestic investment as percentage of total GDP represents the level of domestic investment in fixed assets plus net changes in inventory levels. These data are obtained from the World Bank (2007). Controlling for domestic investment allows for a more rigorous assessment of the effects of foreign investment on both outcomes. We would prefer sector-level measures of domestic investment. However, those data were unavailable at the time of the study.
- Secondary sector activities 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 (2007). Including this measure allows us to assess the extent to which the transnational organization of production in the context of secondary sector foreign investment dependence contributes to higher total carbon dioxide emissions and industrial water pollution as well as carbon dioxide emissions per unit of production, net of the relative scale of the manufacturing sector in host economies.
- Secondary sector exports as percentage of total GDP [ln] controls for the relative level of manufacturing exports of a given country. These data are gathered from the World Bank (2007).

Independent Variables for the Deforestation Analyses

- Accumulated stocks of primary sector foreign direct investment as percentage of total GDP [ln] includes stocks of foreign direct investment in agriculture and forestry as well as mining

and quarrying. These data are for the year 1990. We obtain the foreign investment data from the 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). Total GDP data are measured in 2000 US dollars (World Bank 2007).

- Forest stock [ln], is calculated as the total size of natural forest areas in 1990 (World Resources Institute 2005). Controlling for initial levels of forest stock is necessary when making cross-national comparisons of rates of change in forest cover. This controls for the possibility that either scarcity or abundance of forest areas influences rates of deforestation.
- Total population change is defined as the percent change in a country's total population from 1980 to 1990. Levels of total population for 1980 and 1990 are obtained from the World Bank (2005). These data are transformed into percent change scores.
- GDP per capita [ln] in 1990 is included as a control for level of economic development. These data are measured in 2000 US dollars (World Bank 2007).
- Gross domestic investment as percentage of total GDP represents the level of domestic investment in fixed assets plus net changes in inventory levels in 1990. These data are obtained from the World Bank (2007) and used here for the same reasons as for the carbon dioxide emissions and water pollution analyses.
- Primary sector activities as percentage total GDP, [ln] controls for the extent to which a domestic economy was based on the primary sector in 1990. This measure comprises value added from forestry, hunting, and fishing as well as cultivation of crops and livestock production. These data are obtained from the World Bank (2007).
- Primary sector exports as percentage of total exports, [ln] controls for the extent to which a nation's exports in 1990 were comprised of primary sector products. These include agricultural goods as well as hides and skins, crude rubber, cork and wood, pulp and waste paper, textile fibers, and crude animal and vegetable materials. These data are gathered from the World Bank (2007).

Countries included in the Analyses

To maximize the use of available data, we allow samples to vary among the different outcomes. For the carbon dioxide emissions analyses [both total emissions and emissions per GDP], the sample consists of 37 less-developed countries with a range of 3 to 25 observations spanning the 1975-2000 period. For the water pollution analyses, the sample consists of 2 to 20 observations on 30 less-developed countries from 1980 to 2000. The sample for the deforestation analyses includes 40 less-developed countries where—as we discuss above—all but one of the independent variables are point estimates for 1990, while the outcome is measured as a percent change from 1990 to 2005. Table 1 lists the countries included in each of the samples[1]. Due to

[1] The lower number of countries in the carbon dioxide emissions and water pollution analyses relative to the deforestation analyses is a function of restricting the samples for the former sets to less-developed countries with a minimum of 2 observations for the independent and dependent variables within the analyzed periods. Even with these limitations, the overall size, temporal scope, and methodological rigor of the current analyses are superior to the majority of prior cross-national research on foreign investment and environmental degradation in less-developed countries.

space limitations, we do not report univariate descriptive statistics or bivariate correlations. However, they are available from the authors upon request.

Table 1. Countries Included in the Analyses

CO_2 Models	**Water Pollution Models**	**Deforestation Models**
Argentina	Argentina	Argentina
Bangladesh	Bangladesh	Bangladesh
Benin	Brazil	Bolivia
Brazil	Cameroon	Brazil
Cameroon	China	Bulgaria
China	Colombia	Cambodia
Colombia	Costa Rica	Chile
Costa Rica	Dominican Republic	China
Dominican Republic	Ecuador	Colombia
Ecuador	El Salvador	Costa Rica
El Salvador	Honduras	Czech Republic
Ghana	India	Dominican Republic
Haiti	Indonesia	Ecuador
Honduras	Kenya	El Salvador
India	Malaysia	Guatemala
Indonesia	Mexico	Haiti
Kenya	Morocco	Honduras
Malaysia	Nepal	Hungary
Mexico	Nigeria	India
Morocco	Pakistan	Indonesia
Nepal	Panama	Jamaica
Nicaragua	Peru	Lao P.D.R.
Nigeria	Philippines	Madagascar
Pakistan	Portugal	Mauritania
Panama	Senegal	Mexico
Paraguay	Sri Lanka	Mongolia
Peru	Thailand	Nepal
Philippines	Turkey	Nigeria
Rwanda	Venezuela	Pakistan
Senegal	Zimbabwe	Panama
Sri Lanka		Paraguay
Thailand		Peru
Turkey		Philippines
Uganda		Poland
Venezuela		South Africa
Vietnam		Sri Lanka
Zimbabwe		Thailand
		Turkey
		Venezuela
		Zimbabwe

RESULTS

Findings for the FE analyses of carbon dioxide emissions and industrial organic water pollution are presented in Table 2. We report unstandardized regression coefficients, which are flagged for statistical significance. We also provide standard errors for coefficients as well r-square overall, mean observations per country, and overall sample sizes [N] for each model. For sake of space, we report only the most fully saturated model for each of the three outcomes.

Table 2. Unstandardized Coefficients for the Fixed Effects Regression of Carbon Dioxide Emissions and Industrial Organic Water Pollution on Secondary Sector Foreign Investment and other Selected Independent Variables in Less-Developed Countries

	CO_2	CO_2 / GDP	Water Pollution
Secondary Sector FDI	.056**	.036*	.093***
stocks as % GDP (ln)	(.028)	(.026)	(.038)
Total Population (ln)	.912***	.432***	.761***
	(.047)	(.053)	(.040)
GDP per capita (ln)	.190***	.257***	.473***
	(.067)	(.073)	(.060)
Domestic Investment	.002	-.001	-.003*
as % GDP	(.002)	(.002)	(.002)
Secondary Sector Activities	.004	-.001	.005*
as % GDP	(.003)	(.003)	(.004)
Secondary Sector Exports	.091***	.061**	.021
as % GDP (ln)	(.030)	(.027)	(.047)
Constant	-.773***	.114***	.133***
	(.037)	(.032)	(.045)
R^2 Overall	.788	.216	.827
Mean observations per country	13	13	11.2
N	530	530	366

*Notes: *p<.10 * *p<.05 ***p<.01; standard errors are in parentheses; carbon dioxide emissions analyses for 3 to 25 observations on 37 countries, 1975-2000; water pollution analyses for 2 to 20 observations on 30 countries, 1980-2000*

Prior to discussing the findings of interest for the study, we summarize the correlates between the outcomes and the controls. Consistent with prior research as well as structural human ecology theory, the effect of total population on both scale outcomes is positive and statistically significant. Moreover, its effect on carbon dioxide emissions per unit of production is also positive. Thus, all else equal, besides contributing to larger overall levels of waste, bigger populations tend to be less eco-efficient—at least in the context of anthropogenic emissions of carbon dioxide gas. Level of development [GDP per capita] positively affects all three outcomes, which corresponds with other research in this tradition as well as numerous political-economic perspectives, including world-systems analysis and treadmill of production theory. The effect of secondary sector activities on total water pollution is positive and statistically significant, but non-significant for both carbon dioxide emissions outcomes. Conversely, the effect of secondary sector exports is positive and statistically significant for total and per unit of production carbon dioxide emissions, but non-significant for total water pollution. While the effect of domestic investment on total water pollution is negative and statistically significant, we remind readers that this predictor includes domestic investments in all sectors combined. Thus, we refrain from placing much emphasis on this result as well as the non-significant association between both carbon dioxide emissions outcomes and domestic investment. We hope that sector-level measures of domestic investment will soon become available on a cross-national basis.

Turning to the relationships of interest, we find that all three outcomes are positively associated with dependence on secondary sector foreign investment. Thus, in less-developed countries, transnationally-owned manufacturing enterprises appear to be relatively highly polluting to both the air and water as well as relatively less eco-efficient—at least in the form of carbon dioxide emissions. These results are consistent with prior work as well as emergent theoretical articulations concerning the environmental consequences of foreign investment dependence for less-developed countries (e.g. Dick and Jorgenson forthcoming; Grimes and Kentor 2003; Jorgenson et al. 2007). It is also important to note that while the effect of secondary sector foreign investment is consistent across all three outcomes, the same doesn't apply to the other form of world-economy integration, secondary sector exports, or to the relative scale of manufacturing activities. Overall, these results illustrate how the environmental impacts of domestic factors and world-economy characteristics are far from monolithic, and scholars need to carefully consider such issues in future investigations. We now turn to the forest degradation models, which we report in Table 3.

For the deforestation analyses we report unstandardized regression coefficients [flagged for statistical significance] and corresponding standard errors as well as r-square, adjusted r-square, and sample size [N] for the models. Considering the limited sample size, we present results for the most fully saturated model as well as a reduced model that includes only the predictor of interest as well as the controls with statistically significant effects in the former model.

Not surprisingly, total population growth positively affects deforestation in less-developed countries, while the effect of forest stock is negative and statistically significant. All other controls have non-significant effects. This is most surprising for GDP per capita, but we speculate the non-significant association between forest degradation and level of development is primarily a statistical artifact resulting from a reduced sample [due to data availability] of less-developed countries. Other studies of deforestation yield similar findings for analogous reasons (e.g. Jorgenson 2008; Shandra 2007).

Table 3. Unstandardized Coefficients for the Regression of Deforestation on Primary Sector Foreign Investment and other Selected Independent Variables in Less-Developed Countries: OLS Model Estimates

	Full Model	Reduced Model
Primary Sector FDI stocks as % GDP (ln)	3.376**	3.824**
	(2.025)	(1.861)
Forest Stock (ln)	-2.166**	-2.483***
	(.984)	(.853)
Total Population Change	.715***	.783***
	(.221)	(.180)
GDP per capita (ln)	-.052	
	(3.217)	
Domestic Investment as % GDP	-.089	
	(.266)	
Primary Sector Activities as % GDP	2.231	
	(5.013)	
Primary Sector Exports as % GDP (ln)	-.792	
	(2.792)	
Constant	8.827	13.176**
	(37.724)	(8.001)
R^2	.507	.495
Adjusted R^2	.400	.453
N	40	40

*Notes: *p<.10 * *p<.05 ***p<.01; standard errors are in parentheses; dependent variable is deforestation, 1990-2005*

The results indicate that forest degradation in less-developed countries is partly a function of dependence of primary sector foreign investment. In general, transnationally-owned agricultural, forestry, and extractive operations use methods that are detrimental to forests in a variety of direct and indirect ways. The positive effect of primary sector foreign investment, combined with the non-significant effects of level of primary sector activities and level of primary sector exports, indicate that it isn't necessarily the relative scale of activities or the level

of exports per se[2], but rather the foreign control and transnational organization of primary sector activities that contributes to deforestation in many less-developed countries[3].

CONCLUSION

This research contributes to our collective understanding of the potential environmental consequences of foreign investment dependence for less-developed countries. The results of fixed effects panel regression analyses indicate that secondary sector foreign investment dependence contributes to higher levels of anthropogenic carbon dioxide emissions and industrial organic water pollution as well as higher carbon dioxide emissions per unit of production. Furthermore, the results of OLS analyses indicate that primary sector foreign investment dependence contributes to higher levels of deforestation. These results hold, net of many other relevant factors.

As we highlighted above, different types of environmental degradation are known to contribute to the migration of human populations. Thus, in order to better understand the complex determinants of migration patterns and processes—especially in less-developed countries, special attention to the human causes of environmental harms is critical. This work underscores the importance in considering the associations between environmental degradation and forms of world-economic integration, particularly the transnational organization and control of different activities in the context of foreign investment dependence. With [1] the rapid increase in the relative presence of foreign investment in less-developed countries during recent decades, [2] the contemporary upswing in forms of environmental degradation within their borders, and [3] the potential effects of changing environmental conditions on migration and other social processes, rigorous investigations on such relationships is perhaps more important now than in past decades. It is our hope that this work will encourage other comparative social scientists to consider these sorts of topics and their interrelationships in future research.

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[2] However, research in the ecologically unequal exchange tradition indicates that rather than the level of exports, the structure of international trade—particularly the vertical flow of exports from the periphery to the core—contributes to forest degradation and other forms of environmental degradation in the former (e.g. Jorgenson 2006).

[3] Elsewhere, we include a variety of other statistical controls in analyses of all four outcomes, including measures of state strength and democratization. All additional controls have non-significant effects on the four dependent variables, and their inclusion does not substantively alter the reported relationships between the outcomes and the measures of sector-level foreign direct investment.

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