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Macrosystems as Dynamic Networks: Growth and decline phases of
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What happens when social scientists, mathematical modelers and historians, studying such diverse questions as the evolution of cities and states, development of trade networks, and the emergence of world systems come together with mathematical modelers to more deeply explore possible cross-fertilizations? For this working group, it meant four fruitful days wherein the researchers invited by Douglas White and Henry Wright to the Santa Fe Institute presented their research, models, and modeling methods. During and afterwards, open discussion of the possibilities of dynamic models ensued.

Modeling History:

One combination explored was that of models and history. Apparently, this path has begun to bear fruit. Since biologists have discovered many dynamic relationships between species and their environments, it seems natural that an attempt to model historical demographic processes in a similar manner be made. This dynamic historical analysis is achieved through a straightforward methodology. Careful and thorough review of the historical literature is performed to winnow out the most comprehensive and quantitative sources. Once these are amassed, each is studied and an attempt is made to code each appropriate source into numerical data. This process is tricky, as historical data is often coarse grained, with many areas of missing data, and translating qualitative historical writing into numerical measures could lead to a position where individual codings are open to criticism.

Once this time consuming, but enjoyable process has been completed, all of the statistical analysis tools already common in the social sciences can be applied. Although the number of data points often precludes the use of some techniques from the natural sciences, correlations between variables at a given time can be calculated, linear and non-linear fits can be made, etc. Also, techniques new to the social sciences, such as winding numbers and time-series analysis can be applied. Lastly, in cases where simple plots of the data shows obvious trends, modeling or high-level analysis may be performed on the coded data itself.

Peter Turchin's study of the interactions between social stability and population levels is a prime example of a study that uses historical data and time-series analysis to great effect. His numeric techniques lend themselves to a clear visual and written arguments for the support for and against given theories. The Black Death, standards of living, simple Malthusian theory, are all shown to be poor matches for the coded data relative to a composite variable of

political instability as the key dynamic variable interacting with population rise and fall.

Another example of Turchin using historical dynamics to analyze historical problems is found in his book, Historical Dynamics: Why States Rise and Fall. Here he constructs a model of why traditional agricultural states rise and fall, with solidarity among elite members of the state taking a central role. Again, numerous data culled from the literature form the backbone of a time series analysis which suggests cyclical processes of ethnogenesis pumping the cycle of the rise and fall of states, overshadowed by the historical footprint of the states themselves.

Long Term View Brings Historical and Archaeological Data Together:

Many of the most fascinating questions of human and their society, the rise and fall of states, civilizations, and cultures, and the origins of world spanning trade networks, require a perspective spanning the duration of human species. So, it should be of no surprise that many of the working group participants orient their work from this same viewpoint. From this position, each of them report success using a variety of techniques, similar in some ways to the approach described above, to assemble and view human processes that are at once historical and archaeological.

Accordingly, many historical and archaeological datasets, some carefully constructed through years of effort by the participants themselves, were presented to the group. Bill Thompson used such data to argue that climate affected the rise and fall of early states more than any other variable found in his many data sources. Complementing and contrasting some of the other approaches, Dave Wilkinson, pointing out that interacting states share many aspects of their civilization, used other sources to show that whole groups of interacting states have so rarely collapsed that it is perhaps nonsensical to speak of civilizational collapse. State collapse, regions of wealth and knowledge shifting or struck down, and poor regions rising to become the core of a hegemon are all seen in his coded data, but not civilizational collapse. Chris Chase-Dunn laid out the nested levels of states and trade networks in what has become the single world system and showed how they grew and merged over the course of human history. The importance of studying and explaining the phase transitions seen in the growth of these networks was emphasized. Also, the importance of and current search for, a good visual representation of these network changes over time was discussed. Henry Wright opened up his storehouse of knowledge of the early Mesopotamian states, and took a moment to poignantly illustrate the horrible damage wrought by fighting near some archaeological sites. His interests have brought him a wealth of data. Both in the Americas and the Middle East, data hordes such as the personal letters unearthed at Jemdet-Nasser await analysis. Similarly, Peter Spufford offered up his hard-won encyclopedic knowledge of medieval trade to the delighted scrutiny

of the rest of the group.

Magnificent data attracts many suitors:

But why present this data to the group? Good data demands a well-formed model. A second contingent of working group participants came bearing this complementary currency: modeling techniques.

Douglas White described and suggested an approach with which he has had many successes: dynamic network modeling. Network approaches have for many years teased out findings from data in the form of units (people, businesses, countries, etc.) and relationships between units (friendship, trade, kinship). These techniques based on the mathematical properties and the concise visualization of structural patterns in data, have been strengthened with the addition of time-series analysis methods. A single network diagram may capture the structure of a network at a moment, but a series of snapshots or a "movie" easily capture the way network structure changes over time. The trade networks in ancient Mesopotamia shown by Wright and the world system trade and conflict networks in medieval England shown by White all lend themselves to a dynamic network approach.

Another approach, less familiar to many of the attendees, was introduced by Don Saari. His strategy involves making only the safest of assumptions, such as: human population grows when blessed with unclaimed, fertile, safe land to expand into. Then, in lieu of adding in additional patterns which the social science researcher believes she sees in the data, the full implications of the safest assumption are first explored. In particular, critical points implicitly true if the original assumption is true can be predicted by a method using "winding numbers". This method was demonstrated for models involving continuous functions.

Turchin's methods and tools for dynamic time-series analysis were also presented for general use with a variety of models and research questions.

The larger question:

Hovering above the methods and evidence presented was and is the most important question: is it worth spending time modeling data from the social sciences? Can we get results with reasonable error estimates bounded well within the range of possibilities? Many of the researchers present expressed their doubts and concerns. Others pointed out the patterns in their data and asked how we could dismiss such a reasonable result with possible predictions as meaningless without first testing the predictions.

Judging from this working group, both data collection and modeling are getting more quantitative and well-formed. Soon, this debate may be just one more piece of the human story, one which future historians studying the

development of the social sciences in our time can chuckle over.

Papers and details of modeling and data from the conference can be found online at:

<http://eclectic.ss.uci.edu/~drwhite/Civ/HistoryMaps.html>