# REGIONS AND INTERACTION NETWORKS: AN INSTITUTIONAL-MATERIALIST PERSPECTIVE

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## ABSTRACT

*We contend that interaction networks are far superior to cultural area and regional approaches for bounding human social systems. This article discusses methodological and conceptual issues in bounding human social systems and their interactions with the natural environment and examines several recent innovations in information technology that facilitate the study of interaction networks.*

## Introduction

An ancient debate has waxed and waned over how to bound social systems in time and space for purposes of telling human histories and explaining social change (e.g., Chase-Dunn and Hall 1995, 1997; Mann 1986; Parsons 1966; Tilly 1984; Wallerstein 1974). Sociospheres have long interacted with biospheres and the geosphere, and humans have long painted their stories with attention to the significance of place and the natural world. Theorists of the emergence of complex and hierarchical social systems have treated or ignored geographical and biological contexts depending on their mix of material determinism on the one hand and social and cultural constructionism on the other.

Our theoretical approach can be characterized as institutional materialism: a combination of focusing on the historical evolution of humanly constructed institutions (language, kinship, production technology, states, money, markets, etc.) and the changing ways that humans interact with their biological and physical environment. This theoretical framework deploys what has been called the comparative world-systems approach to bounding social systems. Rather than comparing societies with one another, we compare systems of human societies (or intersocietal systems) and these are empirically bounded in space as interaction networks—bilateral or multilateral regularized exchanges of materials, obligations, threats, and information.

World-systems are human interaction networks that display oscillations of expansion and contraction (i.e., pulsation), with occasional large expansions that bring formerly separate regional systems into systemic intercourse with one another. These waves of expansion, now called globalization, have, in the last two centuries, created a single integrated intercontinental political-economy in which

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all national societies are strongly linked (Chase-Dunn, Kawano, and Brewer 2000; Chase-Dunn et al. 2002). The historical trajectory of structural globalization is an attribute of the modern interstate system as well as earlier systems of societies. We define structural globalization as the increasing spatial scale and intensity of interaction networks. Charles Tilly (1995) proposes a similar definition of globalization as "an increase in the geographic range of locally consequential social interactions, especially when that increase stretches a significant proportion of all interactions across international or intercontinental limits" (Tilly 1995:1-2). Thus, globalization in the structural sense is increasing integration and interdependence.

As Tilly (1984) has emphasized, societies (defined as national communities that share a common language and culture) are messy entities when we consider interaction networks. Many of the networks in which households are deeply involved are local, while many other important interactions strongly link the inhabitants of many different national societies to one another. The world-systems perspective has argued that societies are subsystems within a larger single system, and that in order to understand historical societal development we must focus on the larger system as a whole. Chase-Dunn and Hall (1997) have developed a nested network approach for bounding world-systems that enables the comparison of the modern global system with earlier, smaller regional world-systems (see below). They contend that the world-system rather than societies constitutes the most important unit of analysis for explaining long-term social change. In this article we will: (1) explain this nested network approach to spatially bounding world-systems; (2) discuss the relationship between various forms of structural globalization and interaction networks in the modern world-system and earlier systems of societies; and (3) consider how new developments in network analysis, hierarchical linear modeling (HLM), and geographical information systems (GIS) may allow the questions of the causally most powerful units of analysis to be subjected to testing against contemporary, historical, and prehistoric data.

New developments in our abilities to empirically examine and model spatial characteristics, especially dynamic spatio-temporal GIS, are combining with new interdisciplinary theoretical perspectives, especially the comparative world-systems approach, to herald a new dawn for the explanation of social change. This involves a new way of combining the study of geographical regions with the examination of human interaction networks.

One current problem with regional analysis is the tendency to define regions in terms of allegedly homogenous attributes, either natural or social. Thus, comparative civilizationists have tended to focus on the core cultural characteristics that are embodied in religions or world-views and have tended to construct lists of such culturally defined civilizations that then become the "cases" for the study of social change. Another approach that defines regions as areas with homogenous characteristics is the "culture area" approach developed by Carl Sauer and his colleagues (Wissler 1927). This project gathered information on all sorts of cultural attributes such as languages, architectural styles, technologies of production, and kinship structures, and used these to designate bounded and adjacent "culture areas."

A major problem with both the civilizationist and the cultural area approaches is the assumption that homogeneity is a good approach to bounding social systems that are evolving. Heterogeneity rather than homogeneity has long been an important aspect of human social systems because different kinds of groups often complement one another and interaction often produces differentiation. The effort to bound systems as homogeneous regions obscures this important fact. Spatial distributions of homogeneous characteristics do not bound separate social systems. Indeed, social heterogeneity is often produced by interaction, as in the cases of core/periphery differentiation, urban/rural, and sedentary/nomadic systems. Even sophisticated approaches that examine distributions of spatial characteristics statistically must make quite arbitrary choices in order to specify regional boundaries (Burton 1995).

The world-systems approach focuses instead on human interaction networks, and so it is able to define its units of analysis as systemic combinations of very different kinds of societies. This makes it possible to study multicultural systems and core/periphery relations as cases that can display dynamics of social evolution.

Some social scientists erroneously assume that GIS data structures are restricted to the mapping of attributes that are stationary in space and that GIS is useless for studying things that move. Geographers are now developing GIS techniques based on vectors for mapping prevailing winds, but also for studying migration (Tobler 1995; n.d.).

Another important point is worth making regarding the relationship between natural regions and human interaction networks. Cultural ecology stresses the important ways in which local ecological factors conditioned sociocultural institutions and modes of living. This was an especially compelling perspective for understanding small-scale systems in which people were mainly interacting with adjacent neighbors not very far away. But this kind of local ecological determinism is much less compelling when world-systems get larger because long-distance interaction networks and the development of larger scale technologies enable people to impose socially constructed logics on local ecologies. Some social evolutionists have interpreted this to mean that social institutions have become progressively less ecologically determined (Lenski, Lenski, and Nolan 1995). But what has happened instead is that the spatial scale of ecological determinism has grown to the point where it is operating globally rather than locally (Chase-Dunn and Hall 1997).

## Spatially Bounding World-Systems

The world-systems perspective emerged as a theoretical approach for modeling and interpreting the expansion and deepening of the European system as it engulfed the globe over the past 500 years (Arrighi 1994; Chase-Dunn 1998; Kentor 2000; Shannon 1996; Wallerstein 1974). The idea of a core/periphery hierarchy composed of "advanced," economically developed, and powerful states dominating and exploiting "less developed," peripheral regions, has been a central concept in the world-systems perspective. In the last decade, the world-systems approach has been extended to the analysis of earlier and smaller intersocietal systems. Andre Gunder Frank and Barry Gills (1993) have argued that the contemporary world system is a continuation of a 5000-year old system that emerged with the first states in Mesopotamia. Chase-Dunn and Hall (1997) have modified the basic world-systems concepts to make them useful for a comparative study of very different kinds of systems. They include very small intergroup networks composed of sedentary foragers (Chase-Dunn and Mann 1998), as well as larger regional systems containing chiefdoms, early states, agrarian empires, and the contemporary global political economy in their scope of comparison.

The comparative world-systems perspective is designed to be general enough to allow comparisons between quite different systems. Chase-Dunn and Hall (1997) define world-systems as important networks of interaction that impinge upon a local society and condition social reproduction and social change. They note that different kinds of interaction often have distinct spatial characteristics and degrees of importance in different sorts of systems. And they hold that the question of the nature and degree of systemic interaction between two locales is prior to the question of core/periphery relations. Indeed, they make the existence of core/periphery relations an empirical question in each case, rather than an assumed characteristic of all world-systems.

Spatially bounding world-systems must necessarily proceed from a locale-centric beginning rather than from a whole-system focus. This is because all human societies, even nomadic hunter-gatherers, interact importantly with neighboring societies. Thus, if we consider all indirect interactions to be of systemic importance (even very indirect ones) then there has been a single, global world-system since humankind spread to all the continents. But interaction networks, while they were always intersocietal, have not always been global in the sense that actions in one region had major and relatively quick effects on distant regions. When transportation and communications occurred over short distances the world-systems that affected people were small.

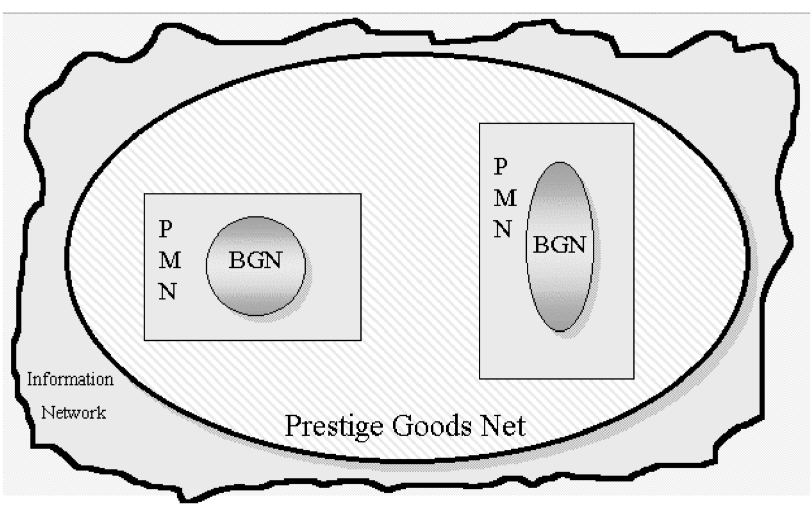
Thus, it is necessary to use the notion of "fall-off" of effects over space to bound the networks of interaction that importantly impinge upon any focal locale. The world-system of which any locality is a part includes those peoples whose actions in production, communication, warfare, alliance, and trade have a large and interactive impact on that locality. It is also important to distinguish between endogenous systemic interaction processes and exogenous impacts that may, importantly, change a system, but are not part of that system. So, maize diffused from Mesoamerica to Eastern North America, but that need not mean that the two areas were part of the same world-system. Or a virulent micro parasite might contact a population with no developed immunity and ravage that population. But such an event does not necessarily mean that the region from which the micro parasite came and the region it penetrated, are parts of a single interactive system. Interactions must be two-way and regularized to be systemic.

Chase-Dunn and Hall (1997) note that in most intersocietal systems there are several important networks of different spatial scales and relative intensities, which impinge upon any particular locale: Information Networks (INs); Prestige Goods Networks (PGNs); Political/Military Networks (PMNs); and Bulk Goods Networks (BGNs).

The largest networks are those in which information travels. Information is light and it travels a long way, even in systems based on down-the-line interaction.[1] These are termed Information Networks (INs). A usually somewhat smaller interaction network is based on the exchange of prestige goods or luxuries that have a high value/weight ratio. Such goods travel far, even in down-the-line systems. These are called Prestige Goods Networks (PGNs). The next largest interaction net is composed of polities that are allying or making war with one another. These are called Political/Military Networks (PMNs). And the smallest networks are those based on a division of labor in the production of basic everyday necessities such a food and raw materials. These are Bulk Goods Networks (BGNs). Figure 1 illustrates how these interaction networks are spatially related in many world-systems.

The first question for any main locale concerns the nature and spatial characteristics of its links with the above four interaction nets. This is prior to any

**Figure 1. Nested Interaction Networks**



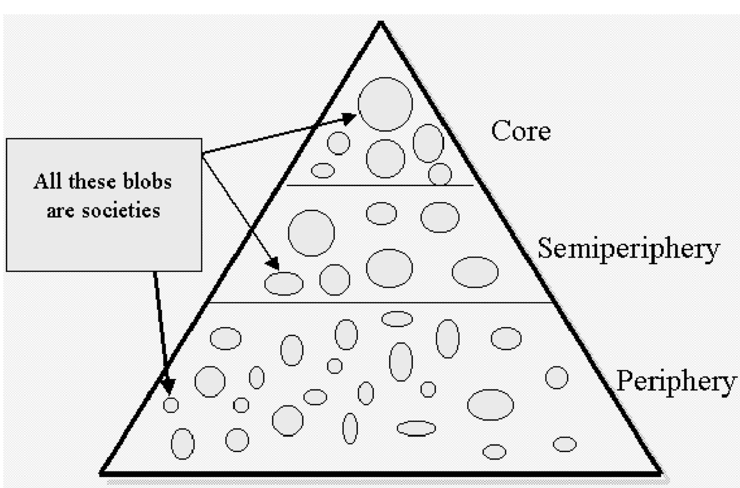
consideration of core/periphery position because one region must be linked to another by systemic interaction in order for a consideration of core/periphery relations to be relevant.

The spatial characteristics of these networks clearly depend on many things: the costs of transportation and communications, and whether or not interaction is only with neighbors or there are regularized, long-distance trips being made. But these factors affect all kinds of interaction and so the relative size of networks is expected to approximate what is shown in Figure 1. As an educated guess, we would suppose that fall-off in the PMN generally occurs after two or three indirect links. Suppose group A is fighting and allying with its immediate neighbors and with the immediate neighbors of its neighbors. So its direct links extend to the neighbors of the neighbors. But how many indirect links will involve actions that will importantly affect this original group? The number of indirect links that bound a PMN is probably either two or three. As polities get larger and interactions occur over greater distances, each indirect link extends much farther across space. But the point of important fall-off will usually be after either two or three indirect links.

Chase-Dunn and Hall (1997) divide the conceptualization of core/periphery relations into two analytically separate aspects: core/periphery differentiation, and core/periphery hierarchy.

Core/periphery differentiation exists when two societies are in systemic interaction with one another and one of these has higher population density and/or greater complexity than the other. The second aspect, core/periphery hierarchy, exists when one society dominates or exploits another. These two aspects often go together because a society with greater population density/complexity usually has more power than a society with less of these, and so can effectively dominate/exploit the less powerful neighbor. But there are important instances of reversal (e.g., the less dense, less complex Central Asian steppe nomads exploit-

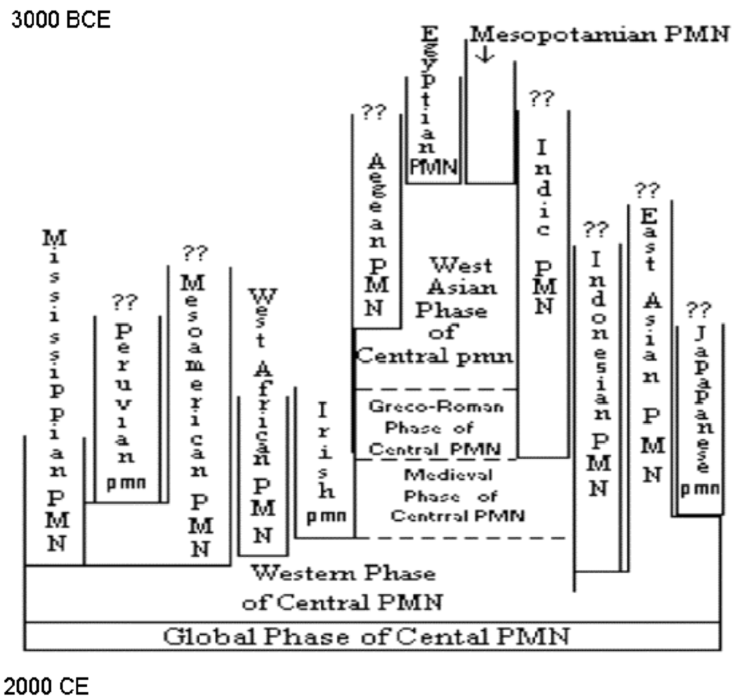
**Figure 2. Core/Periphery Hierarchy**



ed agrarian China) and so this analytical separation is necessary so that the actual relations can be determined in each case. The question of core/periphery relations needs to be asked at each level of interaction designated above. It is more difficult to project power over long distances, and so one would not expect to find strong core/periphery hierarchies at the level of Information or Prestige Goods Networks. Figure 2 illustrates a core/periphery hierarchy.

Using this conceptual apparatus, we can construct spatio-temporal

**Figure 3. Chronograph of PMNs**




chronographs for how the social structures and interaction nets of the human population changed their spatial scales to eventuate in the single global political economy of today. Figure 3 uses PMNs as the unit of analysis to show how a "Central" PMN, composed of the merging of the Mesopotamian and Egyptian PMNs in about 1500 BCE, eventually incorporated all the other PMNs into itself.

## World-System Cycles: Rise-and-Fall Pulsations and Structural Globalization

Comparative research reveals that all world-systems exhibit cyclical processes of change. There are two major cyclical phenomena: the rise and fall of large polities, and pulsations in the spatial extent and intensity of trade networks (i.e., structural globalization). "Rise and fall" corresponds to changes in the centralization of political/military power in a set of polities. It is a question of the relative size and distribution of power across a set of interacting polities. The term "cycling" has been used to describe this phenomenon as it operates among chiefdoms (Anderson 1994).

All world-systems in which there are hierarchical polities experience a cycle in which relatively larger polities grow in power and size and then decline. This applies to interchiefdom systems as well as interstate systems, to systems composed of empires, and to the modern rise and fall of hegemonic core powers (e.g., Britain and the United States). Though very egalitarian and small scale systems such as the sedentary foragers of Northern California (Chase-Dunn and Mann 1998) do not display a cycle of rise and fall, they do experience pulsations.

All systems, including even very small and egalitarian ones, exhibit cyclical expansions and contractions in the spatial extent and intensity of exchange networks. We call this sequence of trade expansion and contraction pulsation. Different kinds of trade (especially bulk goods trade vs. prestige goods trade) usually have different spatial characteristics. It is also possible that different sorts of trade exhibit different temporal sequences of expansion and contraction. It should be an empirical question in each case as to whether or not changes in the volume of exchange correspond to changes in its spatial extent. In the modern global system, large trade networks cannot get larger because they are already global in extent. But they can get denser and more intense relative to smaller networks of exchange.

A good part of what has been called globalization is simply the intensification of larger interaction networks relative to the intensity of smaller ones. With trade and investment, structural globalization is conceptualized as the extent to which international capital flows, investments, and/or trade increases (or decreases) in relationship to the overall size of the world-economy (Chase-Dunn et al. 2000, 2002; Jorgenson and Kick 2003). This kind of integration is often understood to be an upward trend that has attained its greatest peak in recent decades of so-called global capitalism. But research on trade and investment globalization shows that there have been two recent waves of integration, one in the last half of the nineteenth century and the most recent since World War II (Chase-Dunn et al. 2000, 2002). Pulsation in earlier systems of societies should be studied to compare with waves of structural globalization in the modern world-system. This would allow for the identification of structural similarities and differences between different systems of societies in varying historical periods. A simple hypothesis regarding the temporal relationships between rise-and-fall and pulsation is that they occur in tandem. Whether or not this is so, and how it might differ in distinct types of world-systems, is a set of problems amenable to empirical research.

Chase-Dunn and Hall (1997) contend that the causal processes of rise and fall differ depending on the predominant mode of accumulation. One big difference between the rise and fall of empires and the rise and fall of modern hegemons is in the degree of centralization achieved within the core. Tributary systems alternate back and forth between a structure of multiple and competing core states on the one hand, and core-wide (or nearly core-wide) empires on the other. The modern interstate system experiences the rise and fall of hegemons, but these never take over the other core states to form a core-wide empire. This is because modern hegemons are pursuing a capitalist, rather than a tributary form of accumulation.

Analogously, rise and fall works somewhat differently in interchiefdom systems because the institutions that facilitate the extraction of resources from distant groups are not as developed in chiefdom systems. David G. Anderson's (1994) study of the rise and fall of Mississippian chiefdoms in the Savannah River valley provides an excellent and comprehensive review of the anthropological and sociological literature about what Anderson calls "cycling," the processes by which a chiefly polity extended control over adjacent chiefdoms and erected a two-tiered hierarchy of administration over the tops of local communities. At a later point, these regionally centralized, chiefly polities disintegrated back toward a system of smaller and less hierarchical polities.

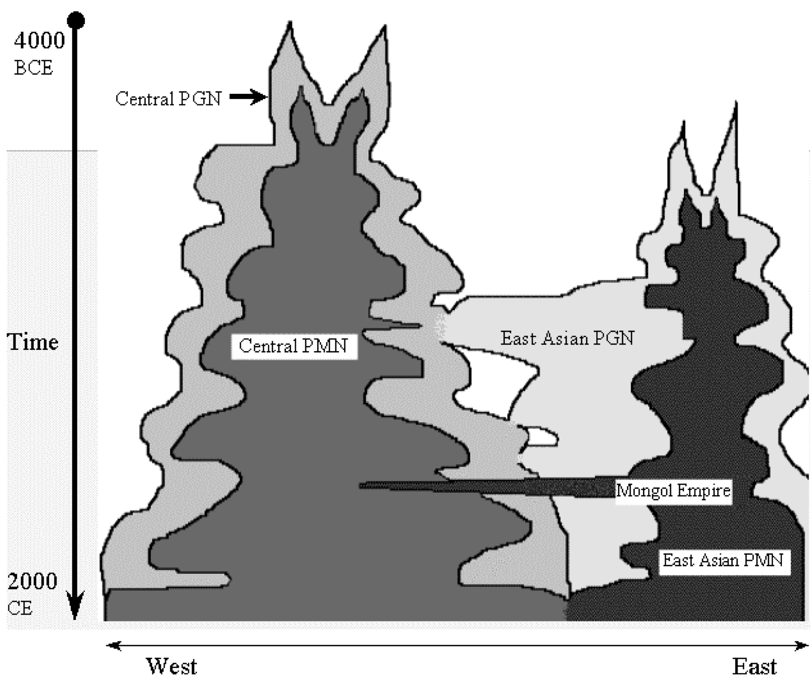
Chiefs relied more completely on hierarchical kinship relations, control of ritual hierarchies, and control of prestige goods imports than the rulers of true states. These chiefly techniques of power are all highly dependent on normative integration and ideological consensus. States developed specialized organizations for extracting resources that chiefdoms lacked—standing armies and bureaucracies. And states and empires in the tributary world-systems were more dependent on the projection of armed force over great distances than modern hegemonic core states have been. The development of commodity production and mechanisms of financial control, as well as further development of bureaucratic techniques of power, have allowed modern hegemons to extract resources from far-away places with much less overhead cost.

The development of techniques of power has made core/periphery relations ever more important for competition among core powers and has altered the way in which the rise-and-fall process works in other respects. Chase-Dunn and Hall (1997, chap. 6) argue that population growth interacting with the environment, and changes in productive technology and social structure, produce social evolution that is marked by cycles and periodic jumps. This is because any world-system varies around an equilibrium or mean as a result of both internal instabilities and environmental fluctuations. Occasionally, on one of the upswings, a system solves its problems in a new way that allows substantial expansion. We want to explain expansions, evolutionary changes in system logic, and collapses. That is the point of comparing world-systems.

The multiscalar regional method of bounding world-systems as nested interaction networks outlined above is complimentary with a multiscalar temporal analysis of the kind suggested by Fernand Braudel's work. Temporal depth, the *longue duree*, needs to be combined with analyses of short-run and middle-run processes to fully understand social change. Perhaps this is not a point that needs to be stressed for an audience of historical social scientists, but the shallow presentism of most social science and contemporary culture needs to be denounced at every opportunity.

A strong case for the very *longue duree* is made by Jared Diamond's (1997) study of original zoological and botanical wealth. The geographical distribution of those species that could be easily and profitably domesticated

**Figure 4. Pulsations and Mergers**




(combined with the relative ease of latitudinal vs. longitudinal diffusion) explains a huge portion of the variance regarding which world-systems expanded and incorporated other world-systems thousands of years ago.

The diagram in Figure 4 depicts the coming together of the East Asian and the West Asian/Mediterranean systems. Both the PGNs and the PMNs are shown, as are the pulsations and rise and fall sequences. The PGNs linked intermittently and then joined. The PMNs were joined briefly by the Mongol conquerors, and then more permanently when the Europeans and Americans established Asian treaty ports.

## Emerging Analytical Techniques

We see the emergence of certain new analytic techniques as having important possibilities for improving the comparative world-systems theoretical research program. Geographic Information Systems (GIS) has been used mainly as a mapping device for linking and comparing geocoded information (Zeiler 1999). In this guise, it has important applications for allowing us to think spatially and to imagine causal explanations for patterns and events. Standardized ways of representing Earthly space (e.g., longitude, latitude, and time) present an opportunity for linking and understanding historical events and relationships among locations into a temporal GIS (TGIS).

Time mapping has been developed to allow researchers to represent changes over time on web-accessible animated maps.[2] Several pertinent projects are listed on the Electronic Cultural Atlas Initiative (ECAI) website (see http://www.ecai.org). In addition to changes in the size and shape of spatial features such as empires and cities, three-dimensional time mapping can represent other variables for purposes of scientific visualization.

But the potential of GIS as an analytic device for suggesting and testing causal models is, as yet, in its infancy. Spatial analysts have developed techniques for optimizing location decisions—where to build a new firehouse or McDonald's restaurant. The next step is to use spatial analysis for testing models of long-term social change. This will involve further elaboration of the ability to represent movement and interaction networks with GIS, and the development of modeling techniques that use change over time as well as location in space to test complex causal models.

One approach would combine GIS with Hierarchical Linear Modeling (HLM); a technique that is used to study causal interactions among different levels of nested interaction networks (e.g., schools, classrooms, and students). HLM is quite useful because it makes it possible to test separate hypotheses about the effects of different levels of analysis (Bryk and Raudenbush 1992; Vogt 1999). With HLM, submodels formally represent each of the levels in a structure. These submodels indicate relationships among variables within a given level, and specify how variables at one level influence relations occurring at other levels (Bryk and Raudenbush 1992). This allows us to address questions concerning what variables at which levels of analysis really are more causally powerful. The debates about whether processes within national societies or world-system level processes are more powerful for explaining social change could be usefully studied using HLM (see Jorgenson 2003).

Multilevel GIS databases with time-coded data are being developed. Although HLM was invented to properly deal with the error structures such data engender, the original problems that led to the development of HLM techniques were not spatial in nature. However, spatial databases are naturally hierarchical with multiple levels of analysis—states, counties, cities, census tracts, nations, regional systems of nations, and world-systems—engendering both hierarchical and spatial error structures.[3] HLM in combination with GIS will allow us to estimate degrees of independence of processes as well as the causal power of variable characteristics of different levels of analysis.

The general comparative method of non-experimental research design assumes that "cases" (units of analysis) are independent instances of the process under study and spatial analysis programs such as *S3* have been developed primarily to correct for spatial autocorrelations (Ponicki and Gruenewald 1997). But when we compare national societies that are clearly not independent from one another in some respects, we want to model this non-independence by including measures of the international, transnational, or world-system level characteristics that are thought to be causes of the dependent variable under study. Currently available spatial analysis techniques have not been developed with these purposes in mind.

GIS can also profitably be combined with Network Analysis as it has been developed by mathematical sociologists of interaction patterns. Network Analysis studies the structure of interaction networks by means of quantitative measures of whole network and node characteristics. With appropriate data, network analysis can be used to examine multiple types of world-systems and interaction flows including capital, commodities, information, and people. Measures of network centrality can also be useful for studying world-systemic patterns over time. Analyzing the degree to which regional centers of finance, organization of production, markets, or political-military structures are at the center would offer evidence of the nature of overlapping interaction networks and entire world- systems.

Sociologists studying global city systems and organizational power in the modern world-economy have recently applied network analysis to their research. Using airline passenger flows between the world's leading cities during 1977 to 1997, Timberlake et al. and Smith and Timberlake measure characteristics of the global city system and its changes during this time period (Timberlake et al. 1999; Smith and Timberlake 1998, 2001). Smith and Timberlake argue that while it might be preferable or more effective to obtain data on capital or commodity flows between major cities, air passengers reflect connections in the network linking the world's cities (Smith and Timberlake 2001). These data indicate the face-to-face contacts between the corporate executives, government officials, international financiers, and entrepreneurs that "grease the wheels" of global production, finance, and commerce (Smith 2000; Smith and Timberlake 1998, 2001).

More recently, Jeffrey Kentor has used network analysis to study the growth of organizational power in the world-economy over a forty-year period (Kentor 2002). He identifies transnational corporate networks by locating the headquarters and foreign subsidiaries of the world's largest manufacturing corporations in the early 1960s to late 1990s. In addition to providing a descriptive analysis of the network characteristics and spatial distribution of ownership and location of subsidiaries, Kentor examines the impact of these network linkages on economic development in non-core countries. Using panel regression analysis, he finds that the number of country to country linkages has a positive effect on per capita GNP growth, while a high concentration of transnational corporate subsidiaries from a single headquarter country has a negative effect on economic development in the host country (Kentor 2002). Kentor's study illustrates how network analyses can provide powerful descriptions of the spatial contours of various forms of interaction networks and lead to more accurate causal explanations of domestic outcomes resulting from different types of structural globalization.[4]

Network analysis is a rather sophisticated analytic technique that is little known outside of mathematical sociology. This method can be used in connection with a GIS containing, for example, city populations, locations of cities, and measures of intercity trade, to analyze change over time in the structure of settlement systems. Linking with GIS-organized data can enhance this analytic approach to spatial relations. GIS has been used for geometric networks, a more elementary process that allows for the modeling of different infrastructures including highways, cables, and pipelines (Zeiler 1999). This suggests the feasibility of combining the two methods. Network analysis, currently a mainly descriptive tool, might also significantly benefit from new GIS and spatial analysis techniques that allow for tests of causality. It is the explicitly spatial aspect that has not been fully utilized in network analysis, which indicates distance only crudely as the number of links between nodes. A more explicit and nuanced incorporation of space into network analysis (Spatial Network Analysis) would provide a valuable tool for the study of social structures of many kinds.

## Conclusion

Waves of structural globalization characterize both the modern interstate system and earlier systems of societies. We define structural globalization as the increasing spatial scale and intensity of interaction networks. Interaction networks, the empirically determinable links among people and groups, are far superior to categorical attributes regarding regions for solving the problem of the spatial bounding of social systems. These allow us to examine the spatial nature of subgroups within societies as well as the important ways in which the members and organizations in different societies are connected with one another. We also see new techniques for using spatially coded data to analyze nested systems as promising tools that will help us to crack the codes of long-term social change and to compare earlier forms of structural globalization with the recent waves that have occurred in the nineteenth and twentieth centuries.

## NOTES

1 Down-the-line trade passes goods from group to group.

2 The *TimeMap*® Project (http://www.TimeMap®.net) tackles the isolation of cultural data through an explicit methodological approach to recording cultural data in time and space—a temporal geographical information system (TGIS). By defining a conceptual mapping between an explicit spatio-temporal data model (the Snapshot-Transition model) and the data actually recorded by any particular project (in whatever format), the methodology allows existing resources to be integrated into a unified structure and interrogated together (Johnson 2000).

3 HLM estimates are biased in the presence of spatial autocorrelation ("Galton's problem." Since spatial autocorrelation by nature contributes to, or increases, the chance of type two errors (false positives), this is a very dangerous thing to do statistically without isolating and adjusting for the spatial component of the error terms.

4 Sangmoon Kim and Eui-Hang Shin (2002) have also recently applied network analysis to a related study that examines the shifting network characteristics of trade between countries, and within and between regions in the world-economy during the period from 1959 to 1996.

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