

ECI retreat October 17, 2008

Session: **Scale and Information Density in the Natural and Social Sciences**

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The session had two goals. First, I was hoping to get people talking about how different disciplines understand the nature of evidence and, in particular, how we think about scale-dependent relationships and scaling up relationships found at one scale or in one place. Second, I am teaching a grad seminar on population and environment in the spring and am looking for ideas and examples to use in that course.

We began with a basic discussion of what people mean when they talk about scale or scale-dependence. To summarize, three types of issues were covered (though using different terms in different research communities). We first talked about things that are true or observable at different scales (for example, certain processes occur on millennial time scales while others occur on decadal or daily time scales). For example, in Sociology, we argue that personal relationships will have more impact at small scales than at large (regional or national) scales. An alternative example is how gravity becomes nearly insignificant at the nano-scale, while surface tension becomes incredibly significant. We then talked about the idea of “scaling,” meaning taking a finding from a particular scale (usually thinking spatial, but could be temporal) and “scale up” or “scale down” to make it applicable at other scales. For example, how do we scale field data up to a river basin or biome level, or scale down global circulation models to model local microclimates? Finally, we talked about the idea of dependence between scales, where you can’t understand one process at a particular scale without thinking about the influences of processes or factors at other scales.

Phenomena Observable at Different Scales

With regard to the first, we discussed how the presence of non-linearities was often the theoretical foundation for understanding why we might observe a process at certain scales and not at others. In particular, threshold effects might lead to this sort of pattern, where you rarely could observe the threshold in a study at a finer scale, while coarser scale studies would be able to capture such non-linear relationships.

We discussed how, in Economics, we talk about partial equilibrium models versus general equilibrium models. General equilibrium tries to incorporate all the important linkages in an economy, while partial equilibrium assumes that some linkages will be stable enough to ignore within a particular context. Essentially the same thing happens in ecology. If you fix everything except the variable of interest, you may be able to determine the relationship, but when you allow the other factors to vary, you can get a completely different result. These together point to the importance theoretically (and for getting the right empirical result) of feedbacks. If you ignore the feedbacks, that is you assume that you can ignore something that you should be paying attention to, you are going to get the wrong answer.

In any given analysis, we tend to assume that we have all the relevant variables (as in the partial equilibrium models discussed above) and that we are looking at the appropriate scale (as in the flock of birds example, where we can arguably understand the flock without looking at the individual birds, or alternatively, that we need to look at the individual birds to build the flock).

Generalizability or Extrapolation

With regard to the second, I consider this a problem of generalizability. In Sociology, we talk about generalizability to versus generalizability across. The first is the statistical sense of generalizability, in which a probability sample allows one to say that results are likely to be true for the population from which the sample was drawn. Generalizability across, in contrast, refers to identifying the particular conditions (or variable values) under which the observed relationships will hold. For example, many

relationships between household characteristics and economic activities or education hold only under certain macroeconomic conditions, and thus differ between developed and developing countries.

When we are extrapolating “up,” we tend to make several assumptions. We assume: 1) no feedbacks; 2) no threshold effects; 3) no non-linearities (that we haven’t captured in our model). For extrapolating “down” (e.g. from community patterns to individual patterns), social scientists have developed approaches because of the difficulty and expense of collecting data from enough individuals. It was pointed out that all approaches have a common basis, in assuming we know all relevant factors and controlling those that we aren’t interested in (either through an experimental or quasi-experimental design or statistically), and then looking first at a factor of interest and second at how the effect of that factor interacts with the effects of other variables. The point was also made that for biogeochemical models, we have a pretty good understanding of which variables matter, but we don’t have enough data to flesh out the models completely. In social models, we might not have as clear an understanding of which variables matter (and there are often a lot more of them, some of which are very difficult to measure [e.g. self-esteem, altruism]). However, as systems change and communities change (we were talking here about microbial or ecological communities, but the point applies to social systems as well) the important relationships we thought we understood may change. This is less true the closer we get to chemicals and physical relationships (e.g. atmospheric ozone) and the farther from living organisms and systems.