Ecological-Evolutionary Theory: A Reanalysis and Reassessment of Lenski's Theory for the 21st Century*

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Gerhard Lenski's ecological-evolutionary theory of human societies, originally presented and tested in Power and Privilege *(1966) and* Human Societies *(1970), makes a number of general and specific predictions about the impact of subsistence technology on the fundamental features of societies, as well as identifying constraints that the techno-economic heritage of currently industrializing societies continue to exercise on their development trajectories. This paper reviews the strategies adopted for presenting and for testing the theory, critically analyzes and extends some important results of its empirical tests, and explores issues confronting the future development and presentation of the theory.*

HOW I MET PROFESSOR LENSKI

Although I had taught using *Human Societies* for several years as a graduate student, I first met Professor Gerhard Lenski in the summer of 1978 when I came to the University of North Carolina at Chapel Hill to finish a paper with Jack Kasarda, whom I had met when he lectured at Temple University. Apologizing for being homebound by air-conditioner repair people, he spent an afternoon and an early evening on his porch discussing sociology and its teaching with a newly minted Ph.D.

ORIGINS

The original outline of what has come to be known as ecological-evolutionary theory (EET) was first presented in Gerhard Lenski's *Power and Privilege* (1966). The focus there was on developing a comprehensive theory of stratification—the factors and forces that affect the distribution of scarce resources in societies. With its fusion of conflict and consensus theories and its shift from structural-functional to evolutionary analysis, it attempted to account for the major features of systems of distribution not just in industrial or contemporary societies but also in human societies.

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The key determinants of stratification identified were the (potential) size of the economic "surplus" in a society and the basis and distribution of power in it.[1] In turn, determinants of the (potential) size of the economic surplus and the basis and potential concentration of power were identified first and foremost as subsistence technology (i.e., the means by which a society produced most of the food, fibers, and materials needed for survival) and secondarily as key characteristics of its environment (i.e., its biophysical and social context).

If power and surplus patterned distributions of scarce and valued social resources in societies, it was subsistence technology that patterned these distributions of power and the (potential) size of surpluses. Moreover, through the process of sociocultural evolution, increasingly powerful and productive subsistence technologies had emerged and had spread through the population or "world-system" of human societies.

The theory thus not only identified and posited an explanation of different and changing patterns of institutions within societies but also identified and posited explanations for the "pattern of these patterns"—trends in the number and types of societies that constituted the population, or "world-system," of societies.

Building on the earlier work of Goldschmidt (1959), the original classification or typology of "societal types" was constructed from readily observable indicators of subsistence technology—the presence of plant cultivation, metallurgy, plow and draught animals, and use of inanimate energy sources—to enable the requisite comparisons. This produced five fundamental types of societies (Lenski 1966:89), in ascending order of "overall technological efficiency":[2] hunting and gathering, simple horticultural, advanced horticultural, agrarian, and industrial; and three "environmentally specialized" types: fishing, herding, and maritime. The typology also explicitly allowed for the possibility of "hybrids" (i.e., curious and complex intermixtures of these technologies).

The potential power of such a theory and typology to order and to explain the growing body of disparate and paradoxical data on stratification that historians, sociologists, and anthropologist had accumulated for a panoply of societies was impressive, but its potential power to order and to explain the most fundamental features of society—e.g., polity, economy, ideology—and trends in their development was nothing short of revolutionary.

ECOLOGICAL-EVOLUTIONARY THEORY AND *HUMAN SOCIETIES*

On the heels of *Power and Privilege*, the first shots of this revolution were fired in *Human Societies* (Lenski 1970). Both the project and the forum chosen for its exposition were bold strokes. The main outlines of ecological-evolutionary theory[3] were to be tested with the most comprehensive cross-cultural data set available at the time—George Peter Murdock's 915-case *Ethnographic Atlas* (Murdock 1967), supplemented with important but much more limited data from Simmons (1945)[4]—and the arguments and tests were to be presented not in a sociological monograph or journal article where they would reach a

[1]I apologize for the awkwardness caused by the continual insertion of "potential" into the discussion, but it is necessary to avoid the inference that certain technologies automatically produce a surplus. A key aspect of EET is that a given technology (e.g., horticulture, agriculture) only makes a surplus possible; a social institution or practice must emerge that draws it forth if it is to become an actuality.

[2]Tentatively, and somewhat inauspiciously, identified as "a society's gross product in international markets divided by the *human energy* expended in its production" (Lenski 1966:93, italics added).

[3]It was actually referred to as the "ecological-evolutionary *approach*" or the "structural-functional-ecological-evolutionary" *approach* (Lenski 1970:24–25, italics added) in the first edition of *Human Societies*.

[4]Simmons reported data on the power of political leaders, development of a legal system, incidence of warfare, and private ownership of land for 31 hunting-and-gathering and horticultural societies.

handful of interested scholars *but in an introductory sociology text where they would reach thousands of beginning students*![5]

The subsistence technology typology was refined slightly for *Human Societies*. The possibility of making a distinction between "advanced" and "simple" agrarian societies, discussed in a footnote to *Power and Privilege* (Lenski 1966:191), was now actualized on the basis of the presence or the absence of the technology for producing iron, resulting in six basic types,[6] and, among contemporary societies, the hybrids of "industrializing horticultural" and "industrializing agrarian" societies were distinguished.

After considering and rejecting alternative explanations for long-term patterns of societal development—racial differences (racialism), geographic determinism, and "great-man" explanations—the text presented a series of tests of the basic argument of EET in a single chapter: that the level and type of subsistence technology are important determinants of the basic features of societies (e.g., median size, level of integration, division of labor, structure of religious beliefs, marriage rules, likelihood of classes and slavery, power of leaders, reliance on law, incidence of warfare, and institutionalization of private property).

This was followed by separate chapters providing detailed descriptions and in-depth discussions of each of the societal types, environmentally specialized societies, some modern "hybrids," and a concluding chapter, "Retrospect and Prospect," which reviewed the human social experience to date and ventured some predictions about its future. As might be expected, issues of stratification continued to receive considerable attention throughout.

The original title, *Human Societies: A Macrolevel Introduction to Sociology* (Lenski and Lenski 1970), was refined to *Human Societies: An Introduction to Macrosociology* in the second and subsequent editions (Lenski and Lenski 1974, 1978, 1982, 1987; Lenski, Lenski, and Nolan 1991; Lenski, Nolan, and Lenski 1995; Nolan and Lenski 1999). The measures and methods of analysis also evolved over successive editions of the text. The clear objective from the beginning was to confront the theory with the best available evidence for the most extensive and representative "sample" of human societies.

As more and better data for more preindustrial societies became known or available, they replaced more limited measures and "samples." A major step in this process was taken in the sixth edition of *Human Societies* (Lenski, Lenski, and Nolan 1991) when data for the full *Ethnographic Atlas*, and a wide variety of data sets for the "standard sample," made available in machine-readable form through the "electronic journal" *World Cultures*, were used to test the theory.[7]

[5]It was clear to me from my first encounter with it that *Human Societies* was not an ordinary introductory sociology text. The title itself was a clue. But even more telling was the fact that I found it was being used simultaneously in Bruce Mayhew's introductory course, to which I was assigned as a teaching assistant, and in his graduate seminar on social organization, in which I was enrolled as a student. Because of its impact on sociology and introductory textbooks in the intervening years, it is difficult now to appreciate just how revolutionary and strikingly different the text was at the time. There literally was nothing else like it. The mere fact that it embodied and empirically tested a theoretical framework—let alone that it had a macro/comparative orientation—sharply distinguished it from the others. Each class of readers was strongly affected by the text. What the other graduate students and I found most striking was the integrating *theoretical framework* and *(macro)comparative* method (both of which were crucial components in the development of my own theoretical views and research interests). Many of us recalled the experience of having completed an undergraduate major in sociology only to be left with the nagging question—yes, but what is *sociology*? The undergraduate students, lacking this experience, were more intrigued by the fact that there were societies, consisting of people biologically indistinguishable from themselves, that were dramatically different from their own. I continue to believe that the major value of the text and of courses organized around it is the fresh perspective it provides students on their own society.

[6]The revised typology actually proposed to distinguish seven major types and four environmentally specialized types, but the distinctions between "simple" and "advanced" hunting and gathering and between "simple" and "advanced" herding are mainly heuristic. They are not used in the data analysis that follows their introduction.

[7]As the citation indicates, this was my first direct involvement with *Human Societies*; my major task was coding data from these sources and using them to reevaluate and extend the analysis of preindustrial societies.

The advantage of the *Ethnographic Atlas* was its greater coverage of societies, 1,267 cases versus the 915 used in previous editions.[8] The advantages of the "standard sample" were its greater coverage of variables—scholars have coded and have made available data on more than 1,000 variables for the 186-case "standard sample" of societies versus the 100 or so available for the full *Ethnographic Atlas*—and the possibility it offered of being a more "representative sample" of human societies. But despite the attractiveness and respective advantages of each, they too remain problematic.

First, neither is truly a "sample" in any real sense. The former is really something more of a "population," the population of known societies for which we have some data or information. It goes without saying that we certainly are missing knowledge and information about innumerable societies, but perhaps even more importantly, we have virtually no idea of how representative the *known* population of societies is of *all* human societies that have existed.

"Representativeness" is the key objective of the standard sample (White and Murdock 1969). It consists of 186 "cases" that were selected to be representative of the full range of regional, cultural, and developmental diversity in human societies. It consists of roughly equal numbers of societies from different regions of the world and from different levels of complexity and development.

This helps to adjust for the fact that, for a variety of historical reasons, we have much more data on some regions and some types of societies than others (e.g., native North American societies), and it also provides a common case base that allows different researchers to cumulate and to compare directly their measures and results.[9] None of these adjustments, however, can overcome completely the fact that it is constructed from the same limited population—known societies.

Both have been used to test EET. The preference and strategy has generally been to test as many aspects of the theory as possible with the full *Ethnographic Atlas* and to use the standard sample to supplement these tests with more nuanced measures for it that are not available for the larger data set. For despite their very real limitations and shortcomings, these data have complementary strengths, and *they remain the very best data we have for testing a theory across the widest range of societal variation.*

The more detailed data on industrial societies was always presented across a number of separate chapters. But here, too, there was an evolution in the framework of its presentation and analysis over time. In the first edition (1970), the focus was on the detailed characteristics of industrial societies (primarily the United States) and on the development trajectories that produced them. Succeeding editions have changed the order and grouping of social institutions for the presentation of data. Different combinations and divisions have been tried because, although the greater volume and detail of data available for industrial societies make it necessary to discuss aspects of the development of industrial societies (e.g., families, ideologies, and economies) in separate chapters, their interrelatedness makes the grouping and ordering of their discussion highly problematic and somewhat arbitrary.

[8]Since some of the data are on communities that are part of larger societies, it is not accurate to call them "societies."

[9]Although this common case base is generally viewed as a strength, I do recall a generalizability problem that developed among cancer researchers because they were all, wittingly or unwittingly, using the same cancer cells to test treatments. It seems that the cells derived from one cancer victim (a Ms. Henrietta Lacks, I believe) were so potent that they eventually replaced all other cells in the laboratories. As a result, for years, potential remedies were tested with this same unrepresentative sample of cancer cells. A similar problem may exist if virtually all researchers use this "standard" sample and if it too is unrepresentative— or proves to be so—of preindustrial human societies.

The changing nature of the "world-system" of societies also influenced the focus and format of the discussion of industrial societies. For example, the contrast and comparison of the "Western democracies" with "revolutionary socialist" societies sharpened in the 1980s and faded in the 1990s following the collapse of the Soviet Empire. And as the role that differences in the population dynamics of industrializing "hybrids" played in effecting the levels and directions of their social and economic development became more apparent, they received more attention.

ECOLOGICAL EVOLUTIONARY THEORY AND THE JOURNALS

Although EET has had a profound influence on those who had been taught by, or who taught with, *Human Societies*, because it was developed and was presented in an introductory text, knowledge of its tenets and the data analyses that support it were known mainly by those who used it in their classes and by their students. The effects of this limitation have been mitigated somewhat, however, by the appearance of a series of journal articles, starting in the mid 1980s, that have presented aspects and tests of the theory to a wider audience in the discipline (e.g., Lenski and Nolan 1984, 1986; Nolan and Lenski 1985, 1996; Breedlove and Nolan 1988; Nolan 1988, 1992, 2003; Crenshaw 1992; Crenshaw and Ameen 1994; Breedlove and Armer 1997).[10]

First, the prediction that the development trajectories of modern technological "hybrids"—industrializing horticultural (IH) and industrializing agrarian societies (IA)—would continue to show the effects of their differing techno-economic heritages (TEH) was tested systematically in Lenski and Nolan (1984). The data strongly indicated that societies that entered the industrial era practicing horticulture (i.e., gardening), continued to lag well behind those who entered it practicing agriculture (i.e., farming) on a variety of fundamental dimensions of societal development: measures of economic and technological development (e.g., gross national product (GNP), and energy consumption per capita and per unit of land area), informational infrastructure (i.e., literacy, school enrollment, newspaper circulation, and publication of scientific journals), rates of economic growth, and population trends (e.g., life expectancy at birth and fertility and mortality rates).

Then, in the final stage of the analysis, potential alternative explanations of the findings—political heritage and world-system theory—were explored and were rejected. The effects of techno-economic heritage remained and in a number of cases were strengthened by the introduction of controls. And in a brief follow-up study (Nolan and Lenski 1986), it was shown that shifting Haiti from IA to IH at the suggestion of Pierre Van den Berghe did not materially alter the results. In fact, by providing a second non-Sub-Saharan IH society, it offered more evidence that it was IH status rather than Sub-Saharan location that affected development trajectory.

One puzzling and disappointing result from this analysis, however, was the relatively weak association that was found between two novel measures of technological and economic "efficiency"—total energy consumption and gross national product per square kilometer—and the techno-economic-heritage dummies. For the 1965 data, the coefficients of determination (R^2) were only .05 ($p = .051$), and .12 ($p = .002$),

[10]The possible impact of TEH on current rates of economic growth has also attracted the interests of the economist Louis Putterman (e.g., 2000). Although he finds support for the EET argument, he, like Crenshaw (1992) and Crenshaw and Ameen (1994), prefers a continuous measure TEH to the dummy variables we developed and used.

respectively. This challenged the fundamental argument that techno-economic heritage was be tied intimately and powerfully to the fundamental efficiency and productivity of these societies.

However, a follow-up analysis (Lenski and Nolan, unpublished) using 1985 figures suggested a reason for this dismal showing. At first, it too found modest associations: .07 ($p = .027$) for energy and .06 ($p = .048$) for GNP. But when the measures were logged to adjust for skew, the coefficients of determination increased to .39 ($p < .001$) and .33 ($p < .001$), respectively. When the original (1965) measures were expressed as logarithms, their coefficients increased also, rising to .41 ($p < .001$) and .40 ($p < .001$). Thus, it was apparently problems with the skew and/or functional form of the relationship and not with the theoretical expectation or operationalization of the measure that was responsible for the disappointing original finding.

In a companion paper, we reported that closer examination of societies in the industrializing agrarian category (Nolan and Lenski 1985) provided support for the venerable "advantage of backwardness" hypothesis. Among other things, the data indicated that "old" agrarian societies were more stratified, had larger, more densely settled populations, and had slower rates of economic growth than did "new" agrarian societies (i.e., those that adopted agriculture in the past 500 years).

Breedlove and Nolan (1988) found that trends in global inequality were also shaped by the techno-economic heritage of societies. Using the per-capita real incomes of societies as their indicators, and Gini coefficients as their measures of inequality, they found that between 1960 and 1980, (1) income inequality in the world-system of societies increased; (2) inequality among industrial societies decreased; and (3) the gap between industrial societies and industrializing societies widened. *The data also suggested that TEH accounted for more variation in global inequality than did alternative measures derived from world-system and dependency theory.*

Income and income inequality within societies also was found to be associated strongly with TEH (Nolan 1992). Not only do industrial societies have less income inequality overall than do industrializing societies, but both their highest- and the lowest-earning households have higher incomes than their nonindustrial counterparts. And although the highest-earning households in the IH receive a greater share of their society's income than do the highest-earning households of IA or I societies, IH societies have the dubious distinction of having the poorest poor and the poorest rich.

Nolan (1988) found that the population dynamics of currently industrializing societies are still shaped strongly by their techno-economic heritages. TEH had direct and indirect effects (e.g., through its affects of child mortality) on trends in crude birth rates and total fertility rates. The importance of this finding is magnified further by the role that rates of population growth play in producing differences in per-capita economic growth rates in these societies.

In these articles and across succeeding editions of *Human Societies*, it increasingly became evident that although the annual *per-capita* rates of economic growth of IH societies lagged well behind those of IAs and that both trailed those of advanced industrial societies, the annual rates of economic growth were all quite similar. For example, between 1970–1995, the gross domestic products (GDPs) of industrial, industrializing agrarian, and industrializing horticultural societies grew at average annual rates of 2.6, 4.0, and 2.6 percent, respectively, yet their *per-capita* GDPs grew at rates of 2.0, 1.8, and −0.1, respectively (Nolan and Lenski 1999:334). Clearly, the economies of IA and IH societies were growing, but their population growth undermined much of that growth. In fact, the −0.1 growth rate of IH societies indicates that their populations were growing faster than their economies, making wealth and income in these societies *negative sum*!

This underscores two important features of their development trajectories: (1) IH societies are steadily falling further behind industrial societies as well as their somewhat advantaged IA contemporaries; and (2) differences in rates and trends in population growth are the major mechanisms responsible for this growing development gap. This reinforces insights from earlier studies of related issues (e.g., Nolan 1983) and suggests that IH and IA societies are at different "stages" of the so-called demographic transition.[11] For despite the fact that crude death rates actually dropped more rapidly in IA than in IH societies, because of the much steeper decline in their crude birth rates, between 1970 and 1995, the population growth rate of IA societies actually *declined* from 2.4 to 2.0 percent while those of IH societies increased from 2.5 to 2.8 percent.

Arguing that techno-economic heritage might be conceived of better as techno-*ecological* heritage, and using "agricultural intensity" as their measure of it, Crenshaw (1992) and Crenshaw and Ameen (1994) found significant and robust effects of TEH on income inequality net of controls for other features of development and economic dependency in contemporary societies.

In their test of the "disarticulation" hypothesis (i.e., that the economies of currently developing societies are "socially" and "sectorally" disconnected and therefore are fundamentally different from those of already developed societies), Breedlove and Armer (1997) found substantial evidence that TEH was a significant (exogenous) determinant of both quality of life change and economic disarticulation in developing societies.[12] They conclude that, since the theories appear to be more complementary than contradictory, dependency theory would "gain" and be "augmented" by incorporation of insights from EET (Breedlove and Armer 1997:673–674).

Nolan and Lenski (1996), addressing the perennial question of whether "materialism" or "idealism" provides the more powerful explanation of social phenomena, compared the relative ability of the subsistence technology (i.e., presence or absence of plow agriculture) to explain variation in an array of variables—jurisdictional hierarchy, marital composition, premarital sex norms, political integration, community size, and class stratification—to one constructed from an ideological variable (i.e., belief in an active, morally supportive, high god). Although ideology was found to be significantly related to a number of the variables, the effects of technology were generally more powerful, more widespread, and more robust.

Finally, a recent paper (Nolan 2003) finds evidence that, as predicted by ecological-evolutionary theory, warfare is more likely to occur in advanced horticultural and agrarian societies than it is in hunting-and-gathering and simple horticultural societies. Although this paper does substantially advance the testing of this hypotheses by using recently reported more precise data on warfare for a larger and more representative sample of preindustrial societies (Ember and Ember 1995), one of the major motivations for writing and for publishing it in a mainstream sociology journal was to present the results to a wider audience of sociologists. The essential findings on the frequency of warfare were reported in the first and succeeding editions of *Human Societies* (Lenski 1970), but I would venture to guess that other than those who use *Human Societies* in their classes, few sociologists were aware of them. I would venture a similar guess about sociologists' knowledge of the relationships demonstrated between subsistence technology and such things as the incidence of slavery and hereditary slavery, child-rearing practices, private

[11]As Figure 14.2 in *Human Societies* (1999:337) shows, when they are displayed across levels of economic development, the pattern of trends in CBR and CDR in the respective types of societies clearly resembles the "stylized" demographic transition (e.g., 1999:307, Figure 13.1).

[12]In fact, Breedlove and Armer (1997:670) note that "this finding means that dependency effects reported in earlier analyses that did not control for techno-economic heritage are arguably open to reinterpretation."

ownership of land, political leaders' reliance on persuasion, and the sexual division of labor.

The effort to bring ecological-evolutionary theory to the attention of mainstream sociology through journal publications has been, in my judgment, at best only a partial success. It may have called attention to the theory's predictions about currently developing societies, but the tenets and test of the core of EET, in my judgment, still are not known widely. Much more will have to be done if the theory—and the evidence adduced in its favor—are to receive a fair hearing.

FATEFUL DECISIONS

Looking back, we can see that two developments in the presenting and testing of the theory were especially fateful: (1) the decision to present the theory and its empirical tests in an introductory textbook; and (2) the successive movement away from the original monograph structure with the tests largely in a single chapter to a more fragmented textbook format where the discussion and test of specific aspects of the theory and typology are scattered across a number of chapters.[13]

For example, while the impact of subsistence technology on population size and belief in a creator god is still presented in an early "overview" chapter, its impact on such things as child-rearing patterns, the power of political leaders, private ownership of land, and the type of games played is presented in the chapter on hunting-and-gathering societies; and its impact on population density, the incidence of slavery, and the incidence of warfare in the chapter on horticultural societies.

Ironically, then, the further fragmentation of the argument and evidence that may have made the material more accessible to instructors and students inadvertently also may have made the theory and its tests even less accessible to a general sociological audience than the earlier, largely monograph format. For now to see the full outline of the theory and its tests, one almost has to be a "user" of the textbook. No longer can one glean the major outlines of the theory from a single chapter. The chapter that originally presented a relatively comprehensive overview of the theory (Nolan and Lenski 1999:ch. 4) now primarily presents only the subsistence technology typology and a brief sketch of its impact on a few other features of societies: permanence of settlements; median size; craft specialization; complex status stratification; and belief in an active, moral, creator high god.

Thus, while this mode and structure of presentation have given a handful of professors and thousands of students a powerful theoretical framework and extensive body of descriptive and analytical evidence regarding human societies,[14] most sociology majors, graduate students, and practicing sociologists have little knowledge of or exposure to it.

[13]Choice of this method and venue for presentation were not accidental; they reflect Gerhard Lenski's core beliefs that sociology has something important to say and that we, as teachers in the introductory course, have a special responsibility not simply to entertain or to titillate our students but to share with them the most fundamental and important things that we have learned about societies. This responsibility is made even more urgent by the fact that, for most students, the introductory course will be their only course in sociology. If they leave the course with the impression that sociology has nothing important to say or to teach them, we are doomed as a discipline. Their experience in the introductory course should not just make them "feel good" or indoctrinate them with ideas that are "good" to think, but it should expose them to our best theories and to the evidence that leads us to accept or to reject them. In my mind, there is no better example of this than the discussion of Marxist societies as "natural experiments" (Nolan and Lenski 1999:ch. 15) that first was introduced in the seventh edition of *Human Societies* (Lenski, Nolan, and Lenski 1995).

[14]By my count, *Human Societies* has been cited substantively (e.g., not simply as an example of an introductory text) in the *American Sociological Review* five times since 1995 (Nielsen and Alderson 1995, 1997; Crenshaw, Ameen, and Christenson 1997; Jenkins and Scanlan 2001; and Mark 2002).

ADDITIONAL CHALLENGES

Two other specific challenges and issues confront the theory as I write. First, there remains a need for a measure of relevant environmental variation—one that can capture in a single measure or index the features of the biophysical environment that impact subsistence and social organization. That is, an objective measure of key dimensions of the environment that is comparable in power and simplicity to that used to index mode of subsistence, yet is simple and available for a substantial number of cases in the standard sample and *Ethnographic Atlas* data sets. This would provide a variable that would potentially cross-cut subsistence technology and would make it truly possible to test and refine an ecological-evolutionary theory of human societies.

It also is appropriate and necessary now to think seriously about developing a measure or criterion for distinguishing "simple" from "advanced" industrial societies. Although it is clearly a misnomer to call advanced industrial societies "postindustrial," since the harnessing and reliance on inanimate energy sources is the defining characteristic of industrialization, the distinction that has been attempted by use of the term is important and worthwhile. Turner (1997:20) suggests we make "a distinction between early industrial and currently industrializing societies, on the one hand, and those where more than 50 percent of the work force is employed in services, gross domestic product is very high, and per-capita incomes are high, and per-capita use of energy is very high, on the other." This is a useful starting point, but it is essential that this distinction be made on the basis of levels or degrees of the *independent* variable (e.g., technology, energy consumption) and not solely or in combination with levels of *dependent* or consequent variables (e.g., life expectancy, urbanization). An adequate solution eluded my own attempts to do this empirically some years ago, convincing me that this will not be a simple task.[15]

Thus, while this powerful and promising theory has accomplished much in the decades following its first development in the mid 1960s and early 1970s, much remains to be done. Rather than being an indictment of the theory, however, this is a testament to it. A good theory *should* provoke more questions than it answers, and it *should* invite its own further refinement. Ecological-evolutionary theory does both. It remains to be seen, however, as Gerry's hair and that of the students and colleagues he has inspired grows ever grayer, if others will take up the gauntlet and will pursue these tasks with the energy and resolve that they deserve.

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[15]At the time (late 1980s), Eastern-European (Soviet bloc) and Arab oil-producing countries provided the most intractable problems. When per-capita energy was used to scale industrialization, the former, because of their very inefficient technologies and economies, scaled too high on the index. And when efficiency was used (e.g., GDP per unit of energy) to correct this problem, the latter, because of their very advanced enclave oil-producing economy, scaled too high.

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