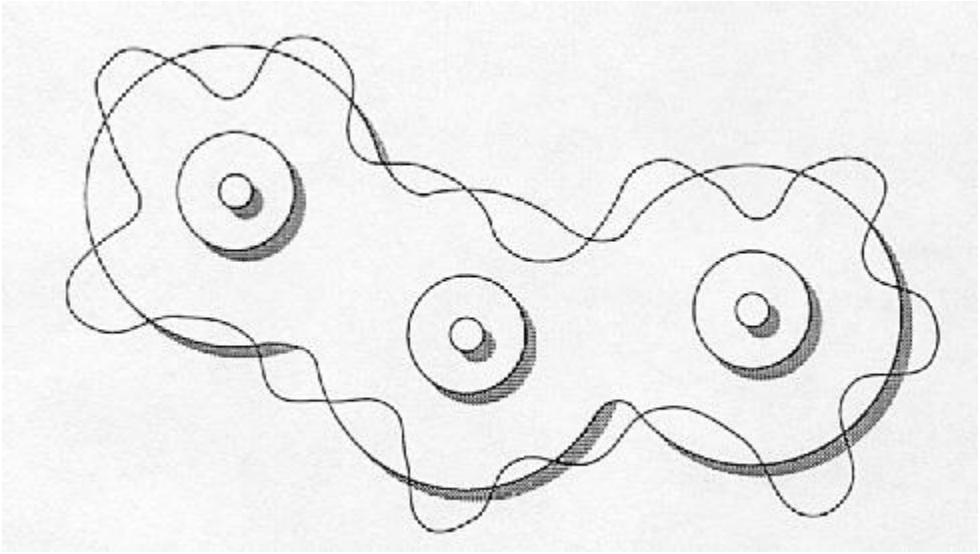
OUTER EDGES, LOGICAL BOUNDARIES AND OTHER CONTENTIOUS ISSUES IN THE SPATIO-TEMPORAL BOUNDING OF WHOLE SYSTEMIC INTERPOLITY NETWORKS



Three adjacent interpolity systems

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Abstract: Formal comparative methods require independent instances of processes for purposes of testing propositions about causal relations among variables. When the unit of analysis is whole interpolity systems (world-systems) the spatio-temporal bounding of these as separate and independent cases involves empirical and conceptual issues that have been debated by those scholars

who have tried to specify these boundaries. Endogeneity vs. exogenous impacts, how to operationalize the existence and magnitude of interactions, and the issue of the nature of different kinds of systemic logics (and interactions among them) are some of the contentious problems discussed in this paper.

The effort to find the best way to bound separate and independent social systems has been a perennial issue in the social sciences since at least the nineteenth century. And social boundaries have long been a contentious matter for human communities themselves, as the people became aware of their relationships with neighbors and distant others. Consciousness of distant others as well as actual objective interconnections with adjacent and distant peoples (whether comprehended or not), have expanded to include ideas about global society, space-ship Earth, and species-wide solidarity (humanism), as well as an emerging notion of global citizenship in contemporary world society. Efforts to understand structural globalization as the expansion and intensification of human interaction networks have focused both public and scholarly attention on how to conceptualize and measure interaction and on the facts of what happened regarding interaction networks in human prehistory and history.

The authors who have contributed to a recent collection that addresses the issues of systemic boundaries (Chase-Dunn and Inoue eds. 2022) specify and debate a set of proposed rules that are intended to enable the comparative testing of theoretical explanations of sociocultural evolution in interpolity systems (world-systems). These authors do not pretend that what they have proposed is the final word on these issues. But they do assert that the problems they are addressing are fundamental issues that need to be resolved if the project of testing explanations of the evolution of human social structures is to move forward.

The main unresolved issues we address in this paper are both conceptual and empirical. We also briefly consider the probable futures of structural globalization as well as efforts that are under way to produce better explanations of human sociocultural evolution. The remaining major conceptual issues that need further examination are:

- the distinctions between endogenous and exogenous social influences,
- the relations between network connections and systemic logics, and
- the whole network approach to systemic bounding proposed by Robert Hanneman in Chapter 3 of Chase-Dunn and Inoue (2022).

Another remaining empirical issue is the tentative nature of the estimates of the timing of the coming together of formerly separate systemic bulk goods, political/military and prestige goods trade networks as listed in Tables 2.1, 2.2 and 2.3 in Chapter 2 of Chase-Dunn and Inoue (2022). These tables are included in this paper in Appendix A. This paper also discusses some of the issues that stem from these estimations.

Endogenous and Exogenous Factors Affecting Human Sociocultural Evolution: "Durable" and "Substantial"

Part of the definition of systemic interaction is that it has substantial consequences for processes of social reproduction and for changing social structures, institutions and modes of accumulation. But exogenous factors may also have large consequences. Biological evolution was redirected about 70 billion years ago when a large asteroid slammed into the Yucatan Peninsula in Mexico. This produced a "nuclear winter" that was a major cause of the extermination of the dinosaurs. This was not an endogenous factor in the processes of biological evolution. It was a contingent (and fortuitous) exogenous event that vacated a huge set of ecological niches that could then be occupied by new forms of life (e.g., the mammals) that had been marginal before the impact. A huge body of research shows that non-anthropogenic climate change has been an important exogenous factor impacting the survival and development of human polities since the emergence of

modern humans. Recent research on human impacts on landscapes has shown that the intentional use of fire by humans has greatly modified local landscapes since the Pleistocene (Stephens *et al* 2019). But this was anthropogenic and so not exogenous. Ecological change and climate change have become partly endogenized into the processes of sociocultural evolution as human actions have caused the rise of the Anthropocene.

It is important to distinguish between those human influences that had important consequences but that were exogenous to local and regional processes of development from those influences that were part of an interactive system of development. Most explanations of sociocultural evolution have focused upon processes that have operated within single polities. The comparative world-systems perspective posits that systemic interaction processes operated in sets of interacting polities and that important conditioning processes operated both within and between these polities. The high bar approach advocated in Chapter 2 of Chase-Dunn and Inoue (2022) contends that the distinction between endogenous and exogenous human social influences is necessary for bounding autonomous systems for purposes of testing theories of sociocultural evolution.

Not all human influences that come from long distances are systemic even though some of them had large consequences for changing local production and interaction patterns. For small and medium-sized world-systems there were "external arenas" (substantially separate and independent other world-systems) that sometimes influenced local institutions and forms of interaction but that were exogenous to the strong developmental processes operating within largely independent interaction systems. For example, the knowledge of how to make Bronze diffused from the West across Central Asia to the valley of the Huang He (Yellow) River to become an important military and ritual element in Shang Civilization in the second millennium BCE.[1] This and other diffusions back and forth between East and West are alleged by some authors to be evidence of the early existence of a single Afroeurasian-wide world-system rather than exogenous influences between largely separate systems (e.g., Chapter 5 in Chase-Dunn and Inoue 2022). But Chapter 2 of Chase-Dunn and Inoue (2022) contends that a level of **substantial two-way interaction** was necessary between two locales for them have been parts of a single integrated world-system. And the criterion of durability employed by David Wilkinson for bounding Political-Military Networks (Chapter 4 in Chase-Dunn and Inoue 2022) was extended to Prestige Goods Networks and to Bulk Goods Networks and to Information/Communications Networks in Chapter 2 in Chase-Dunn and Inoue (2022). Temporary reciprocal connections and connections that are not substantial and lasting did not constitute high bar systemic linkages but were exogenous interactions between predominantly separate regional systems. The determination of what is meant by, and how to measure, "temporary" and "substantial" are issues that will need additional investigation and research as proposed below. But the distinction between exogenous and endogenous influences must be an important element in that investigation.

The discussion of Galton's problem in Chapter 1 of Chase-Dunn and Inoue (2022) notes that it is possible to control for exogenous influences by either selecting cases that are not subject to them or by operationalizing and measuring the exogenous influences and controlling them by including them in the explanatory model. This latter approach is desirable because it enables determination of the effects of exogenous variable and their comparison with endogenous variables.

[1] Other examples of exogenous diffusions that had big impacts, (sweet potatoes from the Andes to the Polynesian islands in the Pacific Ocean, maize planting in North America) are discussed in Chapter 1, Chase-Dunn and Inoue (2022). Philippe Beaujard's (2019) close study of interactions among East Africa, Madagascar, South Asia, and Island and Mainland Southeast Asia tells the story of how domesticated animals and plants diffused, often carried by Austronesian migrants and traders.

Incursions and migrations, the subject of William R. Thompson's Chapter 8 in Chase-Dunn and Inoue (2022), have obviously also been important instances in which formerly external arenas have had important impacts on regional world-systems [see also Thompson and Modelski (1998) and Korotayev (2003)]. Chapter 2 in Chase-Dunn and Inoue (2022)) delineates a high bar criterion for when an incursion should be treated as exogenous and when it should be treated as endogenous. Incursions in which a group invades a territory but is not under the control of the polity from which it came, or does not continue substantial and durable interactions with its polity of origin (e.g."sea peoples") do not constitute a systemic link with the polity from which the immigrants came. But if the invading group continues its relationship with its polity of origin, then it does constitute a systemic link (see Robert Denemark's study of the "Viking empire" in Chapter 9 in Chase-Dunn and Inoue (2022)).

The literature on world-systemic incorporation contends that even mild contacts can have important consequences [Hall (2012) and Tom Hall's Chapter 7 in Chase-Dunn and Inoue (2022)] Hall proposes that rather than employing just one method of bounding whole systemic systems it would be wise to use several methods of bounding and to compare the results. One could operationalize both high and low bar definitions of systemic boundaries to see what differences the definitions make. This is a very sensible suggestion.

One complication of the using systemic interaction networks is that the spatial boundaries of these change over time and so the unit of analysis requires accurate estimation of years in which the networks expanded.[2] The Settlements and Polities Research Working Group (SetPol) framework proposed by Chase-Dunn, Grell-Brisk and Inoue (2022) also proposes comparing results of cases in which systemic boundaries have been estimated with analyses of a set of **temporally constant world regions.** Several studies that do this have been produced.: the boundaries of ten temporally constant world regions were specified in a study of changes in the sizes of largest territorial states and empires (Chase-Dunn *et al* (2015a). The data appendix for that paper also compared Europe as a world region to the expanding Central Political-Military Network to see what difference it makes when we compare an expanding network with a temporally constant world region. The SetPol project has also used world regions to examine changes in the sizes of largest cities (Chase-Dunn *et al* 2015b).

Systemic Logics, Logical Boundaries, Network Connections and The Exogenous/Endogenous Issue

Regarding the distinction between network connections and systemic logics, the issue of endogeneity and exogeneity would seem to imply that we need to have explicit models of systemic logic to know which kinds of human interaction were endogenous and which kinds were exogenous. This would be a problem because the main purpose of specifying rules for designating separate autonomous world-systems is to enable us to use the comparative method to test theories of development and evolution. If we need those theories to designate our cases, we risk building the theories we want to test into the specification of the cases that we want to use the test the theories. It appears that we may have painted ourselves into a logical corner.

Chapter 1 of the Chase-Dunn and Inoue (2022) volume dismissed efforts to bound autonomous social systems based on systemic logics because these are a form of assuming homogeneity rather than allowing heterogeneity within systemic interaction networks. It was pointed out that interaction has often generated heterogeneity rather than homogeneity and several examples

[2] The current versions of these estimates that are contained in the Tables in the Appendix of this paper.

were given. This implies that similarities are not a good approach for bounding systemness, because interaction itself often produces differentiation instead of convergence. This idea was extended to include differences in modes of accumulation and systemic logics of interaction, and it was noted that empirically known interaction networks frequently contain polities that have different modes of accumulation. And it was asserted that evidence of interaction is easier to obtain than is evidence about spatial attributes of systemic logics and is therefore a more easily operationalizable approach for empirically bounding whole systems.

But the problem of endogeneity versus exogeneity complicates the idea that evidence of interaction is a simple indicator of systemness. The notion of endogeneity implies a logic of developmental/evolutionary interaction that is substantially self-contained and that can be used to distinguish between endogenous and exogenous interactions. But this has the problem mentioned above: it uses the theory to designate the cases that are be used to test the theory. This is a big problem.

The way out of this conundrum is to use indicators of exogeneity that do not require assumptions about systemic logic. The criteria of two-way interaction that is substantial and durable can be applied to indicate exogeneity without any assumptions about the nature of qualitatively different systemic logics. If we do this, we will not have conflated our method of spatiotemporal bounding with the theories of development/evolution that we want to test.

Empirical Issues: Measurement and the Accuracy of Temporal Estimates.

Regarding empirical issues, there are a lot of questions raised by the estimated years in Tables 2.1, 2.2 and 2.3 in Chapter 2 of Chase-Dunn and Inoue (2022) that specify when twenty-two bulk goods, political/military and prestige goods networks became merged or incorporated into other networks (see Appendix A, this paper). At the end of David Wilkinson's examination of transition issues in the unification of the Central, Far Eastern, and Indic states-systems in Chapter 4 of Chase-Dunn and Inoue (2022), he lists several transition issues that will require more investigation:

> And on the research agenda as well are the similar issues of states-system expansion and merger that need to be worked out as regards the timing and form of the incorporation of the state systems in Mesoamerica, the Andes, the many sub-Saharan African systems, Japan, and mainland and island Southeast Asia into the Central system during the process of modern politico-military globalization, as well as the linkages between the Indic system and Southeast Asia, the Central system and the Aegean, and even the fusion of Northeast African and Southwest Asian systems that birthed the Central system c. 1500 BC.

As was mentioned in Chapter 2 of Chase-Dunn and Inoue (2022), Claudio Cioffi-Revilla, and Todd Landman (1999) used inscriptions on stelae to study the Mayan states system. The excellent volume on the Postclassic Mesoamerican world-system organized by Michael E. Smith and Frances Berdan [Smith and Berdan (eds.) 2003] used both archaeological and ethnohistorical evidence on trade, warfare, and convergences of iconographic images to examine the nature of systemic interactions in Mesoamerica in the period from 1200 CE to the Spanish conquest. They used a high bar of systemness to explain that what became the Southwest of the United States (Arizona and New Mexico) and Northern Sonora (which they call the Greater Southwest) was external to the late postclassic Mesoamerican system despite the widespread use of turquoise from mines near what is now Santa Fe, New Mexico by the elites of postclassic Mesoamerica. They use the term "contact periphery" to designate the relationship between the Greater Southwest and the Mesoamerican system, but they are clear that they mean that the two regions were not systemically

connected because the distances were so great that the systemic processes in both regions were not substantially influencing each other.

And Matthew Des Lauriers's (2010) study of Cedros Island (off the Pacific coast of Baja California) contends that these islanders were not systemically connected with the peoples on the Baja peninsula from which they obtained obsidian. The indigenous polities of late prehistoric Cedros Island constituted a very small world-system of maritime-adapted diversified foragers that was only systemically connected with those coastal communities that were adjacent to the island according to Des Laurier.

The authors in the Smith and Berdan (2003) volume never mentioned the nomadic and sedentary polities that occupied the peninsula of Baja California. The extreme desertification that emerged in central Baja California about 7000 years ago constrained the possibilities for interpolity trade because most of the nomadic foraging bands did not have tradable surpluses and so their camps (rancherias) were small and were only occupied intermittently as people moved to where enough food and water were available. The big villages that emerged on late prehistoric Cedros Island (Huamalgua) did import obsidian from a distant source on the Baja peninsula, but Des Laurier (2010) concludes that they were not systemically connected beyond those peninsula fishing villages that were adjacent to Cedros Island.

There is ethnohistorical evidence that the Huamalguenos were producing processed seal skins for export, but Des Laurier does not deem this to have constituted a systemic link, and it is not known how far the seal skins may have traveled by down-the-line exchange. There was also no evidence of the use of proto-money like that which emerged on the Channel Islands of Alta California (Arnold 2004). So, this is another use of the high bar of systemness. The implication of this is that environmental conditions such as the scarcity of potable water and edible plants and animals available to neighboring polities constrained the development of complexity in the polities on Cedros Island even though the islanders had more water and more access to food. When neighboring polities do not produce tradeable surpluses there is little incentive to develop beyond subsistence production. It was the lack of water, and therefore of food, that reproduced the very small world-systems of Baja California by constraining the emergence of trade networks between non-adjacent polities.[3]

New archaeological and genomic research is making it possible to study the Mesoamerican, Andean, and African systems with even greater time depth (e.g. Jimenez 2020). But close knowledge of the timing, size and engaged combatants of battles and alliances that is needed to study the boundaries of a political-military network is difficult to glean from archaeological evidence alone and usually must rely on the availability of documents.[4] We have modified our earlier stance that archaeological evidence alone, in the absence of historical documents, is incapable of estimating the boundaries of empires in response to the thoughtful work of Michael E. Smith (2019). Smith (2019) outlined the ways in which archaeological and epigraphic evidence can be used to bound empires and the problems involved in doing this. He notes that some polities are organized as hierarchical

[3] And this same ecological constraint seems to have been the major contextual factor behind the nearly complete extermination of the indigenous populations of Baja California by the processes of incorporation into the Europe-centered system. The Jesuit and Franciscan missionaries, the Spanish soldiers, and the pearl fisheries eventually wiped out almost all the indigenous inhabitants in the Sothern two-thirds of Baja. The Jesuit process of "reduction" – using imported foodstuffs to entice the nomadic foragers into wearing clothes and living together in large groups, ostensibly to save their souls, resulted in recurrent epidemics that eventually killed off the people they were trying to save. The indigenes of Alta California were also demographically clobbered by missionization, settler massacres and endemic diseases, but enough of many of them survived to make a demographic comeback. Another irony: it was syphilis, a disease that originated in the Americas, that was the final death knell of the Baja indigenes (Aschmann 1959).

[4] See also Paris (2008)

links with persons rather than as links with a territorially-bounded polity, and that these person-centric polities often have very complicated and overlapping spatial boundaries. This complicates the problem of designating the spatial boundaries of polities. But Smiths proposed methods do not usefully provide archaeological methods for bounding of political-military networks. For these purposes documents remain a necessary type of evidence.

David Wilkinson has produced an insightful specification of the emergence of geopolitical world-systems in Africa and their linkages with each other and with the Central Political-Military Network (Wilkinson 2015). Four of these autonomous African Political-Military Networks designated by Wilkinson are included in the tables in Chapter 2 of Chase-Dunn and Inoue (2022) (in Appendix A of this paper): Egypt, West Africa, West Central Africa and East Africa. Wilkinson also thinks it likely that there may have been an autonomous Political-Military Network in the African Great Lakes region, and he lists thirteen other regions in Africa that either may have been autonomous states systems or that were linked with larger Political-Military Networks (see Figure 1).[5]

Evidence based on archaeologically visible survivable trade objects is good for ascertaining the rise and expansion of exchange networks. New and improved methods for doing this continue to emerge. Thorough archaeological surveys of large regions allow us to study how interaction networks and core/periphery relations changed over long periods of time (e.g. Feinman and Nicolas 2017 for a summary of the project that focused on the Valley of Oaxaca and some of its surrounding regions). New techniques for studying the human genome are allowing us to better distinguish between migrations and diffusions (Raff 2022). And less cumbersome techniques for sourcing obsidian (volcanic glass) have emerged (Millhauser, Rodríguez-Alegría and Glascock 2011). Regarding East Asia, there has been an explosion of new studies based on documentary evidence for trade and geopolitical interactions (e.g., Gunn 2018).

A lot of new work has been done on the Indian Ocean as a systemically linked world region (e.g., Beaujard 2005; 2019) and further archaeological and historical research on African settlement systems and trade will allow the addition of more independent networks (e.g. Kea 2004). Wilkinson also included Chibchan, a culture area on the Central American Isthmus and in Northern South America, as a possible interpolity system separate from the Andean and the Mesoamerican. If we examine world-systems with settlements smaller than ten thousand residents this enables the addition of a very large number of whole-system cases. Wilkinson also suggested that there was a separate Irish interpolity system (but see Chapter 9, Chase-Dunn and Inoue (2022)). Our estimates of the years in which non-Central interpolity networks and trade networks merged or were engulfed by one another need to be checked by area experts. The methods developed by the SESHAT project for coding degrees of certitude should be employed for improving the estimates in the appended tables.

[5] Recall that Wilkinson uses a largest city-size cut-off of 10,000 residents before he thinks that cities and states existed in a region. If we are also interested in world-systems with smaller settlements and less complex polities (chiefdoms) then all the regions he mentions were autonomous systems before the emergence of large settlements.

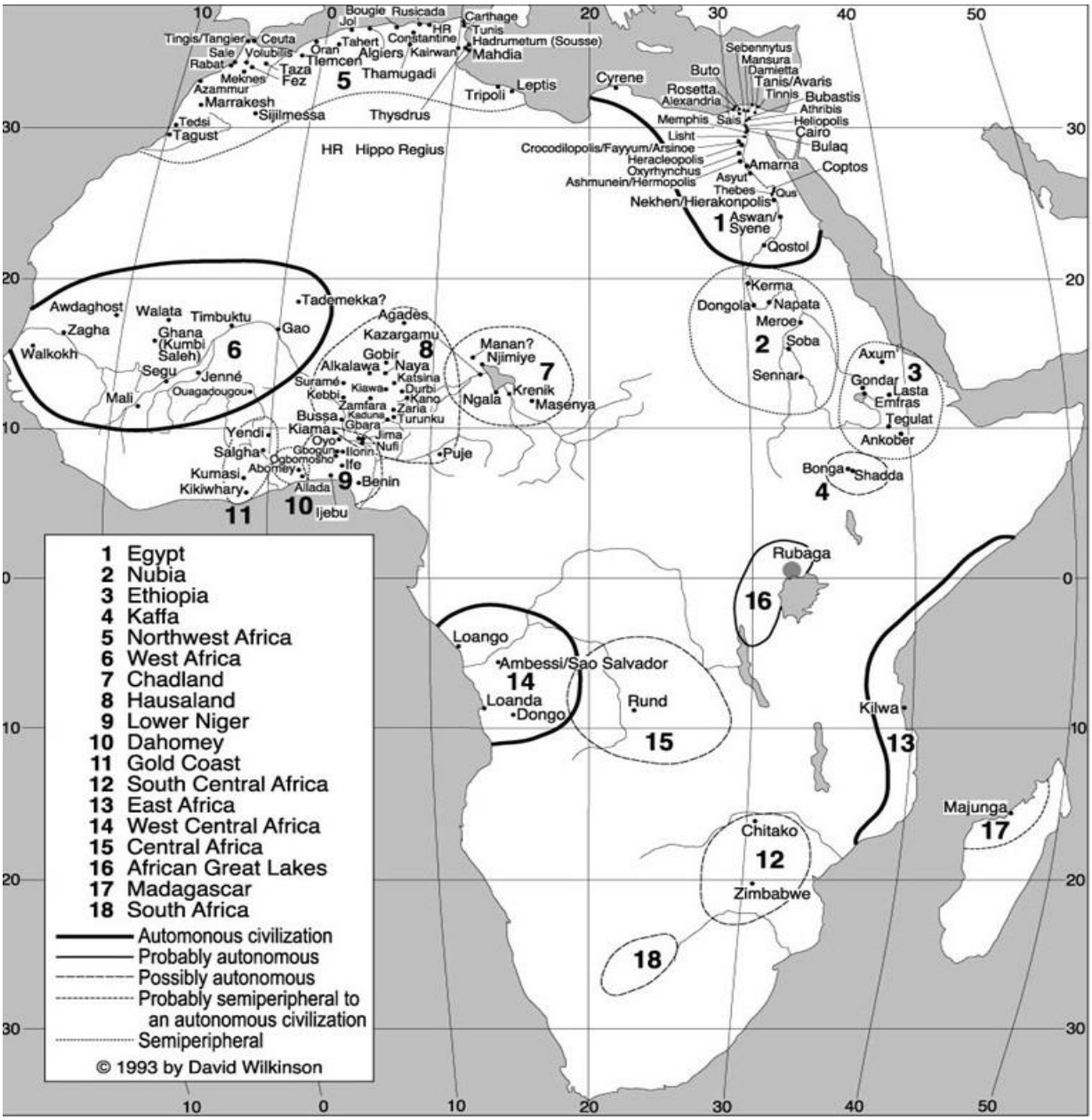


Figure 1: African Cities and Political-Military Networks, Sources: Wilkinson (1993, 2015)

Whole Networks vs. Place-Centricity

Chapter 3 in Chase-Dunn and Inoue (2022) by sociologist Robert Hanneman, proposes a method for using formal network analysis to bound interaction networks by using data on whole multidimensional networks focusing on cities as nodes. Multidimensional means that different kinds of links or interactions between cities can by analyzed separately or can be combined to produce a specification of modular regions based on the combination of different kinds of connectedness. Hanneman uses formal network analysis to calculate modularity – a measure of the degree to which groups of nodes have greater interactional density of ties relative to other groups of nodes in the territory being studied. He studies interactions among settlements (cities), which is a very good approach, and notes how social network analysis can be used to look at settlement networks while

also considering that groups of settlements are affiliated with one another by virtue of being within territorial states.

This is a promising alternative approach to spatially bounding interaction systems that does not require the place-centric and fall-off assumptions proposed in Chapters 1 and 2 of Chase-Dunn and Inoue 2022). Not having to designate a focal locale by having information about an entire network composed of nodes makes it possible, as Hanneman demonstrates with two empirical settlement networks, to allow the boundaries between sub-networks to emerge from the data. The modularity approach compares the connection densities among nodes to produce those sets of nodes that are more connected. Regions are subgroups of nodes that are more densely connected with one another than they are with nodes in other regions. Hanneman uses the Girvan-Newman modularity algorithm allows the picking of an optimal number of regions for a given set of nodes.[6] Hanneman also points out that groups of nodes can be analyzed in terms of shared characteristics such as having the same language or being part of a larger territorial state.

Hanneman uses two sets of settlements to illustrate how network modularity can divide a set of cities into groups that are more tightly connected with one another. The first network is a set of forty-four cities that were within the Roman Empire during the early Christian period. The second set is forty-nine cities that were trading with cities in Southern German states around 1500 CE. Neither of these cases plausibly contained whole world-systems. The regions produced by the modularity algorithm were subregions within either a single state (the Roman Empire) or within a small segment of the expanding Europe-centered world-system of the sixteenth century.
All world-systems are nested networks, with subregions within larger regions. Hanneman also notes that the trade networks in Central Europe designated in Peter Spufford's (2002) study were not complete networks because they were based on statistics from Southern German cities and states. To have complete network data it is important to know all the connections among all the nodes, not just the connections of some of the nodes. In practice this requires using trade data from all, or nearly all the nodes, not from a subset of nodes.

The method proposed by Hanneman has the great advantage of allowing the systemic networks to emerge from the data rather than being produced by the place-centric and fall-off constraints proposed in Chapters 1 and 2 of Chase-Dunn and Inoue (2022). What needs to be done is to apply this method to places and times for which true network-wide information on node interactions are available and that plausibly contain more than one interactive world-system. One danger in using historical collections is that they usually rely on records from one (or a few) particular location(s) (so-called ego-centric networks), which reintroduces place-centricity and provides only a sample of what the complete network would look like if information were available about all the connections of all the nodes.[7] The modularity approach needs to be tested using truly network-wide information about connections among nodes and for regions in which there is plausibly more than one world-system.

The modularity approach might produce a set of regions that would enable us to test the hypotheses about the eight interaction regions in 13th century CE Afroeurasia proposed by Janet Abu-Lughod (1989) (see Figure 2).[8] One huge advantage of the Hanneman modularity approach is

[6] Though in the examples given in Hanneman's Chapter 3, in Chase-Dunn and Inoue (2022)) there are instances in which the algorithm produces different numbers of regions with nearly the same degrees of connectedness. See discussion of Figure 3.3 in Chase-Dunn and Inoue (2022)

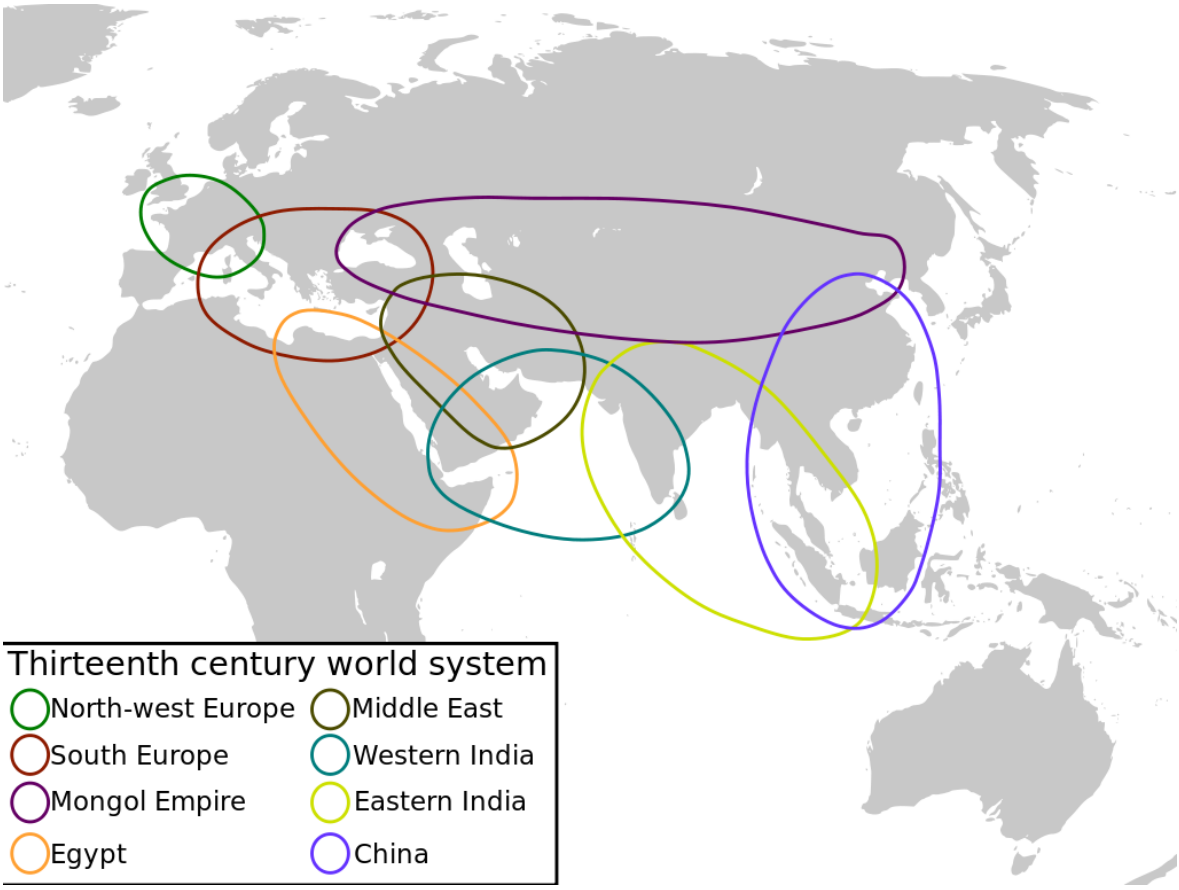
[7] This is especially a problem with the Ciolek's (2000) compilation of trade routes, which Hanneman used to indicate trade routes among Roman cities.

[8] Abu-Lughod's eight overlapping trade regions have been adopted as illustrating "archaic globalization" in the Wikipedia article on that topic.

that it makes it possible to study different kinds of interaction separately and to combine them. The nested network world-system structure posited in Chapter 1 of Chase-Dunn and Inoue (2022) could be empirically evaluated by looking at Bulk Goods networks, Political/Military networks, Prestige Goods networks, and Information networks separately and comparing them. Hanneman also suggests several ways for combining different kinds of interactions:

> An alternative general approach is to consider all the forms of relations among settlements simultaneously. There are a variety of ways that one might do this, and each conceptualizes the meaning of "region" and "boundary" in somewhat different ways. One method would be to scale the multiple relations to create a single quantitative index of the strengths of dyadic ties. A second approach could be to characterize the relation between the members of each dyad as having a qualitative type or profile, according to which types of ties predominate. Equivalence analysis could also be applied. Structural equivalence methods would identify settlements as being in the same region if they had similar patterns of ties to other specific settlements.

All three of these approaches should be tried. The single quantitative index could be used to examine what was said in Chapters 1 and 2 of Chas-Dunn and Inoue (2022) regarding the likelihood that the Bulk Goods and Political/Military networks are probably more systemic than the Prestige Goods and Information networks.[9]



[9] The World Historical Gazetteer project (http://whgazetteer.org/) is producing a huge data set of temporally scoped place records derived from historical sources that will be useful for producing more complete interaction networks.

Figure 2: Thirteenth century Afroeurasian globalization based on the Janet Abu-Lughod's *Before European Hegemony: The World System A.D. 1250-1350*
https://commons.wikimedia.org/wiki/File:Archaic_globalization.svg

This approach would be especially valuable for studying whole world regions such as the Indian Ocean or Afroeurasia or the global nineteenth century in which the East Asian and Europe-centered Political-Military Networks were merging.[10] Janet Abu-Lughod's focus on the Thirteenth century CE is totemic (see Figure 2), and now we have Philippe Beaujard's (2019) detailed and theoretically sophisticated world history that looks at Afroeurasia from the perspective of Madagascar and the Indian Ocean, but that covers a much longer period than Abu-Lughod did with the same geographical breadth. Beaujard's maps of the Afroeurasian world-system since the first millennium BCE (Beaujard, 2019, vol. I: p. 424 ff. and vol. II : pp. 110ff and 590ff) show his cycles of the expansion of regional world-systems as well as the locations of large cities, core areas and semiperipheral regions. The Hanneman modularity approach could be used to verify or modify Beaujard's depiction of systemic boundaries. If data were available on battles and alliances the Hanneman approach could also be used to test David Wilkinson's depiction of world-systems in Africa (see Figure 1 above).

Waves of Globalization and Deglobalization: Durability, Oscillations and Collapse

Structural globalization is defined as intensifying and expanding interconnectedness, a process that has been occurring since all humans were nomadic foragers in the Paleolithic. Annual migration circuits got smaller as bands got larger and population density increased. Staying longer in the winter camp was on the way to sedentism. The first year-round settlements emerged in the Mesolithic when some people moved down the food chain to harvest natural stands of grain and to hunt smaller animals and to fish. These were forms of the appropriation of nature that had faster recoveries and allowed for greater population density. This made it possible for people to stay in the same place and still get enough food. Village life also made it easier to have more children. And trade between settlements substituted for raiding and made larger populations possible. Horticulture emerged in places in which there were already sedentary foragers. It was more work than gathering, but allowed a larger population to be fed, increasing the sizes of villages.

The emergence of trading networks among diversified foragers is visible in the archaeological record in those instances in which goods were traded that are resistant to the ravages of time. Obsidian is volcanic glass. It can be chipped to make very sharp blades or projectile points. It can also be bombarded with x-rays to determine its chemical composition which allows archaeologists to distinguish between different obsidian outcrops. This geographical sourcing can be done on both finished tools and on "debitage," the waste chips that are produced during the process of toolmaking. Obsidian also begins absorbing moisture as soon as a new surface is exposed, so the depth of the absorption layer is a rough indicator of how long it has been since the piece was worked.

Obsidian was not available to all those peoples who were producing stone tools, but where it was available, we can use archaeological evidence to study the expansion and contraction of trade networks and we can see how obsidian from different sites was used across space.[11] We can also use

[10] The critique of Eurocentrism has produced some very good place-centric studies starting from mainland Southeast Asia (Lieberman 2003, 2009), or Central Asia (Barfield 1989; Beckwith 2009), but good close studies that focus on the whole Afroeurasian system are still rare.

[11] A valuable overview of obsidian studies in Mesoamerica is contained in the collection edited by Mark N. Levine and David M. Carballo (2014). Gary Feinman and Linda Nicolas (2020) use the collection of sourced obsidian they have

archaeological artifacts such as shells, or shell-beads (beads made from shells) to study the emergence and contraction of trade networks.

The long-run story of globalization is about the expansion of small interaction networks that merged with one another and became engulfed by larger ones to eventuate in the single global network of today. But human interaction networks contract as well as expand. The long-term expansion trend is broken up into several short or middle-run oscillations in which there were periods of geographical contraction and decreases in the spatial extent and intensity of exchange networks. These cycles can be seen in the archaeological evidence as having operated in the small world-system of Northern California. Chase-Dunn and Mann (1996:36, 140-141) discuss "pulsating" trade networks and describe archaeological evidence for the rise and fall of interpolity trade networks based on different kinds of shell beads that emerged to link the small-scale polities of Northern California with peoples in the Great Basin and in Central California. The first wave that linked the coast of Northern California with the Great Basin emerged from about 2000 BCE to 200 BCE, then contracted from 200 BCE to 700 CE, and then expanded again from 700 CE to 1500 CE. Beginning in the 16th century CE there was a major expansion within what became California based on a different kind of shell (clam disk beads), that linked Northern California with bead producers near Clear Lake in Central California who used clam shells obtained by trade from coastal Bodega Bay.

The high-bar durability rule that we have adopted from David Wilkinson would seem to occlude these oscillations (contractions), but the systemic boundaries approach can also be extended to pay greater attention to both the periods of expansion *and the periods of contraction*. Doing this would help us test explanations of the institutional and technological conditions that were needed to establish and maintain larger and more intense connectedness.[12]

Whereas it is true that all world-systems seem to exhibit cycles of trade expansion and contraction, studies of long-term change also show that periods of contraction and collapse have always been followed by renewed periods of expansion (Wilkinson 1995; Inoue *et al* 2012; Inoue *et al* 2015 Beaujard 2019: Volume 2.).

Modeling, Simulating and Testing Theories of Sociocultural Evolution

Macrosociologist Michael Mann (2016) argued that human world history, when traced as the patterned development of his four types of social power, does not reveal trends or patterns that can be understood as sociocultural evolution because the causes of the episodic and uneven emergence of complexity and hierarchy have not been well formulated or tested. We agree that the theorization of human social change has been distorted because most theorists use the wrong level of analysis – single polities instead of systems of interacting polities. The specification of decision rules for bounding whole systems has been intended to facilitate the use of the comparative method for formal testing of causal explanations of sociocultural evolution.

But the next problem is to develop theoretical models that explain the dynamics of interacting causes of the emergence and expansion of hierarchies and sociocultural complexity both within polities and in interpolity systems. Chase-Dunn and Hall (1997: Chapter 6) formulated an "iteration model" of whole world-systems that was intended to explain systemic continuities across small, medium, and large world-systems. Empirical studies of the causes of fluctuations in settlement sizes and the territorial sizes of polities reveal that some of the upsweeps of these kinds of scale were

assembled to study and interpret long-term changes in Mesoamerican trade networks and to focus on the nature of systemic interactions between Monte Alban and Teotihuacan.

[12] Chase-Dunn, Kim and Alvarez (2020) and Kim (2021) are studies that focus on recent periods of structural deglobalization

not explained by characteristics of whole world-systems but rather by processes operating within single polities. And so, Hiroko Inoue and Christopher Chase-Dunn (2021) have proposed a multilevel model inspired by the Goldstone/Turchin structural demographic model of state collapse (e.g. Turchin and Nefedov 2009) and the system-level iteration (spiral) model proposed in Chase-Dunn and Hall (1997). Philippe Beaujard (Chapter 11, Chase-Dunn and Inoue (2022)) also proposes a related causal model of world-system cycles before the sixteenth century CE. These models provide causal explanations, but not testing.

Formal quantitative models can be used to perform computational simulations in which the model's assumptions regarding the nature of causal connections among variables and the hypothesized quantitative forms of these relationships are specified (estimated) and then the models are run to see what happens. The big advantage of computational simulation modeling is that real data are not required. The inclusion of variables, the posited causal relations among the variables and the hypothesized quantitative nature of those connections are inspired by either knowledge of how things happened in particular cases or by knowledge about earlier explanations. The outcomes of these simulations can be compared with what is known to happen in the real world and unexpected results inform reexamination of the modeling assumptions.

Fletcher *et al* (2011) performed a computational simulation of comparative world-systems theory's iteration model of early small-scale human societies. The polities modeled were composed of sedentary foragers and simple horticulturalists that rely upon basic subsistence technologies and display low levels of internal differentiation. The world-systems theory's iteration model proposed by Chase-Dunn and Hall (1996: Chapter 6) integrated several processes of demographic regulation: environmental constraints, migration, circumscription. intra-polity conflict, and inter-polity warfare. Computer simulation of this model reveals that different degrees of resource richness, land area, and initial population size have important effects on the average population levels and the behavior of interacting polities. A well-known ecological phenomenon, "the paradox of enrichment," emerges when polities interact through warfare. Variations in the size and resources of local and regional areas, along with climatic variation, provide explanations of patterns of warfare in such systems. To make the iteration model compatible with other existing simulations of early human societal demographic regulation, the authors also demonstrated that the ability of polities to regulate fertility has large consequences for both population sizes and inter-polity relations. This initial simulation holds technology and social organization constant to examine the demographic consequences of resource use and competition among polities for resources.

Models can also be tested by finding plausible quantitative data that can be used as proxy measures for the variables in the model. Measurement error models can also be developed to help construct multivariable indicators. An example of the testing of a system-level model is provided by Peter Turchin's (2016) structural-demographic study of political strife in the United States over the past 200 years. Turchin evaluated his model by operationalizing the variables.[13]

For cross-world-system quantitative testing it would be desirable to have at least thirty separate world-systems instead of the twenty-two included in the tables in Appendix A. Thirty is a number that is widely understood as the minimum for testing multivariate statistical models. So, the extensions suggested above to the list of systems that can be spatio-temporally bounded to assure that they are non-overlapping, a requisite of the comparative method discussed in Chapter 1, would make the multilevel models of the kind proposed by Inoue and Chase-Dunn statistically testable using multiple regression. The practice of starting elsewhere to generate more whole non-

[13] Time series analyses using Granger test of antecedence can be used to infer causal relations among variables that are attributes of a single case using time points as the unit of analysis.

overlapping systems can benefit from the coding produced by the SESHAT Global History Data Bank that studies thirty targeted Natural Geographical Regions (SESHAT n.d.). The ArchaeoGLOBE Project (Lucas 2019) and the World Historical Gazetteer also contain valuable evidence that should be used to expand the number of independent world-system cases.

Qualitative comparative studies of world-systems are also an expanding cottage industry that need not wait for the building of a quantitative world-historical data set. New studies inspired by Andre Gunder Frank's (1997) *Reorient* and Giovanni Arrighi's (2008) *Adam Smith in Beijing* are reexamining 19th century so-called "Chinese stagnation" and the processes by which the Central and East Asian systems became connected (e.g., Gunn 2018; Ru 2020).[14]

The Future of Systemic Boundaries

Some might reasonably imagine that world-system boundaries have stopped expanding at the level of the whole Earth, but the processes of the expanded and intensified integration punctuated by periods of deglobalization is not done and may never be. The next few decades of the 21st century may well see a period of uneven deglobalization as discussed above, but if humanity can manage to survive another period of multipolarity and deglobalization there will probably be future waves of increasing integration and decline.

The problems that humanity has presented to itself in the 21st century are huge and frightening: anthropogenic climate change, massive global inequalities, waves of global pandemics, another phase of structural deglobalization, a new cold war between the declining hegemon (the United States) and a rising China and a resurgent Russia (Foster 2021), another wave of population pressure as the total human population reaches its peak, and the consequences of the changes in the age distribution that is part of the demographic transition from higher to lower death and birth rates. If these issues can be mediated while also avoiding interstate warfare with weapons of mass destruction, another upswing of globalization will emerge before the end of the 21st century. Global economic and political integration will very probably continue. And transportation and communications technologies will continue to reduce the tyranny of distance. Even if a major conflagration and sustained collapse occurs, it is likely that the survivors will try again and will eventually arrive back to a somewhat similar situation to the one that we now face.

The upward trajectory of globalization will probably continue in an eventual renewed phase after the current time of troubles. One question for social scientists and for humanity is whether the expansions of humanity into physical space (astrosociology) and cyberspace will qualitatively change the dynamics of development or will just be a somewhat evolved version of the global capitalism that has emerged in the late 20th and early 21st centuries (Bergesen 2019)? If human history and the patterns of sociocultural evolution are kept in mind, some things remain the same while other things go through qualitative transformations. A more democratic, humane, and sustainable global society is a possibility, but not an inevitability. We are somewhat optimistic that our species will be able to meet the challenges of the 21st century and to continue the evolution of sociocultural complexity that began in the Stone Age. Species are born, they live and the die, like regimes, polities, organizations, and individual humans. But humans (and the transhumans and our AI mind children) probably have a long future both on this planet and in space. We will probably survive the current time of troubles, but how far back we get knocked and how long it takes to recover are big issues. The important thing to do now is to remind each other that situations of the current kind have happened before and that ideas about a better world society and institutional experiments with those ideas will likely become relevant again at some point in the future.

[14] Ho-fung Hung's Chapter 14 (Chase-Dunn and Inoue (2022)) discusses the capabilities of East Asian capitalism in the seventeenth and eighteenth centuries.

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Appendix A: Years of merger or incorporation of twenty-two bulk goods, political-military and prestige goods network (from Chapter 2 of Chase-Dunn and Inoue (2022)

Bulk Goods Networks (BGN)	**Durably Linked or Engulfed (c.)**	**Notes (in most cases the estimated connections are later than for the PMN connections estimated in Table 2.2)**
Mesopotamian	1000 BCE	Merged with Egyptian at the beginning of the 1st millennium BCE
Egyptian	1000 BCE	Merged with Mesopotamian at the beginning of the 1st millennium BCE,
Aegean	400 BCE	May have been part of the Central BGN after 1000 BCE
South Asian (Indic)	1000 CE	
Japanese	1000 CE/ 1850 CE	Linked with East Asian BGN/ engulfed by Central in 19th century CE
East Asian	1900 CE	Linked with Central BGN
Mesoamerican	1800 CE	Engulfed by Central PGN, colonial agriculture may have been substantially linked earlier.
Northern California	1870 CE	Engulfed by Central BGN (see discussion above)
Southern California	1870 CE	Engulfed by Central BGN (see Patterson 2014)
Chibchan	1800 CE	Engulfed by Central BGN
Andean	1800 CE	Engulfed by the Central BGN
West African	1900 CE	Colonial economies
West Central African	1900 CE	Colonial economies
East African	1900 CE	Colonial economies
Mainland Southeast Asian	100 CE /1400 CE/ 1900 CE	Linked w East Asian BGN/ linked with South Asian BGN; linked w Central BGN (colonial economies) see Chapter 12, this volume.
Island Southeast Asia	1000 CE/1500 CE	Linked to South Asian East Asian BGNs/ Engulfed by Central BGN (Dutch colonial economy) see Chapter 12, this volume
Mississippian	1800 CE	The Old Northwest
Andean	1700 CE	Colonial economy
Hawaiian	1850 CE	Engulfed by the Central BGN; sugar

Irish	850 CE	Bulk goods carried along with prestige goods (see discussion above)
Scandinavian	1200 CE	Viking expansion becomes dependent on bulk goods from the Central BGN
Central	1000 BCE	Formed by the merger of Egyptian and Mesopotamian BGNs, and see above

Table 2.1: Twenty-two Bulk Goods Networks (BGNs) and the mergers and engulfments with other BGNs

Interpolity System (PMN)	**Durably Linked or Engulfed (c.)**	**notes**
Mesopotamian	1500 BCE	Merged with Egyptian PMN in the middle of the 2nd millennium BCE. See Chapter 1, this volume
Egyptian	1500 BCE	Merged with Mesopotamian PMN in the middle of the 2nd millennium BCE, see Chapter 1, this volume
Aegean	600 BCE	May have been part of the Central PMN after 1500 BCE
South Asian (Indic)	1850 CE	British Raj (see discussion above)
Japanese	650 CE/1850 CE	Linked to the East Asian PMN through Korea. Battle of Baekgang/ engulfed by Central PMN in 19th century CE
East Asian	1850 CE	See Chase-Dunn *et al* 2019 linked by European trading ports
Mesoamerican[15]	1550 CE	Engulfed by Central PMN
Northern California	1850	Engulfed by Central See Chase-Dunn and Mann (1998)
Southern California	1800	Engulfed by Central See Chapter 13, this volume and Chase-Dunn *et al* (2013)
Chibchan	1600 CE	Engulfed by Central PMN
Andean	1600 CE	Engulfed by the Central PMN
West African	1550 CE	Engulfed by Central PMN; Wilkinson (2015)
West Central African	1500 CE	Engulfed by Central PMN; Wilkinson (2015)[16]

[15] Cioffi-Revilla and Landman (1999) use inscriptions on stelae (stone monuments) to map out the Mayan PMN, a sub-system of the larger precontact Mesoamerican PMN [see also Blanton, Kowalewski and Feinman (1992) and Smith and Berdan (2003)].

[16] David Wilkinson (2015) says: "It seems clear that this area lost its politico-historical autonomy by 1506 and never regained it, becoming instead more deeply involved in the spheres of influence and the political struggles of the Central states system." Earlier political/military and trade interactions, including Austronesian incursions, are discussed in Beaujard 2019: Volume 2.

East African	1500 CE	Engulfed by Central PMN Wilkinson (2015) [17]
Mainland Southeast Asian	200 BCE /1000 CE/ 1900 CE	Han military engagement with Vietnam/ link with South Asian PMN; French and British colonies, see Chapter 12, this volume
Island Southeast Asia	600 CE/1500 CE	First Linked to South Asian PMN and East Asian PMN/ Engulfed by Central PMN (Portuguese and Dutch colonies) see Chapter 12, this volume
Mississippian	1700 CE	Collapsed. Remains engulfed by Central PMN
Andean	1600 CE	Pizarro
Hawaiian	1900 CE	Engulfed by the Central PMN
Irish	700 CE/850 CE	Engulfed by the Scandinavian PMN (see Chapter 9, this volume) which then linked with the Central PMN
Scandinavian	850 CE	Incursions link to Central PMN (see Chapter 9 this volume)
Central	1500 BCE	Formed by the merger of Egyptian and Mesopotamian.

Table 2.2: Twenty-two interpolity systems (PMNs): mergers and engulfments with other PMNs

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Prestige Goods Trade Network	**Durably Merged or Engulfed (c.)**	**notes**
Mesopotamia	3000 BCE	Mesopotamian and Egyptian PGNs merged, see Chapter 10, this volume
Egypt	3000 BCE	Mesopotamian and Egyptian PGNs merged, see Chapter 10, this volume
Aegean	1800 BCE	Linked with Central PGN
South Asian	1000 BCE	Linked to Central PGN by Dilmun by 2000 BCE but not durably
Japanese	500 BCE	Japan traded iron tools and weapons from the East Asian PGN (see Chapter 15, this volume)
East Asian	1000 CE	Merged with Central PGN. Earlier Silk Road links were temporary.
Mesoamerican	1600 CE	Engulfed by Central PMN
Chibchan	1600 CE	Engulfed by the Central PGN
Andean	1600 CE	Engulfed by the Central PGN

[17] David Wilkinson (2015) says: "The isolated autonomy of the East African civilization will then have ended in 1502, in consequence of Portuguese threats, landings, force, tribute and vassalization. "

West African	600 CE	Gold. Wilkinson (2015)
West Central African	1400 CE	Linked with Central PGN
East African	1000 CE	Beaujard (2019: Volume 2)
Hawaiian	1825 CE	Engulfed by Central PGN, Sandalwood, Sugar
Mainland Southeast Asian	500 CE/1000 CE/1500 CE	Linked with East Asian PGN (Funan)/linked with South Asian PGN/linked with Central PGN. See Chapter 12, this volume.
Island Southeast Asia	400 CE/1500 CE	First linked with South Asian/ 1500 Portuguese colonies link it with Central. See Chapter 12, this volume
Mississippian	1600 CE	May have been linked to Mesoamerican PGN in the late Mississippian (Southern Cult)
Northern California	1850 CE	Engulfed by Central See Chase-Dunn and Mann (1998)
Southern California	1800 CE	Engulfed by Central See Chase-Dunn *et al* (2013); Patterson (2014)
Andean	1500 CE	Engulfed by Central PGN
Irish	2500 BCE	Irish trade with Bronze Age Atlantic Central PMN; (See Chapter 9, this volume)
Scandinavian	850 CE	Linked with Central PGN (See Chapter 9, this volume)
Central	3000 BCE	Mesopotamian and Egyptian PGNs merged

Table 2.3: Twenty-two Prestige Goods Trade Networks (PGNs), mergers or engulfments with other PGNs