Structural Human Ecology and STIRPAT: Theory and Method

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As Hummel et al. demonstrate in their background paper for this cyberseminar, population-environment (P-E) analysis takes many theoretical and methodological forms. One approach to P-E analysis is STIRPAT which I discuss here. I will focus on providing a brief but informative overview of STIRPAT, highlighting some of the important issues raised by Hummel et al, and include a discussion of some misconceptions about STIRPAT.

STIRPAT comprises three coordinated elements: A theoretical framework (Structural Human Ecology or SHE), a composite of first principles derived from IPAT, and a research program that comprises an analytic frame that is fully distinct from IPAT. Thomas Dietz and Eugene Rosa founded STIRPAT and the research program was strengthened considerably with the addition of Richard York (see www.stirpat.org). STIRPAT is an interdisciplinary innovation inspired by the variables of IPAT, an environmental accounting equation familiar to natural scientists, and linked to social science theory and methods (Dietz and Rosa 1994).

STIRPAT is a radical reformulation of the IPAT environmental accounting equation into stochastic form which is estimated using regression techniques common in the social sciences[1]. The IPAT equation is not prepared to test hypotheses because it constrains *a priori* the effects of each driver to be proportional. STIRPAT retains the ecological foundation and multiplicative logic of IPAT, but reformulates it by 1) allowing for the estimation of the net effect of each anthropogenic driver on the environmental threat or impact, 2) allowing for hypothesis testing, and 3) making possible the inclusion of other theoretically relevant variables including political, social, and cultural factors (Dietz and Rosa 1994). Thus, the STIRPAT reformulation is an analytic frame for disciplining conceptual models with empirical tests.

For an in-depth discussion of IPAT and STIRPAT, see York et al. (2003b). Here it is more important to address four issues concerning the model: 1) How are population-environment relationships conceptualized? 2) At what scales can the model be applied? 3) To what measures of environmental threat or impact can the model be applied? 4) Can the model be used to inform policy?

[1] The acronym, STIRPAT, stands for Stochastic Impacts by Regression on Population, Affluence, and Technology.

First, STIRPAT recognizes that context must be considered when analyzing population-environment relationships. This is achieved by adding theoretically relevant control variables to the model. Furthermore, demographic characteristics other than population size can be included in the model such as age structure and urbanization (e.g., Dietz et al. 2007; Knight 2008). STIRPAT, therefore, incorporates some of the complexity of the connections between ecological variables and other factors influencing environmental threats or impacts. Second, while most STIRPAT analyses have been applied at the macro-level of countries, the model is applicable to any spatial scale from nations to cities (e.g., Scholz 2006). Third, the STIRPAT model is not confined to analyses of any specific environmental threat such as the ecological footprint, but can accommodate any impact variable. The first empirical application of STIRPAT analyzed the anthropogenic drivers of carbon dioxide emissions (Dietz and Rosa 1997) while later applications have focused on not only emissions, but especially the ecological footprint (e.g., Dietz et al. 2007; Rosa et al. 2004; York et al. 2003a, 2003c). Fourth, STIRPAT can inform policy. By identifying key drivers of environmental impacts and their relative importance, the model can point to policies with the greatest leverage for reducing anthropogenic environmental degradation. Also, the model can be used to project future environmental impacts and to inform climate models.

As a research program, STIRPAT is guided by the theoretical framework of structural human ecology. Structural human ecology (SHE) conceptualizes the relationship between society and the environment as the human ecosystem which comprises four interacting components: population, social organization, environment, and technology (Duncan 1964; Catton 1987; Dietz and Rosa 1994; Dunlap et al. 1994). This theoretical approach emphasizes the effects of social systems on the natural environment and vice versa. The focus of this line of inquiry is to understand the social structural drivers of environmental impacts with an emphasis on the macro-level. Structural human ecology emphasizes the role of population size, growth, density, and structure in explaining environmental impacts (York et al. 2003a). Biophysical factors such as biogeography and climate are also considered important contextual factors conditioning the social structural drivers of environmental impacts (Rosa and Dietz 1998; York et al. 2003a). Furthermore, SHE and the STIRPAT research program can be considered an aggregated version of CHANS (Liu et al. 2007).

STIRPAT is used to operationalize the concept of the human ecosystem. This allows for the systematic testing of hypotheses about the drivers of ecological threats or impacts, and this has been the principal pre-occupation of the research program (Dietz and Rosa 1997; Rosa et al. 2004; York et al. 2003b). Another significant preoccupation of STIRPAT has been to test predictions from other environmental social science perspectives such as world-systems theory and ecological modernization theory (York et al. 2003a, 2003c). Key findings include: 1) Population size is consistently the primary driver of environmental threats, except for CO_2. 2) Affluence is a major driver (the primary driver of CO_2 emissions), though the magnitude of effect varies between different types of environmental impact. 3) Other contributing factors include population

composition, urbanization, and climate (Dietz et al. 2007; Rosa 2004; York et al. 2003a, 2003b, 2003c).

Conclusion: STIRPAT owes its ecological principles, its multiplicative form, and part of its theoretical orientation to IPAT. However, STIRPAT's analytic framework is not IPAT on steroids. Instead, it is a radically different approach to executing scientific procedures. One of the major differences between STIRPAT and many other approaches to P-E analysis is the type of explanation being sought. STIRPAT is useful for those interested in nomothetic explanations. In order to be able to generate this type of explanation, the STIRPAT model emphasizes generality and precision over realism (Rosa 2004). Thus, while STIRPAT (at present) does not offer the same level of complexity as some other approaches, it does offer a more disciplined understanding of society-environment interaction.

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