De-Carbonization in Post-Soviet States, 1992-1999:

De-Modernization and the Environment

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Abstract

Here we use panel data to empirically assess the effects of a variety of theoretically important structural factors on national level CO_2 emissions in a "de-modernizing" context, that of post-Soviet states. A diversity of theories address the effects of modernization on the environment, but all of these theories have been developed in a context of modernization and aim at assessing the effects of further modernization on the environment. Unlike the trends in most other nations over the twentieth-century, post-Soviet states in the 1990's saw their collective population size, economy, military, level of urbanization, level of industrialization, and international trade decline, and, thus, they provide an ideal context in which to assess the effects of de-modernization on the environment. First, we found that population has a disproportionately large effect on CO_2 emissions in this context, countering claims that changes in population size have minimal implications of the environment. Second, we found that de-modernization, as indicated by declines in GDP per capita and urbanization, leads to declines in CO_2 emissions, countering the argument of ecological modernization theorists that further modernization is necessary to resolve the environmental crisis. Finally, we found that, as suggested by the "treadmill of destruction" thesis, militarization has an effect on CO_2 emissions above and beyond that of economic development, and that declines in militarization in post-Soviet states led to declines in CO_2 emissions.

Introduction

Despite the claims of some prominent politicians and figures in business, the scientific community is nearly unanimous that human activities are influencing the global climate (IPCC 2001). The rise in greenhouse gas (GHG) emissions, particularly carbon dioxide (CO_2) emissions stemming from the combustion of fossil fuels, over the industrial era has changed the composition of the atmosphere, increasing the retention of heat energy (IPCC 2001). The average global temperature has risen substantially over pre-industrial levels, and is projected to continue to rise sharply over this century, especially if societies continue to use fossil fuel energy sources (IPCC 2001). Concerns about anthropogenic (human induced) climate change have led most developed nations, with one notable exception being the United States, to agree to curtail CO_2 emissions, the leading GHG, as specified in the Kyoto Protocol. In the context of rising concentrations of CO_2 in the atmosphere and societal concern about potential dramatic climate change in the near future due to the accumulation of GHGs, it is increasingly necessary to gain an understanding of the social factors that drive CO_2 emissions and of the types of structural changes that are likely to curb these emissions.

Affluent nations are often looked to for examples of environmental reform, with the hope that modernization holds the key to successfully addressing our environmental problems (Fisher and Freudenburg 2004; Mol 1995, 2001). However, the most striking example of de-carbonization – i.e., absolute reduction in CO_2 emissions – comes not from the societies most often touted as exemplars of ecological modernization, such as Japan and the nations of Western Europe, but from post-Soviet states, where CO_2 emissions dropped dramatically during the 1990's. Almost all sociological theorizing on environmental trends in contemporary societies has concerned itself with the likely effects of the continuation of current global trends, such as economic development, urbanization, and globalization (Frank, Hironaka, and Schoefer 2000; Mol 1995, 2001; Schnaiberg 1980; Schnaiberg and Gould 1994; Spaargaren and Mol 1992). However, the question of what occurs when a developed society experiences erosion of social and economic structures has not typically been addressed by such theorists, although recently societal collapses have received prominent attention due to scholarship outside of sociology (Diamond 2005). We are, thus, faced with an asymmetry in the current literature, where there is a substantial body of work addressing what happens to the environment as societies "develop" or "modernize," but virtually no research explicitly addressing what happens when many of the trends of the modern era are reversed. The aim of this research, therefore, is to begin to fill this gap by examining CO_2 emissions following the collapse of the Soviet Union in societies that composed the Union (henceforth referred to as "post-Soviet states").

Table 1 here

Unlike most other nations in the world, post-Soviet states as a whole saw their economy, level of urbanization, industrialization, and international trade decline over the 1990's (see Table 1). Since each of these factors is frequently cited as an indicator of modernization, it is reasonable to argue that post-Soviet states have experienced an unprecedented degree of *de*-modernization, marking them as unique in the contemporary world. Furthermore, due to low fertility rates and increasing mortality rates, the collective population of these nations also declined during the 1990's (see Table 1). Although some affluent nations, where fertility rates are below replacement level, and some sub-Saharan regions that have been struck particularly hard by the AIDS epidemic, have seen their population sizes decline or expect decline in the coming decades, post-Soviet states are nearly alone in the world in having both low fertility and increasingly high mortality rates. With trends in the above mentioned structural factors running counter to those experienced in most other nations, post-Soviet states are a uniquely appropriate context in which to examine the environmental consequences of de-modernization.

Our goal here is to assess the effects on CO_2 emissions of various factors identified by social scientists of various perspectives as key forces contributing to environmental degradation. We begin by reviewing the debate about the effect of modernization on the environment, the primary focus of our concern here. We also discuss the related debates about the effects of demographic factors on environmental problems and the role of militarization in degrading the environment. We then move into explaining our empirical analytic strategy, where we use the best available data and sophisticated statistical methods to tease out the often subtle effects of the various factors hypothesized to influence environmental degradation, CO_2 emissions in this particular study. We then present the results of our analysis and interpret their implications for the theoretical debates we discuss.

Modernization and De-Modernization

As concern for environmental problems became increasingly prominent in developed nations in the 1960's and 1970's, scholars struggled to understand the social forces that lead societies to degrade the environment. Many core features of modernity –

such as economic development, urbanization, and industrialization – were frequently identified as the primary causes of the emerging environmental crisis (Commoner 1971; Devall and Sessions 1985). Although there were those who denied the existence of serious environment problems altogether (Simon 1981), in many intellectual circles it became widely accepted that a fundamental restructuring of the modernization project, or even its total abandonment, was necessary to stem the tide of ecological deterioration. In environmental sociology, Catton (1980), Foster (1992), O'Connor (1988) and Schnaiberg (1980) among others critiqued the commitment of modern societies to relentless growth, technological optimism, and the globalization of market economies. Schnaiberg's (1980) well-known "treadmill of production" thesis argued that the only way to end environmental degradation was to fundamentally restructure societies by wrestling power from the economic elite who are responsible for the drive to expand production (and, thereby, profits) at the expense of social and ecological sustainability. The basic argument shared by these scholars who critiqued modernization was that a disregard for environmental sustainability was so fundamental to major features of the modernization project that reform was not possible – only radical change would be sufficient to curb the escalating environmental crisis.

Running counter to the above view, a defense of the modernization project emerged in the 1990's and has become fairly prominent in sociology. Two of the leading advocates of "ecological modernization theory" argue that, far from inevitably leading to ecological crises, the modernization project offers the best hope for overcoming our environmental challenges and obtaining a sustainable society (Mol 1995; Mol and Spaargaren 2000; Spaargaren and Mol 1992). In fact, ecological modernization theorists assert that "the only possible way *out* of the ecological crisis is by going further *into* the process of modernization" (emphases in original) (Mol 1995: 42). Ecological modernization theorists are closely allied with "environmental Kuznets curve" (EKC) analysts in economics (Grossman and Krueger 1995; Dinda 2004), who argue that as societies grow in affluence they become more concerned with environmental protection, leading to the expectation that the most affluent or "modern" societies will be the ones on the forefront of environmental improvements. Ecological modernization theorists add a level of subtly to the purely economic perspective, by arguing that key features of modernity are rationality and reflexivity – i.e., modern societies are prone to critical self examination and rational rectification of perceived problems. Such theorists suggest that modernization pushes the diffusion of rationality into all aspects of society, leading to the emergence of an "ecological rationality" in the major institutions of modernity. This ecological rationality is expected to push institutions – governments, corporations, and other organizations – to reform their environmental practices. In contrast to scholars critical of modernization, ecological modernization theorists argue that radical *ecological* reform does not require radical structural changes to the social, cultural and economic institutions of modernity – e.g., capitalism and industrialization are not seen by ecological modernization theorists as inherently anti-ecological.

A central theoretical tension in environmental sociology that is relevant to the present analysis, then, stems from these opposing views. On the one hand, theorists of a critical bent, represented in environmental sociology by Schnaiberg's (1980) "treadmill of production" perspective, argue that some form of *de*-modernization is necessary to substantially alleviate environmental problems. On the other hand, ecological modernization theorists argue that de-modernization will not resolve environmental problems – only further modernization can do that. Given these opposing expectations, this issue is a prime candidate for resolution via empirical analysis.

One of the central problems for assessing alternative hypotheses about modernization is that appropriate operationalization of the concept is elusive. Ecological modernization theorists have often been reluctant to give a clear empirical specification of the concept of modernization and are prone to crediting any perceived environmental improvements that happen in contemporary developed societies to the forces of modernization (see York [2004] and York and Rosa [2003] for a critique of this tendency). However, such an approach is analytically useless – if any and all developments in the contemporary world are by definition the result of modernization, *resistance* to dominant social forces (e.g., expansion of market economies, technological development), as well as processes independent of them, are subsumed into an undifferentiated whole that is simply referred to as modernity. For example, although unionization in the early part of the twentieth century in the U.S. and Western Europe was occurring in "modernizing" capitalist nations, in an important analytical sense it was aimed at *resisting* major aspects of modernity (the dominance of the market and the rise of laissez-faire capitalism, in particular). Modernization clearly needs to be operationalized in a manner that allows for analytical distinction between the forces that define it and drive it and the forces that run counter to it, resist it, or are independent from it.

The key empirical indicators typically used for modernization in cross-national studies include GDP per capita (the key factor for economists wedded to the EKC hypothesis), urbanization, industrialization, and connection to global markets (Ehrhardt-Martinez 1998; Ehrhardt-Martinez, Crenshaw, and Jenkins 2002; Fisher and Freudenburg 2004; Jorgenson 2003; York et al. 2003a, 2003b, 2003c). These will be the factors we focus on here, since they, to a large extent, represent the key forces that led to dramatic changes in what are now considered "modern" societies over the past two centuries. Furthermore, these are the factors that illustrate the dramatic changes that have occurred in post-Soviet states. Although the Soviet Union collapsed in what is often referred to as "late modernity," the subsequent developments in the nations born of this collapse are quite different from – in fact, in many senses, the opposite of – the trends that are generally considered to be indicative of modernization. Therefore, post-Soviet states offer the best available opportunity for assessing the consequences of de-modernization. This analysis, thus, enters interesting and under-theorized territory, since nearly all theorists, even those highly critical of modernization, have developed their theories in the context of the expansion of modernization (at least as indicated by the above mentioned factors) and generally take as given that these forces will continue on their present trajectory, at least in the near future. The Soviet Union provides a striking argument for why this should not necessarily be assumed to be so and, therefore, for why it is important to begin to consider what may happen in a context where the modernization project has been derailed.

Militarization and De-Militarization

The twentieth century saw the rise of military superpowers, and militarism was tightly linked with economic expansion and globalization in many nations. The post-

Soviet context provides a prime opportunity for assessing recent theorizing about the influence of militarization on the environment, an issue that is related to the debate on modernization, but which has been almost completely neglected by environmental sociologists. Hooks and Smith (2004, 2005) address this lacuna in their assessment of the impacts of militarism on the natural environment. They argue that although militarism is connected to economic interests, it is also substantially independent of them. Furthermore, they argue that the logic of militarism drives expansion of the military, and the focus on military objectives undermines protection of the environment, as well as social justice. Therefore, they characterize militarism as the "treadmill of destruction," a force that contributes to environmental degradation above and beyond the forces of economic development (the treadmill of production). Hooks and Smith (2004) provide an empirical assessment of the impact of military development within the U.S. on Native American communities. However, their thesis has not been empirically tested at the cross-national level. Since the size of the military in post-Soviet states declined dramatically over the 1990's, this region is an excellent context in which to assess whether the development of the military has impacts on the environment in excess of those of economic development.

Demographic Trends

Demographic factors, particularly population size and growth, have often been identified as primary forces influencing the scale of human impacts on the natural environment (Catton 1980; Cohen 1995; Dietz and Rosa 1994; Duncan 1959; Ehrlich and Holdren 1971). Scholars examining population-environment connections make a straightforward ecological argument: all people require resources for their survival and, therefore, more people, all else being equal, will consume more resources, thereby leading to more ecological problems. Countering this position, some scholars have declared the study of the connections between population and the environment "taboo" from the start (primarily for perceived political implications of "population control") and, therefore, are unapologetic about their neglect of the topic (Spaargaren 1997: 7). Others, while acknowledging that demography is not entirely irrelevant, have denied that population is a major contributor to environmental problems and argued that reversals of population growth are unlikely to help alleviate environmental problems (Schnaiberg 1981). Still others have argued that population growth does not contribute to environmental problems at all, that large and growing populations are, if anything, good for environmental quality (Simon 1981).

The post-Soviet societies are a novel and interesting context in which to examine the effects of demographic factors since they are unique in the world in having a declining population driven by both low fertility and decreasing life expectancy. Throughout most of the twentieth century, nearly all nations on earth experienced substantial population growth. Therefore, virtually all studies of the connection between population and the environment have been done in a context of growth, not contraction. Although the population of the world as a whole is expected to grow in the foreseeable future, several nations, particularly those in Europe, are expected to see their populations decline in the coming decades and it remains an open question as to what effect this will have on environmental conditions. The post-Soviet context, then, provides an important opportunity to glimpse what may happen in nations when populations decline.

Demographic factors other than population size have not been extensively explored. Dietz and Rosa (1994) argue for the importance of considering a wider range of demographic factors. Population age structure stands out as a potentially important factor, since it influences the number of workers in an economy, national consumption patterns, household structure, and the type of public services needed by a population. York et al. (2003c) have examined the effect of the proportion of the population that is of "non-dependent" age – i.e., 15 to 64 years of age – and found that, controlling for other factors, nations that have a higher proportion of non-dependent age people have somewhat higher resource consumption and waste emissions than other nations. This is an important issue to investigate further since the age structures of most populations in the world are shifting dramatically as fertility rates and mortality rates change. The post-Soviet states in particular are seeing a rise in the proportion of their populations that are of non-dependent age since the fertility rate is low and the average life expectancy has declined substantially over the past decade in these nations.

Data and Methods

We use an elasticity model (a type of model that is commonly used in economics) that has been specifically adapted for analyses of environmental impacts as the basis for our statistical estimation. The model is called STIRPAT, for STochastic Impacts by Regression on Population, Affluence, and Technology, and was originally developed by Dietz and Rosa (1994; 1997; Rosa and Dietz 1998), and has been widely applied to analyses of a variety of environmental impacts (Cole and Neumayer 2004; Crammer 1998; Rosa et al. 2004; Shandra et al. 2004; Shi 2003; York et al. 2003a, 2003b, 2003c).

Elasticity models, like STIRPAT, are used for models where the dependent variable is conceptualized as a multiplicative function of the independent variables. A long line of research on the driving forces of environmental degradation is based on a conceptualization of environmental impacts as arising from a multiplicative combination of population, affluence, and technology (for a review of this research, see Dietz and Rosa [1994] and York et al. [2003b, 2003c]). Multiplicative models intrinsically take into account one type of interaction among factors, by recognizing that a change in one independent variable does not simply add to (or subtract from) the dependent variable directly, but rather scales it relative to the values of the other factors. For example, the STIRPAT model is structured to take into account the fact that population growth does not have the same additive effect on environmental impacts in each nation, but rather has an effect dependent on the nation-specific level of affluence, the types of technologies used for production, and other factors. The conceptualization of a multiplicative structure among factors is, therefore, appropriate for our analyses here.

Elasticity models are estimated by converting all variables in the analysis into logarithmic form and utilizing an additive regression model (note that addition in logarithmic form is the equivalent of multiplication in original units). The coefficients of an elasticity model are particularly easy to interpret. The coefficient for each continuous independent variable is the estimated percentage change in the dependent variable associated with a 1% increase in the independent variable, controlling for other factors in the model. The interpretation of polynomials is somewhat more complicated (York et al. 2003b), and we present appropriate interpretations of these below in the results section. Since we are utilizing an elasticity (STIRPAT) model, all variables discussed below, except unit and period dummy variables, are converted into natural logarithmic form for the analyses.

We use a cross-sectional time-series Prais-Winsten regression model with panel-corrected standard errors (PCSE) (Beck and Katz 1995), allowing for disturbances that are heteroskedastic and contemporaneously correlated across panels, correcting for first-order autocorrelation. We use PCSE because the feasible generalized least-squares (FGLS) estimator developed by Parks (1967) that is commonly used to analyze panel data produces standard errors that can lead to extreme overconfidence with panel datasets that do not have many more time periods than panels, as Beck and Katz (1995) demonstrate. We correct for AR(1) disturbances (first-order autocorrelation) within panels, treating the AR(1) process as common to all panels (since there is no theoretical reason to assume the process is panel specific – see Beck and Katz [1995: 638]). We use a fixed-effects model, controlling for both panel specific and period specific disturbances.[1] Our model, therefore, is

$$\ln(y_{it}) = \alpha + \beta_1 \ln(x_{it1}) + \beta_2 \ln(x_{it2}) + \ldots + \beta_k \ln(x_{itk}) + u_i + w_t + e_{it}$$

where the subscripts i and t represent each nation (unit) and time period respectively, y_{it} is the dependent variable (national CO_2 emissions for each point in time) in original units, α is a constant (in logarithmic form) that scales the model, x_{itk} represents the independent variables in original units for each observation, β_k represents the (elasticity) coefficient for each independent variable, u_i is the nation-specific disturbance term that is constant over time, w_t is the time-specific disturbance term that is constant across nations, and e_{it} is the disturbance term unique to each nation at each point in time. In a model based simply on pooling the data, the error (residual) term is the sum of u_i, w_t, and e_{it}. Here we use dummy variables to control for u_i and w_t, leaving e_{it} as the stochastic element in the model. This approach controls for potential unobserved heterogeneity that is temporally invariant within nations (e.g., geographic factors), by including nation-specific dummy variables (u_i), and that is cross-sectionally invariant within periods ("period effects"), by including period-specific dummy variables (w_t). Therefore, the model is robust against omitted control variables, thereby more closely approximating experimental conditions. This is a standard approach used in econometrics (Greene 2000; Hsiao 2003).

We have data on the 15 post-Soviet states – Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan – for each year from 1992 to 1999, giving us a total of 120 observations. Data for all variables comes from the World Bank (2003). The dependent variable is CO_2 emissions stemming from the combustion of fossil fuels (including solid, liquid, and gas fuels, as well as gas flaring) and the production of cement, measured in millions of metric tons. The independent variables include demographic, economic, and other structural factors. The key demographic variables are population size and the percentage of the population that is of "non-dependent" age (15-64 years). The indicators of modernization are GDP per capita (measured in constant 1995 US$), the percentage of the population living in urban areas, and the percentage of GDP coming from the industrial sector of the economy. We also include quadratic versions of both GDP per capita and urbanization (squaring each variable in logarithmic form)[2] to test for the EKC that has been hypothesized for each factor. As indicators of connection to the global economy, we include both imports as a percentage of GDP and exports as a percentage of GDP. Finally, as an indicator of militarization, we include the proportion of the population that is in the military.[3]

Results and Discussion

Table 2 here

The results of our analyses are presented in Table 2. Note that due to missing data, the sample size declines slightly as more variables are added to the model. All models provide an excellent fit as indicated by the R^2 (all of which are above 0.99), which is common in fixed-effects models. Note, however, that the substantive variables alone have excellent explanative power. For example, if Model 6 is estimated without the unit and period dummies, the R^2 is still high, being equal to 0.975. This is consistent with findings from other similar analyses (Rosa et al. 2004; Shi 2003; York et al. 2003a, 2003b, 2003c), and affirms the explanative utility of structural models such as STIRPAT.

We begin out assessment with Model 1, which is the most basic model, including only population, GDP per capita, and the quadratic of GDP per capita. All three variables have statistically significant coefficients. In Model 2, we add the age structure variable, giving us the basic demographic-economic model. The age structure variable has a non-significant effect, and its inclusion does not substantially affect the coefficients of the other variables. In each successive model we add an additional modernization indicator. Urbanization and its quadratic are added in Model 3, where their coefficients are significant. Their inclusion somewhat attenuates the estimated effect of GDP per capita and accentuates the estimated effect of population. Industrialization is added in Model 4, to little effect – its coefficient is non-significant and the coefficients of other factors remain largely unchanged (although the quadratic of urbanization fall to non-significance). Imports and exports as a percentage of GDP are added in Model 5. The coefficients of other factors in the model are not dramatically affected, except the quadratic of urbanization, which declines substantially. Although the coefficient for exports in non-significant, the coefficient for imports is significant and positive. Finally, militarization is added in Model 6, where its coefficient is significant and positive. The coefficient for imports falls to non-significance, the population coefficient increases somewhat, and the estimated effect of GDP per capita is attenuated, but remains significant. Since Model 6 is the most complete model, containing all independent variables, and the estimated effects of factors remains fairly consistent across models, we focus our interpretation on Model 6.

Population age structure, level of industrialization, and connection to the global economy do not have significant effects on CO_2 emissions, once other factors are controlled. Population size, economic development, urbanization, and militarization appear to be the primary factors determining the scale of national CO_2 emissions.

Population clearly has a substantial positive influence on CO_2 emissions. The coefficient in Model 6 indicates that, controlling for other factors in the model, a 1% increase in population corresponds approximately with a 2.7% increase in CO_2 emissions, or, stated more appropriately for this particular context, a 1% decrease in population corresponds approximately with a 2.7% decrease in CO_2 emissions. Other research has found that the relationship across a broad range of environmental impact indicators is typically close to unity (i.e., the population coefficient is generally approximately equal to 1.0) (Rosa et al. 2004; York et al. 2003c), although coefficients in the range of 1.5

were found in an analysis of CO_2 emissions in non-Soviet nations over the period 1960-1996 (Shi 2003). The particularly strong relationship found here, then, may be taken to indicate that in a context where population is generally declining, it has a disproportionately large influence on CO_2 emissions relative to its effect when population is growing.

Figure 1 here

Since the coefficients for both GDP per capita and its quadratic are significant, the effect of GDP per capita on CO_2 emissions is non-linear even in logarithmic form, indicating that the elasticity coefficient for GDP per capita changes over the range of GDP per capita. To illustrate this, we present the estimated instantaneous elasticity coefficient for the range of observed values of GDP per capita in Figure 1.[4] Note that although the elasticity coefficient declines as GDP per capita increases, it is always greater than zero for all observed values, indicating that GDP per capita has a positive effect on CO_2 emissions, although this effect is quite modest at the high end of observed values. However, it is important to interpret this relationship in the specific context of post-Soviet states, where GDP per capita has generally declined quite dramatically over the period of data analyzed here. The results suggest at higher values of GDP per capita, CO_2 emissions are fairly resistant to changes (typically decreases) in GDP per capita. However, at lower GDP per capita values, CO_2 emissions respond more readily to changes in GDP per capita (although the relationship is always inelastic – i.e., the coefficient is between 0 and 1 – within the range of observations).

Figure 2 here

Although the linear urbanization coefficient is significant, the quadratic term is not. If the model (Model 6) is re-estimated excluding the quadratic term, the coefficient for the linear term is 2.394, indicating a positive elastic relationship between urbanization and CO_2 emissions. However, the negative coefficient on the quadratic of urbanization does suggest a tendency for the elasticity of the relationship to decline at higher level of urbanization. Figure 2 presents the instantaneous elasticity coefficient for urbanization over the range of urbanization values, based on the coefficients for urbanization and its quadratic from Model 6. Although the elasticity does decline sharply over the range of observed urbanization values, it is always positive, indicating that decreases in urbanization correspond with decreases in CO_2 emissions.

Finally, the militarization coefficient is clearly significant and positive. This indicates that a decline in the proportion of the population that is in the military is expected to lead to a decline in CO_2 emissions. To illustrate this relationship, consider a hypothetical nation that had the cross-national weighted-average for the sample in 1992 of 9.06 military personnel per 1000 people and declined to the cross-national weighted-average for the sample in 1999 of 5.54 (see Table 1). All else being equal, its CO_2 emissions are predicted to decline by nearly 9%. Such an effect is clearly non-trivial and supports the contention that militarization contributes to environmental problems above and beyond that which is expected based on indicators of modernization alone.

These finding taken together directly address the theoretical issues discussed in the introduction. They clearly support the argument that population size is a key determinant of national environmental impacts (Ehrlich and Holdren 1971), counter the argument that population should be ignored in environmental analyses (Spaargaren

1997), and belie claims that population declines will not lead to reductions in environmental degradation (Schnaiberg 1981; Simon 1981). They also provide the first empirical assessment at the cross-national level of Hooks and Smith's (2004, 2005) "treadmill of destruction" thesis, clearly supporting their argument that militarization contributes to environmental degradation above and beyond the impact of economic development. Finally, they provide an assessment of theoretical claims about the potential for de-modernization to alleviate environmental problems.

Although industrialization and connections to the global economy do not appear to have significant effects on CO_2 emissions, economic development and urbanization clearly do. In this context of de-modernization, we find that CO_2 emissions decrease as nations de-urbanization and their economies decline. These findings contradict the claims of ecological modernization theorists that further modernization, rather than de-modernization, is necessary to reduce environmental degradation, and bolster the arguments of critical political economists, such as those supporting the treadmill of production thesis, that modernization is incompatible with ecological sustainability. Counter to Mol's (1995: 42) claim, quoted above, *de*-modernization may in fact be the way out of the ecological crisis.

Conclusion

The development and testing of realist theories in non-experimental sciences is often hindered by limitations in the available data. Furthermore, the validity of theories is often dubious when they are assumed to apply in a context different from that in which they were developed. Such is the case with most contemporary theories about the social forces driving environmental degradation, particularly those aimed at assessing the connections between modernization and ecological sustainability. Modernization theorists and those critical of the modernization project have generally focused their theorizing on the consequences of modernization, and only addressed the possible consequences of de-modernization as an aside. One reason for the neglect of de-modernization is obvious: few examples exist of such a process since reliable national level data became available after the mid-twentieth century. Several critical scholars have suggested that an abandonment of the modernization project is necessary to curb environmental deterioration, while ecological modernization theorists have argued that further modernization is the only means by which societies can reduce their impact on the environment. Post-Soviet states, which underwent dramatic economic decline, de-industrialization, and de-urbanization, as well as a decline in international trade, during the 1990's provide a rare opportunity for assessing the effects of de-modernization on the environment. Taking advantage of this opportunity, here we assessed the effects of indicators of modernization, as well as militarization and demographic characteristics, on CO_2 emissions to address a variety of theories about the social structural factors that influence human-environment interactions.

Our findings clearly suggest that, at least as indicated by GDP per capita and urbanization, de-modernization led to substantial reductions in CO_2 emissions in the post-Soviet context. These findings clearly challenge the notion that further modernization is necessary to solve environmental problems, and suggest that shifting away from the modernization project may help curtail the escalating ecological crisis. Population decline also contributed substantially to reductions in CO_2 emissions, indicating the importance of demographic factors in environmental analyses. We also found that de-militarization also spurred declines in CO_2 emissions, providing support for the treadmill of destruction thesis, which identifies the military as a major source of environmental destruction.

Obviously, the economic collapse and social hardships experienced by people in post-Soviet states during the 1990's are not desirable for a variety of reasons, and we are not suggesting that the post-Soviet experience serve as a model for addressing environmental problems. However, the post-Soviet experience is highly informative from an analytical point of view, since it provides an opportunity to examine the effects of structural factors on the environment in a different context than they have typically been examined. The development of sophisticated theory about human-environment interactions requires examination of various contexts to tease out the subtlety of relationships among factor of theoretical interest. So, although the post-Soviet experience does not provide a socially desirable model of environmental reform, it does allow for assessing key questions about the influence of specific features of modern societies on the environment. The finding of our analysis suggest that certain aspects of de-modernization can lead to substantial reductions in environmental problems, at least as indicated by CO_2 emissions. If these aspects can be pursued in a manner that does not lead to the social problems experienced in post-Soviet states, a route to ecological sustainability may be found.

References

Beck, Nathaniel and Jonathan N. Katz. 1995. "What to Do (and Note to Do) with Time-Series Cross-Section Data." *American Political Science Review* 89(3): 634-647.

Catton, William R., Jr. 1980. *Overshoot: The Ecological Basis of Revolutionary Change*. Chicago: University of Illinois Press.

Cohen, Joel E. 1995. *How Many People Can the Earth Support?* New York: W. W. Norton & Co.

Cole, Matthew A. and Eric Neumayer. 2004. "Examining the Impact of Demographic Factors on Air Pollution." *Population and Environment* 26(1): 5-21.

Commoner, Barry. 1971. *The Closing Circle*. New York: Knopf.

Cramer, James C. 1998. "Population Growth and Air Quality in California." *Demography* 35: 45-56.

Devall, Bill and George Sessions. 1985. *Deep ecology*. Salt Lake City: Peregrine Smith Books.

Diamond, Jared. 2005. *Collapse: How Societies Choose to Fail or Succeed*. New York: Viking.

Dietz, Thomas and Eugene A. Rosa. 1994. "Rethinking the Environmental Impacts of Population, Affluence and Technology." *Human Ecology Review* 1:277-300.

________. 1997. "Effects of Population and Affluence on CO_2 Emissions." *Proceedings of the National Academy of Sciences of the USA* 94:175-179.

Dinda, Soumyananda. 2004. "Environmental Kuznets Curve Hypothesis: A Survey." *Ecological Economics* 49: 431-455.

Duncan, Otis Dudley. 1959. "Human Ecology and Population Studies." In *The Study of Population*. P.M. Hauser and O.D. Duncan eds. Chicago: University of Chicago Press. Pp. 678-716.

Ehrhardt-Martinez, Karen. 1998. "Social Determinants of Deforestation in Developing Countries: A Cross-National Study." *Social Forces* 77(2): 567-86.

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(1): 226-243.

Ehrlich, Paul and John Holdren. 1971. "Impact of Population Growth." *Science* 171:1212-1217.

Fisher, Dana R. and William R. Freudenburg. 2004. "Postindustrialization and Environmental Quality: An Empirical Analysis of the Environmental State." *Social Forces* 83(1): 157-188.

Foster, John Bellamy. 1992. "The Absolute General Law of Environmental Degradation Under Capitalism." *Capitalism, Nature, Socialism* 2(3): 77-82.

Greene, William H. 2000. *Econometric Analysis* (fourth edition). Upper Saddle River, NJ: Prentice Hall.

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

Hooks, Gregory and Chad L. Smith. 2004. "The Treadmill of Destruction: National Sacrifice Areas and Native Americans." *American Sociological Review* 69(4): 558-575.

Hooks, Gregory and Chad L. Smith. 2005. "Treadmills of Production and Destruction: Threats to the Environment Posed by Militarism." *Organization & Environment* 18(1): 19-37.

Hsiao, Cheng. 2003. *Analysis of Panel Data* (second edition). Cambridge, U.K.: Cambridge University Press.

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

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

Mol, Arthur P. J. 1995. *The Refinement of Production: Ecological Modernization Theory and the Chemical Industry.* Utrecht: Van Arkel.

________. 2001. *Globalization and Environmental Reform*. Cambridge, MA: MIT Press.

Neter, John, William Wasserman, and Michael H. Kutner. 1990. *Applied Linear Statistical Models* (Third Edition). Boston: Irwin.

O'Connor, James. 1988. "Capitalism, Nature, Socialism: A Theoretical Introduction." *Capitalism, Nature, Socialism* 1(1): 11-38.

Parks, Richard. 1967. "Efficient Estimation of a System of Regression Equations When Disturbances Are Both Serially and Contemporaneously Correlated." *Journal of the American Statistical Association* 62: 500-509.

Rosa, Eugene A. and Thomas Dietz. 1998. "Climate Change and Society: Speculation, Construction and Scientific Investigation." *International Sociology* 13(4): 421-455.

Rosa, Eugene A., Richard York, and Thomas Dietz. 2004. "Tracking the Anthropogenic Drivers of Ecological Impacts." *Ambio* 33(8): 509-512.

Schnaiberg, Allan. 1980. *The Environment: From Surplus to Scarcity.* New York: Oxford University Press.

________. 1981. "Will Population Slowdowns Yield Resource Conservation? Some Social Demurrers." *Qualitative Sociology* 4(1): 21-33.

Shandra, J. M. B. London, O. P. Whooley, and J. B. Williamson. 2004. "International Non-Governmental Organizations and Carbon Dioxide Emissions in the Developing World: A Quantitative, Cross-National Analysis." *Sociological Inquiry* 74(4).

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.

Simon, Julian L. 1981. *The Ultimate Resource*. Princeton, New Jersey: Princeton University Press.

Spaargaren, Gert. 1997. *The Ecological Modernization of Production and Consumption: Essays in Environmental Sociology*. Wageningen: Department of Environmental Sociology WAU (dissertation).

Spaargaren, Gert and Arthur P. J. Mol. 1992. "Sociology, Environment and Modernity: Ecological Modernization as a Theory of Social Change." *Society and Natural Resources* 5: 323-344.

World Bank. 2003. *World Development Indicators*. CD-ROM.

York, Richard. 2004. "The Treadmill of (Diversifying) Production." *Organization & Environment* 17(3): 355-362.

York, Richard and Eugene A. Rosa. 2003. "Key Challenges to Ecological Modernization Theory: Institutional Efficacy, Case Study Evidence, Units of Analysis, and the Pace of Eco-Efficiency." *Organization & Environment* 16(3): 273-288.

York, Richard, Eugene A. Rosa, and Thomas Dietz. 2003a. "A Rift in Modernity? Assessing the Anthropogenic Sources of Global Climate Change with the STIRPAT Model." *International Journal of Sociology and Social Policy* 23(10): 31-51.

________. 2003b. "STIRPAT, IPAT, and ImPACT: Analytic Tools for Unpacking the Driving Forces of Environmental Impacts." *Ecological Economics* 46(3): 351-365.

________. 2003c. "Footprints on the Earth: The Environmental Consequences of Modernity." *American Sociological Review* 68(2): 279-300.

Table 1. Summary statistics for variables in the analyses for the 15 post-Soviet states combined (in original units) and the number of nations showing a decrease in each of these factors.

	1992	1999	Change	# w/ decrease
CO_2	3,246	2,228	-1,018 (-31.4%)	13
Population (million)	292.0	289.7	-2.3 (-0.8%)	9
Pop. aged 15-64 (%)	64.5	66.6	+2.1	1
Urbanization (%)	65.3	64.2	-1.1	10
GDP, p.c.	2,150	1,580	-570 (-26.5%)	12
Industry (% GDP)	42.8*	35.2*	-7.6	14
Imports (% GDP)	47.9**	33.3	-14.6	9
Exports (% GDP)	51.9**	44.6	-7.3	10
Military (per 1000)	9.06***	5.54	-3.52	6

* For Turkmenistan 1993 and 1998 values were used
** For Turkmenistan 1993 values were used. For Tajikistan 1997 values were used.
*** For Georgia and Kazakhstan 1993 values were used.

Table 2. Results from cross-sectional time-series Prais-Winsten regression elasticity models of CO_2 emissions in post-Soviet states, 1992-1999, with panel-corrected standard errors and correction of AR(1) disturbances common across panels.

	Model 1 Coef. (S.E.)	Model 2 Coef. (S.E.)	Model 3 Coef. (S.E.)	Model 4 Coef. (S.E.)	Model 5 Coef. (S.E.)	Model 6 Coef. (S.E.)
Population	2.062*** (.372)	2.009*** (.364)	2.757*** (.491)	2.747*** (.588)	2.217*** (.578)	2.738*** (.735)
Pop. 15-64		2.249 (3.535)	2.953 (3.744)	2.954 (3.921)	2.667 (1.466)	.955 (.713)
GDP, p.c.	.627*** (.120)	.650*** (.113)	.584*** (.104)	.588*** (.115)	.618*** (.088)	.468*** (.068)
$(GDP, p.c.)^2$	-.335*** (.079)	-.336*** (.075)	-.178* (.085)	-.169 (.087)	-.199*** (.053)	-.155** (.054)
Urban pop.			2.809*** (.763)	2.837** (.854)	2.016*** (.526)	2.667*** (.540)
$(Urban pop.)^2$			-4.088* (1.859)	-4.034 (2.096)	-.798 (1.875)	-3.125 (1.851)
Industry				.013 (.131)	.078 (.074)	-.001 (.066)
Imports					.178** (.059)	.057 (.063)
Exports					-.091 (.056)	.019 (.056)
Military						.188*** (.041)
R^2	.992	.992	.993	.993	.994	.996
N	120	120	120	118	113	111
Rho	.252	.245	.214	.199	.194	.015

Two-tailed significance tests: * $p<.05$ ** $p<.01$ *** $p<.001$

Note: All models include nation and period dummies.

Figure 1. Affluence (GDP per capita) elasticity of CO_2 emissions over the range of observed GDP per capita values (based on Model 6, Table 2).

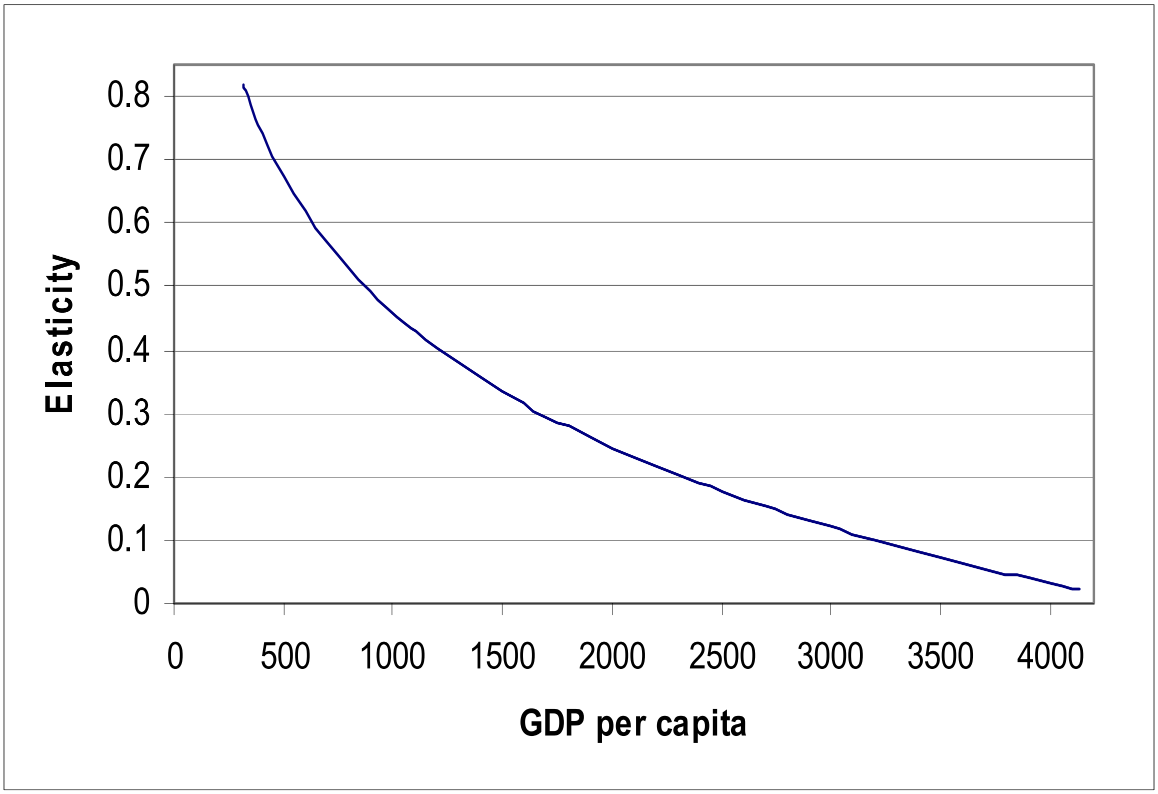
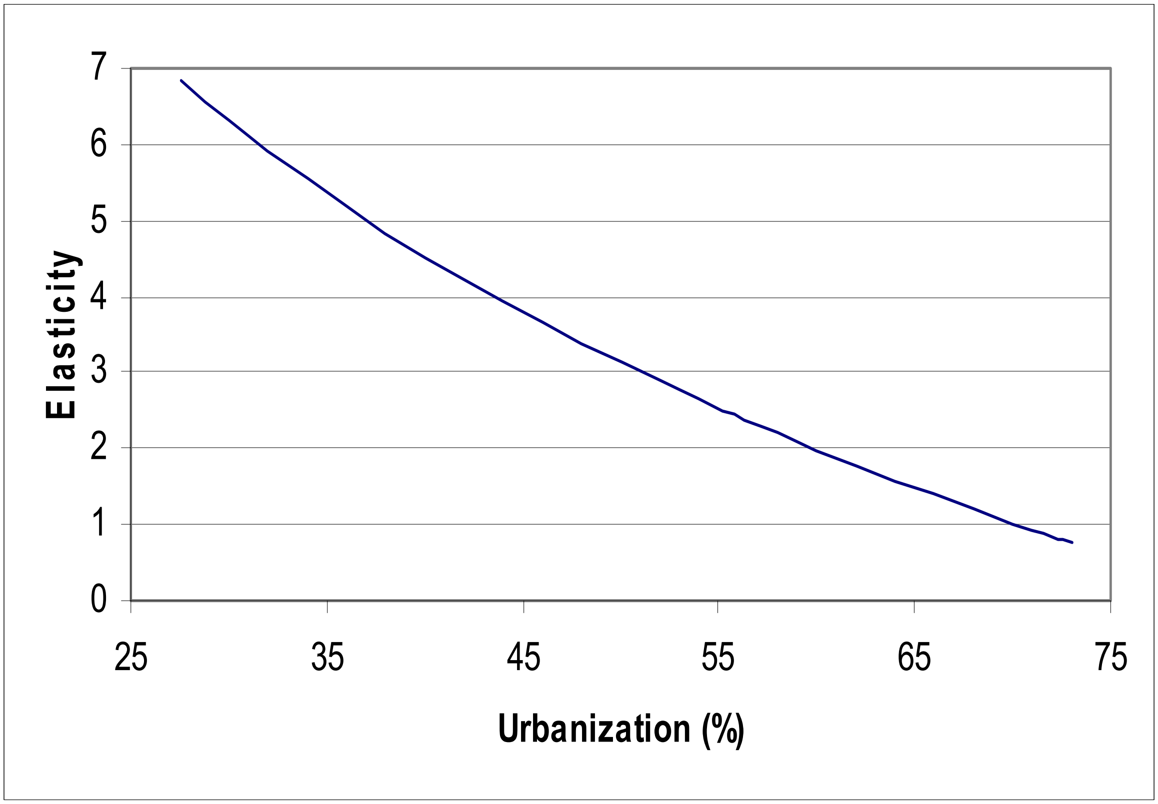


Figure 2. Urbanization elasticity of CO_2 emissions over the range of observed urbanization values (based on Model 6, Table 2).



Endnotes

[1] Greene (2000) and Hsiao (2003) provide discussions of the relative advantages of random-effects (RE) and fixed-effects (FE) models. The primary advantage of RE models over FE models is that they have more statistical power. However, RE models are subject to bias from omitted control variables that vary cross-sectionally but not temporally, whereas FE models are not.

[2] We centered (by subtracting the sample mean) each variable (GDP per capita and urbanization, both in logarithmic form) before generating the quadratic, so as to reduce problems with collinearity between each quadratic and its linear counterpart, as recommended by Neter, Wasserman, and Kutner (1990: 315-316). Note that using centered variables does not affect the fitted shape of the curve compared to using non-centered variables. It simply reduces the standard error of the linear term. The sample mean of GDP per capita in logarithmic form is 6.882 and the sample mean of urbanization in logarithmic form is 3.985.

[3] We use this instead of the military spending as a percentage of GDP because data is available for more cases.

[4] These values are calculated by taking the first partial derivative of the regression equation with respect to the log of GDP per capita, as explained by York et al. (2003b).