Urban scaling in the ancient world: Considerations for the SFI meeting.

April 29, 2014

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Urban scaling research examines human societies as complex systems and seeks to identify and explain emergent properties of these systems. The guiding principle of this work is that humans generally benefit by creating strongly-interacting social networks in space, over which goods, services and information flow through interpersonal contacts. Because people must move across space to interact, space acts to reduce the total connectivity of a social network below the theoretical limit of $\sim N^2$ contacts (where everyone is connected to everyone else). But as the number of interacting people grows, the space needed by each person declines due to the benefits of interaction. As a result the infrastructural requirements of social groups tend to increase only $\sim N^{.85}$, and the total connectivity of human social networks tends to grow $\sim N^{1.15}$. These relationships emerge routinely from analyses of aggregate quantities across settlements in contemporary urban systems. The goal of this working group is to examine the extent to which these emergent properties of human social networks are expressed in the archaeological record, in pre-modern and even pre-urban settlement systems.

A variety of quantities are amenable to scaling analysis, but there are 2-3 basic requirements for the data (whether historical or archaeological). We use the term “sample” here to refer to a batch of cities whose scaling relationships can be plotted and studied.

1. ***Samples of settlements.*** A rather large batch of settlements from a given tradition or context is needed in order to examine quantitative patterns. Although larger sample sizes are always better, the number of data points is not as important as the range of the data—the more orders of magnitude the data encompass, the better. If the cities in a given sample have different levels of technology and institutions (political and economic) this should be noted, since these may affect the quantitative patterning. There are no hard-and-fast rules for how much temporal, spatial, or other variability can be included in a coherent sample. Having data from one or two or even five sites is not adequate; nor are data from only the largest settlements in a system. An ideal dataset should sample the full range of settlement populations in a region.

   The chronology of the settlements may or may not be important depending on the details of local history. What we have found from our initial investigations is that the relationship between population and other aggregate quantities did not change much in many systems, so settlements with imprecise chronologies, and even dating to different periods, can still be useful.

2. ***Population size.*** Population estimates must be available (or generated) for all settlements in a case study. But if at all possible, these estimates should not be a linear function of settled area, as this will factor out many of the scaling relations we seek to examine. So if populations can be measured using roofed space, house counts, or some other technique that allows the population densities of settled areas to vary with size, this would be preferable.

3. ***Settled area.*** It is helpful to have estimates of the total settled area to go along with the population estimates, as both measures are incorporated into current models. If populations are not available settled areas can substitute, as current models can be solved for settled area as well as population.

Beyond these three parameters, a whole number of associated quantities are potentially useful. These can be expressed in terms of averages or totals for each settlement, estimated from samples or counted directly. The kinds of measures that appear to have the most promise include:

Socio-economic outputs. Measures related to economic productivity, capital accumulation, craft production, public works and civic architecture are all useful. Measures might include the mean of measured house sizes, the total roofed area, amounts produced (expressed as totals or per capita), household artifact inventories, volumes of public works, and plaza or market areas. In some cases it may also be necessary to derive estimates for the populations involved in the production of the aggregate measures as opposed to total city populations.

Infrastructure. Measures of infrastructure, such as the lengths of roads and paths between buildings, reservoir volumes or water transport networks (in Roman cities, for example), or the number of workshops of a given type, could be useful.

Functional differentiation. An additional property of modern urban systems is that the division of labor, as proxied by the number of distinct professions, scales the same way as area and infrastructure. Archaeological measures of functional differentiation might include the number of different kinds of goods produced in settlements of different sizes, the proportion of goods that are imported from elsewhere, the number of site types, the number of different artifact types, the number of different kinds of craft industries, or any other measures of the division and specialization of labor.