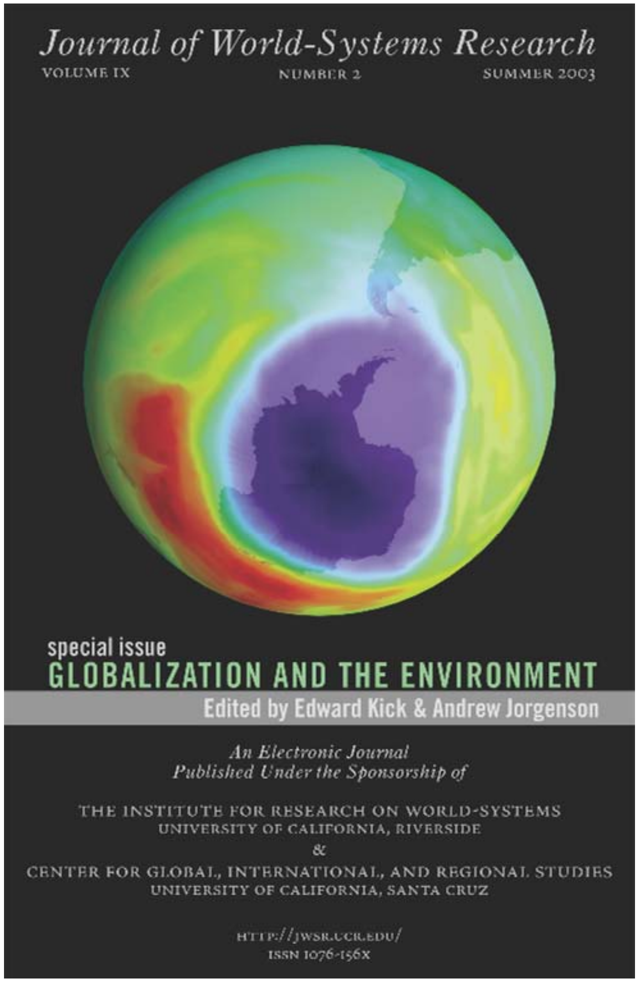

ABSTRACT

This research examines the impact of foreign investment dependence on carbon dioxide emissions between 1980 and 1996. In a cross-national panel regression analysis of 66 less developed countries, we find that foreign capital penetration in 1980 has a significant positive effect on the growth of CO_2 emissions between 1980 and 1996. Domestic investment, however, has no systematic effect. We suggest several reasons for these findings. Foreign investment is more concentrated in those industries that require more energy. Second, transnational corporations may relocate highly polluting industries to countries with fewer environmental controls. Third, the movement of inputs and outputs resulting from the global dispersion of production over the past 30 years is likely to be more energy-expensive in countries with poorer infrastructure. Finally, power generation in the countries receiving foreign investment is considerably less efficient than within the countries of the core.

Exporting the Greenhouse: Foreign Capital Penetration and CO_2 Emissions 1980–1996

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INTRODUCTION

Most of the work on global warming to date has been done by physical scientists. In general their focus has been on detailing the chemistry and physics involved, and demonstrating that human emission of compounds essential to the process have been growing (e.g CO_2, Methane, CFC's, CHFC's). At the same time, their work has proven that average global temperatures have indeed been rising at rates predicted by their theoretical expectations (see the publications of the *Intergovernmental Panel on Climate Change*, esp Houghton *et. al.*, 2001).

The precision of this scientific effort has been extremely helpful in both legitimizing and popularizing the vital importance of the issue, and succeeded in raising it to the highest levels of global political concern. However, the dominant contribution of the physical scientists has distracted public attention from the potential contribution of the social scientists.

Physical science can explain the thermodynamic issues of atmospheric heat entrapment, identify the chemical compounds responsible, and even isolate the kinds of human activities responsible for creating those compounds. However, experts in these questions cannot address the political, economic, and social forces that explain the **choice** of systems, machinery, and locations employing those compounds. The logic explaining these most fundamental choices can

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only be understood by using the analytical tools of the **social sciences**—tools untaught to practitioners of the physical sciences. At a time when wars over the control of oil are more frequent, it is particularly important that we understand the social forces behind both the thirst for oil and the atmospheric warming following its use.

Fortunately, a growing number of social scientists working within a world-system perspective have begun to address this disciplinary gap (Bergeson and Parisi, 1997; Burns, Davis, and Kick, 1997; Grimes, Roberts, and Manale, 1993 and in this issue; Grimes and Roberts, 1995; Roberts and Grimes, 1997). After a brief review of the contributions from the physical scientists we will evaluate these recent contributions from world-system theorists and show how our work here both extends and supports their findings.

GLOBAL WARMING AND ITS COST

Daily changes in weather have accustomed all of us to the instability of temperature over the short run. But these daily and seasonal fluctuations tend to cancel out; leaving the impression that Earth's "thermostat" is always the same. The reality is far more subtle, of course. Earth's surface temperature is the outcome of energy flows that are dynamic, sensitively re-adjusting to a fluid balance of forces. The incoming warmth from the sun and the internal heat from the molten core beneath the mantle are continuously being radiated out into space, and the difference between these rates of warming and cooling creates the surface temperatures we must cope with. The atmosphere ultimately governs this race between heating and cooling by acting as a "valve" regulating the rate of heat loss from infrared radiation into space, and the size of this valve—the "clarity" of the infrared "window"—is mainly due to CO_2. Along with Methane, CFC's, and CHFC's, CO_2 captures heat, acting like a gaseous blanket over the planet. Although heat (infrared light-radiation) still works its way out through this chemical blanket, the blanket slows its progress enough to retard cooling and raise the global surface temperature.

If it were not for naturally occurring levels of atmospheric CO_2 in the past, the surface temperature of our planet would be below freezing (–18c), liquid water would not exist, and life as we know it impossible (Cowen 1995). Corroborating evidence is provided by the dating of sequential strata of seabed sediment indicating that periods of glaciation are actually the norm, while inter-glacial times like the last 10,000 years are the ***exception*** (e.g. Monastersky 1996a & b).

It is a delicate balance. Evidence from the fossil record and Antarctic ice cores reveal that levels of atmospheric CO_2 have risen inversely with periods of glaciation for at least the past 100,000 years. These same ice cores show that levels of atmospheric CO_2 have risen 27% during the period 1800-1990, from 280ppm to 355ppm (CDIAC 1991, 1993, 1999, 2001). The increase in levels of CO_2 since 1800 is almost certainly due to human activity—massive deforestation during the 19^{th} Century added to in the 20^{th} by the burning of fossil fuels. Today all automobiles, planes, and ships burning fossil fuels emit CO_2, along with all coal or oil fired electric generators. Hence almost all of the machinery used in modern production contributes to CO_2 emissions.

The Intergovernmental Panel on Climate Change has reached consensus that global warming is already well along (Houghton, 1990, 1992, 2001). Temperatures in the northern hemisphere have shot up dramatically since 1900, well above their average for the previous five centuries. Glacial ice-packs are retreating at unprecedented rates (Jacobs *et. al.*, 2002; Meier and Dyurgerov, 2002), while plants and butterflies have been documented moving higher up mountains and further north (Peters and Lovejoy 1992).

Warming implies a general movement toward the poles of the climates appropriate for the major food crops (wheat, rice, and maize). For the majority of plants not under human cultivation, the polar shift in climate may outrun their ability to migrate, leading to their extinction along with the life forms dependent on them (Peters and Lovejoy 1992; Etterson and Shaw 2001). Melting ice suggests rising sea levels, which satellite data now confirm (Jacobs *et. al*. 2002). The remaining glacial ice, if fully melted, would add another 250 feet (Robinson 1993: Chapter 9). While we are yet far from that point, a rise of only one or two feet would permanently flood the currently arable land around the Nile, and has been estimated to be able to cut agricultural production globally by as much as 20 percent. Further, rising sea levels pose the potential for flooding important ports and coastal cities, as well as entire pacific island nations. Finally, climate models predict more frequent storms having higher wind-speeds with increased warming, implying corresponding increases in deaths and infrastructural damage. Because the global population is growing, and most of that population lives near rivers and seacoasts, the mortality figures could become truly staggering, as well as the costs of repair.

THE SOCIAL STRUCTURE OF WARMING

Fossil fuels are consumed throughout the activities of daily life, being used to power homes, businesses, and transportation. But the support for this consumption requires an expensive infrastructure of pipelines, wires and roads, as well as the money to pay for the fuels themselves. Consequently the use of these fuels reflects the distribution of global income and political power, and is just as highly polarized. In 1995, 80 percent of the world's emissions of CO_2 emerged from the countries of the core, with the United States ***alone*** accounting for 27 percent (WRI 1996). Further, until recent decades this polarized distribution of fuel consumption also tracked economic output (Burns, Davis, and Kick 1997). That is, both the overall volume of carbon and the emission of pounds of carbon per dollar of GDP was greatest among the countries of the core and lowest among those of the periphery, appearing to show that energy ***efficiency*** was also higher among the poor than the rich.

However, recent research has demonstrated that this apparent link between production output and energy efficiency was a transient phenomenon, found in the data for the 25 years following the second World War, but falling quickly apart during the decade of the 1970's (Roberts and Grimes, 1997; Roberts, Grimes, and Manale in this issue). Even though core countries continue to be the greatest contributors to the overall **volume** of atmospheric CO_2 (Burns, Davis, and Kick 1997), by 1990 the **ratio** of CO_2/GDP has grown to vary by nearly one **hundredfold**, while emissions of carbon dioxide per capita varies now by over two **thousandfold** (WRI 1992; CDIAC 1991/1993). Even among nations with the same GDP *per capita* the ratio varies considerably.

This growing divergence in CO_2/GDP since the 1970's appears as a dramatic ***increase*** in energy efficiency within the core against an equal ***decrease*** in efficiency within the semi-periphery and upper periphery (Roberts and Grimes, 1997). At the same time, the variation among those countries with dropping efficiency has itself grown rapidly. Previous research has also demonstrated that in 1990, holding world-system position constant, the least efficient producers were also the most politically repressive. They had the fewest political freedoms, the weakest unions, and the strongest internal military presence (Burns, Davis, and Kick, 1997; Roberts, Grimes, and Manale here). It was argued there that the recent flight of production capital away from the unions and regulations of the core and into the cheaper locations provided by the repressive regimes of the Americas and East Asia was the key unlocking both the increasing carbon efficiency in the core and its drop among some members of the semiperiphery.

To summarise, world-system research on CO_2 production to date has found that the volume of energy consumption and thus CO_2 production continues to track world-system position, being greatest in the core, intermediate in the semi-periphery, and lowest in the periphery (Burns, Davis, and Kick 1997). However, since 1975 the production efficiency (as measured by the ratio of CO_2/GDP) within the core appears to be growing while that within the semi-periphery is falling, presumably due to the relocation of manufacturing away from the high wages of the core toward the lower and more politically repressed wages found in the semi-periphery (Roberts and Grimes 1997; Roberts, Grimes, and Manale 1993 and here). While this previous work has suggested that capital flight out

of the core may have been the mechanism responsible for the rise in the ratio of CO_2/GDP observed over time in the semi-periphery, no research has yet sought to validate this implication by actually tying the flow of investment capital to observed changes in the volume of output CO2 over time. After a brief theoretical review, that will be the empirical project to which we will ultimately turn.

THE GLOBALIZATION OF PRODUCTION

The past twenty five years have witnessed a massive shift in the geographical distribution of production from the core to less developed areas of the world economy (Sassen 1996), as transnational corporations searched for lower wages, closer proximity to markets and raw materials, and a way to diffuse the power of labor. Less developed countries became "parts suppliers" to the global economy, which has given rise to global commodity chains (Gereffi and Korzeniewicz 1994). Facilitated by increasingly efficient, low cost transportation, it became cost effective to distribute the production of individual components of a given product (i.e. autos) across several geographically distant locations, have the parts assembled in another country, and then re-shipped to markets throughout the world for sale. While this globalization of production may increase the profits of transnational corporations, it also increases the amount of international transportation, which accelerates the consumption of fossil fuels.

This global relocation of production was fueled by a dramatic expansion of foreign investment. As Beer and Boswell explain (2002: 31):

> …foreign direct investment has dramatically increased in importance over the last two decades, and is currently the primary source of resource flows to developing nations (Froot 1993; Tsai 1995). In 1998, FDI surpassed all other forms of lending as a source of foreign capital to developing nations (WDR [World Bank] 1991). In 1982, the total value of global inward FDI stock stood at almost 6 billion (US$), by 1990 that figure had reached 1.7 trillion (US$), and by 1999 it had reached 4.7 trillion (WIR 2000). The ratio of world FDI stock to world GDP increased from 5% in 1980 10 16% in 2000 (WIR [World Bank] 2000).

The countries competing for and receiving this capital flight out of the core were primarily located in East Asia and Latin America (geographically), and in the semi-periphery and upper periphery (structurally). But although this move cheapened the labor and political costs of production, it increased the actual consumption of energy (and carbon emission) used in that production.

There are several reasons to expect that production outside of the core would be more energy consumptive than inside the core. Most important is the relatively poor infrastructure. States outside of the core lack the tax revenues to finance much new construction or keep up repairs on the old. So roads are less often paved or maintained, rail service spotty, and the electricity grid fragile and prone to frequent blackouts. The trucks and rolling stock using these facilities are themselves second or even third-hand, whether state or privately owned. Finally, power generation facilities use both older equipment and the cheapest fuels, which are often the most polluting. For all of these reasons it takes more fuel to move raw materials in and finished products out of factories outside of the core than those within, and providing power to those factories is more polluting (including productive of CO_2) than it is within the core.

So while the *motivation* for capital to leave the core during the 1970's and 1980's may have been mainly about lower wage and raw material costs, a side-effect was to increase both the volume and per dollar amount of CO_2 introduced into the atmosphere by the countries in the semi-periphery and periphery.

Yet before we can examine the data, one last argument needs to be disposed of.

KUZNET'S GHOST

In 1955, Simon Kuznets wrote a now classic piece on income inequality around the world. In it, he observed that the cross-national data on internal income inequality then available appeared to sequentially rise and then fall when graphed against rising national wealth. Although the cross-sectional nature of the data prevented him from drawing any firm conclusions about change over time, he speculated that the phenomenon might be a reflection of just such a change. In particular, he suggested that the initial accumulation of capital required for long term development would generate the large inequalities observed in the middle-income countries. Meanwhile, the poorest countries were devoid of such accumulation altogether; and the richest had developed so many areas of accumulation and enough political complexity that sharp divisions in income had been smoothed out. Of course it is no coincidence that Kuznet's influential publication emerged during the intellectual boom period of modernization theory, which argued precisely that the world's wealthiest countries portrayed a future achievable to the world's poor.

Now, 50 years on, students of development have more realistically appreciated both the legacy of colonialism and its reincarnation in current market mechanisms. As a consequence the accumulation of capital and its effects on the quality of life are more typically understood to be ***global*** processes transcending international borders (e.g. Chase-Dunn and Grimes, 1995; Grimes, 1999; Kentor, 1998). Viewed from this more sophisticated perspective, the degrees of internal inequality, political repression, physical infrastructure, and other qualities of the political-economy of production are each attributes of an *international division of labor* that works for the accumulation of capital on a **global scale**—a true "world-economy." Hence the data pattern observed by Dr. Kuznets in 1955 would today

be interpreted quite differently: not as revealing the stages of an accumulation process across separate units (nation-states) but instead as revealing the geography of political repression within one single unit (the world-economy).

Despite this theoretical advance some—perhaps in ignorance of it—have sought to regress to Kuznets in order to explain a similar rise and fall in pollutants (expressed either as *per capita* or as *per unit GDP*) when nations are arrayed across measures of rising national wealth (Roberts and Grimes 1997). When Kuznets made his original assertions about the future of inequality within the sunny assumptions of modernization theory it implied to politicians that the "solution" was to do nothing, because the trajectory of national development (capital accumulation) would eventually lift all countries high enough up that income inequality would shrink automatically. Now, during a time of growing popular concern over the deteriorating state of the world's environment it may not be coincidental that a few authors (some affiliated with the World Bank) have found it soothing to suggest an analogous "environmental" Kuznets curve, with its comforting illusion that we need do nothing again but wait until "development" (again assumed to be an autonomous national process) restores balance with the biosphere anew.

Because Kuznet's speculation was informed by an erroneous theory, his predictions were equally wrong: today inequality among the middle-income countries is greater than ever. Hence it is with no surprise that Roberts and Grimes (1997) showed that from 1960–1990, the ghost of Kuznets as applied to environmental pollution was just as wrong as it was when applied to inequality.

THE METHOD AND DATA

Here the hypothesis that foreign investment has re-located many important sources of emissions from the core into the semi-periphery since 1980 is explored directly. We combined data sets on foreign investment and CO_2 emissions to see whether the two were linked in the ways we expected. More specifically, we wanted to see if the destinations of investments made in the past were the same as the places where CO_2/GDP is now the highest. As the tables below show, our expectations were supported fully by the data.

Panel regression analysis was used to estimate the effects of foreign and domestic investment on CO_2 emissions between 1980 and 1996. In this type of analysis, the lagged dependent variable is included as an independent variable. This method controls for prior states of the countries included in the analyses and controls for the possibility of reciprocal causality.

Countries included in the Analyses

We include only less developed countries in these analyses, which is a common practice in similar cross-national research on the effects of foreign capital penetration (Bornschier and Chase-Dunn 1978; Crenshaw and Ameen 1994; Dixon and Boswell 1996; Firebaugh 1992, 1996; Flegg 1979; Kentor 1998, 2001; Kentor and Boswell 2003). The basic argument is that the impact of foreign capital penetration is different for less developed countries than for developed nations.

We empirically define less developed countries as those nations with per capita GNP of less than $ 15,000 in 1980. It should be noted, though, that the results are not sensitive to this specific cut-off point. Similar results are found with lower values (e.g. $10,000) as well. A list-wise deletion of cases leaves 66 cases in the analyses. A list of these countries is given in Appendix A.

Variables included in the Analysis[1]

Dependent Variable

The dependent variable is the level of CO_2 emissions in 1996, which has been logged (Ln) to correct the extreme skewness of this measure. The data are taken from the United Nations (World Resource Institute 2000). We use absolute levels rather than CO_2 / GDP, because we are interested in assessing the impact of foreign capital penetration on the environment.

Independent Variables

Foreign Direct Investment Stocks / GDP (natural log) is the measure of foreign capital penetration included in most current analyses (Dixon and Boswell 1996; Firebaugh 1996; Grimes and Kentor 1998; Kentor 1998, 2001, Soysa and Oneal 1999) and indicates the extent to which foreign capital dominates the investment structure of the host economy. This variable is logged due to its skewed distribution. These data are provided by UNCTAD (1997).

Gross Domestic Investment / GDP is the rate of domestic investment in fixed assets plus note changes in inventory levels, and is provided by the World Bank (1999).

Trade / GDP is included as a control for a country's level of integration in the world-economy (Bornschier and Chase-Dunn 1985; Chase-Dunn 1975; Dixon and Boswell 1996; Firebaugh 1992, 1996; Grimes and Kentor 1998; Soysa and Oneal 1999). Data are taken from the World Bank (1999).

[1] Descriptive statistics and correlations for all variables in the analyses are given in Appendix B.

Table 1 – The Effects of domestic and foreign investment on Total CO_2 emissions 1980–96

DEPENDENT VAR: CO_2 1996 (Ln)

	Model 1			Model 2		
INDEPENDENT VARS	***b***	***Beta***	**t**	***b***	***Beta***	**t**
FDI/GDP 1980 (Ln)	**0.71**	**0.32**	**2.36****	**0.79**	**0.36**	**2.52****
GDI/GDP 1980	0.01	0.04	0.28	0.01	0.02	0.13
Exports/GDP 1980	–0.03	–0.23	–1.59	–0.02	–0.24	–1.66
GNPpc 1980 (Ln)	0.01	0.003	0.02	–0.44	–0.19	–0.97
CO_2 – total (Ln) 1980	**0.65**	**0.55**	**4.22******	**0.56**	**0.47**	**3.35*****
Agriculture/GDP 1980				–0.03	–0.15	–0.66
Africa Dummy				–1.19	–0.21	–1.52
Constant	–1.46		–0.69	4.22		0.42
Adjusted R^2	**0.29**			**0.31**		
N	**66**			**66**		

***p<.05, **p<.01, ***p<.001 (two-tailed tests)**

GNP per capita (natural log) is a measure of a country's wealth and, therefore, an indicator of level of development (Arrighi and Drangel 1986). Data are provided by the World Bank (1996, 1999).

Agriculture, % of GDP, controls for the structure of the host economy. Agricultural production typically generates less CO_2 than the industrial sector of the economy.

Total CO_2 Emissions 1980 (natural log) is the lagged dependent variable. It is included in the analyses to control for the prior state of the dependent variable and for the possibility of reciprocal causality. This variable, too, has been logged to correct the skewness of the distribution.

Africa is a dummy variable that controls for geographical differences in the global economy. This variable is coded "1" if the country is on the African Continent, and "0" if not.

RESULTS

The primary finding of these analyses is that foreign capital penetration in 1980 has a significant positive effect on growth in total CO_2 emissions between 1980 and 1995 in less developed countries, net of the other independent variables. We find no systematic effect of domestic investment on total CO_2 emissions over the same period.

The results are given in Table 1. Two models are presented. In Model 1, total CO_2 emissions in 1996 is regressed on gross domestic investment, foreign capital penetration, trade, GNP per capita, and total CO_2 emissions, all measured in 1980. Model 2 adds the additional control variables of agricultural production, and the Africa dummy, also measured in 1980. Both analyses were tested for outliers and influential cases, but none were found. Variance Inflation Factors (VIF) were also examined for possible effects of multi-collinearity. VIF values for all variables were within acceptable limits.

The coefficients for models 1 and 2 are similar, indicating that the two additional control variables included in the second model do not have a significant impact on the relationships examined in the first model. Therefore, we discuss the findings for the more comprehensive model two. Foreign capital penetration in 1980 has a significant positive effect on change in total CO_2 emissions between 1980 and 1996 (beta = .36). Gross domestic investment, however, does not have a significant effect. The only other significant effect is that of the lagged dependent variable. The coefficients for two of the control variables, trade/GDP and the Africa dummy, while not significant, are more than twice their standard errors.

DISCUSSION AND CONCLUSIONS

The central finding of these analyses is that *dependence on foreign capital accelerates* the rate of growth of CO_2 emissions in less developed countries. This effect is driven by the global diffusion of production that has occurred over the past twenty-five years in several ways. First, foreign investment in LDCs is concentrated in energy consumptive industries. Second, the "new" logic of commodity chains, while cost efficient, increases the amount of transportation involved in the overall manufacture of goods. Third, the countries to which production has been transferred have poor domestic infrastructures, which result in less energy efficient production. The contribution of domestic capital is negligible, because only *foreign* capital can purchase the equipment required for highly automated (and energy-consumptive) production. Finally, transnational corporations may be less likely to invest in pollution controls for production in less developed countries, which tend to have fewer environmental controls.

These results support the findings of other research which notes an increase in energy efficiency measured as CO_2/GDP in the core and a fall in that same efficiency within the periphery during that same 1975/1980–2000 period (Roberts, Grimes, & Manale 2003).

It is important to consider the policy implications of this study. It is clear from these results that controlling CO_2 emissions requires a global perspective. It is not sufficient to address the generation of greenhouse gasses in the core, without regard to whether production of CO_2 has simply been transferred to, and possibly accelerated in, less developed countries.

Finally, this work suggests at least two areas for further research. First, it would be useful to examine the types of investments that have traveled to less developed countries in the last two decades and how this global diffusion of production is reflected in energy consumptive industries, less efficient production and greater environmental impact. Second, cross- national research doesn't provide much insight into country specific processes. It would be worthwhile to study the ways in which the dynamics of foreign investment play out in a given country over time, with a focus on the ways in which political policies are shaped by these investments.

REFERENCES

Arrighi, Giovanni and Jessica Drangel (1986). "The Stratification of the World-Economy: An Exploration of the Semiperipheral Zone," *Review* 10(1):9–74, Summer.

Beer Linda and Terry Boswell (2002). "The Resilience of Dependency Effects in Explaining Income Inequality in the Global Economy: A Cross National Analysis, 1975–1995," *Journal of World Systems Research* http://jwsr.ucr.edu 8:30–59.

Bergesen, Albert, and Laura Parisi (1997). "Ecosociology and Toxic Emissions." Pp. 43–58 in *Ecology and the World-System*, edited by Walter Goldfrank, David Goodman, and Andrew Szasz. Westport, CT: Greenwood Press.

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

Burns, Thomas J., Byron L. Davis, and Edward L. Kick (1997). "Position in the World-System and National Emissions of Greenhouse Gases," *Journal of World-Systems Research* http://jwsr.ucr.edu 3:432–466.

CDIAC (Carbon Dioxide Information and Analysis Center), Boden, T.A., R.J. Sepanski, and F.W. Stoss (eds.) (1991, 1993, 1999, 2001). *Trends: A Compendia of Data on Global Change*. ORNL/CDIAC–46. Carbon Dioxide Information and Analysis Center. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Chase-Dunn, Christopher (1975). "The Effects of International Economic Dependence on Development and Inequality: A Cross-National Study," *American Sociological Review* 40:720–38.

Chase-Dunn, Christopher and Peter Grimes (1995). "World-Systems Analysis," *Annual Review of Sociology* 21:387–417.

Cowen, Richard (1995). *History of Life*. Cambridge, MA: Blackwell Science.

Crenshaw, Edward and Ansari Ameen (1994). "The Distribution of Income Across National Populations: Testing Multiple Paradigms," *Social Science Research* 23:1–22.

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

Etterson, Julie R., and Ruth G. Shaw (2001). "Constraint to Adaptive Evolution in Response to Global Warming" *Science* 294:151–154.

Firebaugh, Glenn (1992). "Growth Effects of Foreign and Domestic Investment," *American Journal of Sociology* 98:105–30.

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.

Flegg, A.T. (1979). "The Role of Inequality of Income in the Determination of Birth Rates," *Population Studies* 33:457–473.

Froot, Kenneth A. (*ed.*) (1993). *Foreign Direct Investment*. Chicago, IL: University of Chicago Press.

Gereffi, Gary, and Miguel Korzeniewicz (eds.). (1994). *Commodity Chains and Global Capitalism*. New York: Praeger.

Grimes, Peter E. (1999). "Recent Research on World Systems." Pp. 29–55 in *A World-Systems Reader: New Perspectives on Gender, Urbanism, Cultures, Indigenous Peoples, and Ecology,* edited by Tom Hall. New York, NY: Rowman and Littlefield.

Grimes, Peter E. and Jeffrey Kentor (1998). "Exporting The Greenhouse: The Effects of Foreign Investment on CO_2 Emissions, 1980–1990." A paper presented at the Annual Meeting of the American Sociological Association, San Francisco, CA.

Grimes, Peter E., J. Timmons Roberts, and Jody Manale (1993). "Social Roots of Environmental Damage: A World-Systems Analysis of Global Warming." Paper presented at the annual meeting of the American Sociological Association, Miami, Florida.

Grimes, Peter E., and J. Timmons Roberts (1995). "Oscillations in Atmospheric Carbon Dioxide and Long Cycles of Production in the World Economy, 1790–1990." Paper presented at the annual meetings of the American Sociuological Association.

Houghton, John T, G. J. Jenkins, and J.J. Ephraums (eds.) (1990). *Climate Change: The IPCC Scientific Assessment.* Port Chester, NY: Cambridge University Press.

Houghton, John T, B.A. Callander, and S.K. Varney (eds.) (1992). *Climate Change 1992: The Supplementary Report to the IPCC Scientific Assessment.* Port Chester, NY: Cambridge University Press.

Houghton, John T, Y. Ding, D. J. Griggs, M. Noguer, 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.

Jacobs, S.S, C.F. Giulivi, and P.A. Mele (2002). "Freshening of the Ross Sea During the Late 20th Century," *Science* 297:386–389.

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 (2000). *Capital and Coercion*. New York and London: Garland Press.

Kentor, Jeffrey (2001). "The Long Term Effects of Globalization on Population Growth, Inequality, 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* 301–313.

Kuznets, Simon (1955). "Economic Growth and Income Inequality." *American Economic Review* (March, 1955):1–28.

Meier, Mark F, and Mark B. Dyurgerov (2002). "How Alaska Affects the World," *Science* 297:350–351.

Monastersky, Richard (1996a). "Deep desires in Antarctica and Greenland," *Science News* 149(22):341.

Monastersky, Richard (1996b). "Climate modelers: Go talk to the trees," *Science News* 149(23):358.

Peters, Robert L., and Thomas E. Lovejoy (eds.). (1992). *Global Warming and Biological Diversity*. New Haven, CT: Yale University Press.

Roberts, J. Timmons and Peter E. Grimes (1997). "Carbon Intensity and Economic Development 1962–1991: A Brief Exploration of the Environmental Kuznets Curve," *World Development* 25:181–187.

Timmons, J. Roberts, Peter E. Grimes, & Jodie L. Manale (2003). "Social Roots of Global Environmental Change: A WorldSystems Analysis Of Carbon Dioxide Emissions," *Journal of World-Systems Research* http://jwsr.ucr.edu 9(2).

Robinson, Andrew (1993). *Earth Shock: Hurricanes, Volcanos, Earthquakes, Tornados and Other Forces of Nature.* London: Thames and Hudson, LTD.

Sassen, Saskia (1991). *The Global City: New York, London, Tokyo*. Princeton, NJ: Princeton University Press.

Soysa, Indra and John Oneal (1999). "Boon or Bane? Reassessing the Productivity of Foreign Direct Investment," *American Sociological Review* 64:766–782.

Tsai, Pan-Long (1995) "Foreign Direct Investment and Income Inequality: Further Evidence," *World Development* 23:469–483.

United Nations Conference on Trade and Development (1997). *World Investment Report 1997.* New York and Geneva: United Nations.

United Nations Conference on Trade and Development (2000). *World Investment Report 2000: Cross-Border Mergers and Acquisitions and Development*. New York and Geneva: United Nations.

World Bank (1991). *World Development Report 1991: The Challenge of Development.* New York, NY: World Bank/Oxford University Press.

World Bank (1996). *World Tables*. Washington, DC: World Bank.

World Bank (1999). *World Development Indicators*. Washington, DC: World Bank.

World Resources Institute (1990, 1992, 1996. 2002). *World Resources.*New York, NY: Oxford University Press.

World Resources Institute (2000). *World Resources 2000–2001 People and Ecosystems: The Fraying Web of Life*. CD-ROM. Washington, DC: World Resource Institute.

Appendix A – Countries included in the analyses: N=66

Algeria
Argentina
Bangladesh
Barbados
Benin
Botswana
Brazil
Burkina Faso
Burundi
Cameroon
Central African
Chad
Chile
China
Colombia
Comoros
Congo, Rep.
Costa Rica
Cote d'Ivoire
Dominican Rep.
Ecuador
Gabon
Gambia, The
Greece
Guatemala
Honduras
Hong Kong, China
India
Indonesia
Iran
Italy
Jordan
Kenya
Korea, Rep.
Madagascar
Malawi
Malaysia
Mali
Malta
Mauritania
Mexico
Morocco
New Zealand
Nicaragua
Niger
Nigeria
Oman
Panama
Papua New Guinea
Philippines
Rwanda
Saudi Arabia
Senegal
Seychelles
Singapore
South Africa
Sri Lanka
Swaziland
Thailand
Togo
Trinidad and To
Tunisia
Turkey
Uruguay
Venezuela
Zambia

Appendix B – Descriptive Statistics and Correlations for Variables in the Analyses: N=66.

	Mean	S.D.	GDI 1980	FCP 1980	Exports 1980	GNP pc 1980	CO2 1980	Agric 1980	Africa
CO2 1996, total (Ln)	8.73	2.87	.20	.13	-.07	.24	.53	-.34	-.33
Gross Domestic Investment/GDP 1980	25.41	7.77		.44	.49	.36	.25	-.47	-.14
Foreign Capital Penetration 1980 (ln)	1.66	1.29			.57	.30	-.14	-.38	.14
Exports / GDP	35.55	31.44				.43	-.07	-.47	-.06
GNP per capita (Ln)	7.12	1.28					.42	-.84	-.53
CO2, Total 1980 (Ln)	14.38	2.41						-.50	-.47
Agriculture/GDP 1980	20.95	13.68							.45
Africa Dummy	0.39	0.49							