

RESEARCH ARTICLE

# Disruptive innovation in the economic organization of China and the West

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## Abstract

We explore how macro and micro networks influence the diffusion of technological innovation and cultural/social behavior. Across the historical regimes in China and Europe, dynastic lordship's macro networks afforded different advantages in technological innovation. A network particular to Europe, the Roman Church, extended deep into local parishes with ethical norms prescribing fairness to strangers, and these cultural foundations helped guilds, trade associations, merchant courts, and universities operate cooperatively far beyond kinship. In contrast, Chinese emperors relied on ancient Confucian moral codes and system-spanning Confucian-educated officialdom; but fiscal limitations compelled officials to defer to local lineage orders, resulting in an enduring cultural pattern of *guanxi* and a polity whose institutional problem-solving capacity falter beyond the local level. Yet the civil service system has enabled China to outperform similar lineage-dependent regimes. Probing network topologies, we find that system-spanning networks can facilitate technological diffusion, but local networks influence cultural and behavioral change.

**Key words:** Comparative development; cultural persistence; economic structure; Europe and China; networks; political economy; social innovation

## 1. Introduction: network structure and function in historical regimes

In the modern world, information sharing is everywhere, and it is easy to see how information technologies accelerate the dynamics of interdependence within and among nations. Yet one can also find, in the premodern blending of beliefs and institutions of many sparsely governed societies, a unity of the collective. In this comparison of two historical societies, China and Western Europe, we observe how system topographies influenced discrete patterns of node agglomeration, and from their resulting networks, we can discover how information diffused across populations and functioned to underpin systems of innovation.<sup>1</sup> We will explore the particular diffusion mechanisms that permitted the long-lived historical regimes in Europe and China, long before the appearance of communication technologies, to scale from their original tribal and village networks into broader communities, kingdoms, states, and ultimately civilizations, capable of coordinating complex, multilayered functions of leadership succession, property transfer, the mobilization of revenue and arms, and the development of codes of conduct and moral persuasion.

We find that that identifying the topologies within a large-scale network is key to understanding the dynamics of how information and technological change spread. System-spanning networks can facilitate technological diffusion, but the network for technological diffusion and those for cultural

<sup>1</sup>Networks grow because they accumulate more nodes, not because nodes grow larger.

or social behavior are not the same. Local networks have greater influence over cultural and behavioral change. Understanding the role network topology plays in technological and sociological transitions allows a contextualization of China's competition with the West not found in other models of societal change.

Indeed, scholars who focus on questions of long-term cultural and institutional differences between China and the West offer rival explanations based in economic, geographic, demographic, or political interpretations, but one theme is consistent: China was centralized, while Europe was not.<sup>2</sup> Yet decentralized Europe was not entirely decomposable into separate units. System-spanning network structures existed in both early China and Western Europe that made the behaviors of each component depend upon the behaviors of all other components, and this raises an important question: How does a system's overall design, its network structure, affect its cultural and institutional emergence at both the micro and macro levels?<sup>3</sup>

*2 Macro-Level Connectivity* looks at one such network structure, the macro-level system of royal and aristocratic dynasties across both premodern China and the West, and the network properties that enabled the role of hereditary succession. In both cultures, hereditary lordship arose for the purpose of expanding reach and power – in 'network language,' to enable and increase connectivity across wider swaths of the environment. We examine how senior-level political structures affected elite recruitment and social mobility, and shaped center-to-periphery connectivity with impacts on innovation, long-term growth trajectory, and system stability (Hedström, 2005; Hedström and Swedberg, 1998).

*3 The Organization of Cooperation in Local Networks* examines variations in the diffusion of interpersonal trust, cultural norms, and moral protocols at local levels, with feedbacks that reached back to affect the macro system itself. We trace how the European capacity to anonymize market transactions at local levels allowed the macro structure of continental society to transition into an 'open access order.' In China, meanwhile, subnetworks built on kinship or personalized markers of trustworthiness are able to proliferate but not to develop into autonomous institutions in parallel with the state. Taking into particular consideration the fact that China lacks any historical equivalent to the trust-building networks that were fundamental to Western Europe's institutional development, we infer that the differences in the network topology that originate in ancient times continue to shape the evolution of these two societies and afford different advantages to the spread of information in each.

## 2. Macro-level connectivity

### 2.1 The emergence of network structure that enables regime formation

Discoveries in network science have made the characteristics of several major network structures ripe for exploration. The focus of social network analysis has shifted from single-node centrality and small-graph connection mapping to consideration of the large-scale properties of the graph (the network structure) itself. Not only can we study particular networks, e.g., the interaction of private and public hierarchies; the rise and fall of organizations of trade and finance; marriage; ethnicity; or patterns of residential discrimination within cities. We can now extend the range of the analysis to large networks and systems, from which we can collect global information about these network structures, such as the existence of their underlying characteristics that pervade the entire social system.<sup>4</sup> These structural characteristics give rise to the mechanisms that enable system-level connectivity and the diffusion

<sup>2</sup>Europe's dynamism is attributed to its decentralized interstate competition in (Bloch, 2014: 431; Greif and Tabellini, 2010; Ko *et al.*, 2018; Landes, 2006; Mokyr, 1990: 231; Rosenberg and Birdzell, 1986). Other scholars who rely on the paradigm of the competitive state system versus a unified imperium include Montesquieu (trans. 1900); (Diamond, 2005; Parker, 1996, 2008; Wallerstein, 2004; Weber, 1927).

<sup>3</sup>In this analysis systems are hierarchical assemblages of networks.

<sup>4</sup>Complex networks are explored in (Borgatti *et al.*, 2017; Kirman, 2016; Newman, 2003; Newman *et al.*, 2006; Vega-Redondo, 2007). On historical social networks, see (Kerschbaumer *et al.*, 2020). How networks come into being, not whether they did or not, but how they did and in the different ways that they did remains unanswered?

of innovation for large-scale cooperation – and ensure that the systems themselves coevolve with the communities they support.

Network analysis shows us that China and the West share a property common to other large-scale systems, even though they evolved independently. Both are structured as small worlds, meaning that any node in the network can reach any other node by a small number of steps. In a foundational contribution to network analysis, Granovetter (1973) demonstrated the importance that even ‘weak’ ties can play in social networks because of their embedded links. This insight underpins a conceptual breakthrough by Watts and Strogatz (1998), who solved the puzzle of how to enable information diffusion to move from local clusters out across a wider network. They showed how a ring network transforms from a world of randomly scattered clusters, or communities, into a small world simply by adding a few random links connecting those clusters. The ring network had only to display both numerous local clusters, which they termed a *high clustering coefficient*, and short average *path lengths* between clusters (‘short’ here does not refer to measurable distance, but to efficiency, as in the number of steps, or the path length).<sup>5</sup> It takes only a few ‘bridge nodes’ (the connecting and intermediate nodes) and ‘bridges’ (links) between large clusters to facilitate information flow and help spread information from any part of the network to its other parts (Barabasi, 2003; Watts, 2004).<sup>6</sup> Introducing long bridges into separate clusters can dramatically reduce path length and the ‘degrees of separation of the population and thereby increase the speed’ of information diffusion across the greater network (Centola and Macy, 2007).

Even the emergence of a few hubs, or pivotal clusters, can shorten the average path length so that information can ‘bridge’ the distance and diffuse quickly. The essential significance of this small-world connectivity in social organization and regime formation derives from its capacity to spread information while minimizing the number of links required to do so.

## 2.2 *The royal origins of system stability in China and the west*

In the historical regimes of both China and Europe, the royal houses, secured as they were by accepted customs and rules, served as both path shorteners and bridge nodes. In their role as system-spanning path shorteners in China and in Europe, the royal houses along with the Church, more than any other network (merchants, nobles, scholars), were responsible for the macro-political stability of the entire system. In both China and the West, the demise of the royal system would have been more impactful than the elimination of any other network because it had power, wealth, and reach enough to enhance the efficiency of communication across the wider network. An important difference was that in Europe the rules by which the royal lineages could claim legitimacy had the backing of the Roman Church, which offered ceremonial anointment to the monarchs and preferred political segmentation so that it could more readily project its own power. This worked to maintain the persistence of the overlapping coalitions of intermarried royal families, their alliances with one another and with the Church, prevented any single lineage from eliminating its rivals and becoming a hegemon.

In both regimes, rule through dynastic succession was the overarching basis of system-level stability. Despite the fact that each system arose in relative isolation from the other and at about the same time, in both regions, monarchs acquired the right to bequeath their status and privileges to their children.<sup>7</sup>

<sup>5</sup>By adding a few random long links to bridge the circle of their ring model. The idea of ‘six degrees of separation,’ memorialized on Broadway in the 1990s, is a small-world phenomenon common to social networks. Long before the idea became popularized, Travers and Milgram (1969) showed that the modern communications infrastructure could be modeled as a ‘small world.’ Their model assumes first-world communication infrastructure, whereas we explore its application to social relationships before electrical circuitry or steamships.

<sup>6</sup>Centola and Macy (2007) model generative mechanisms that diffuse complex contagions along complex social topologies. Related work in computer science (Kleinberg, 2000), epidemiology (Keeling, 1999); and physics (Newman *et al.*, 2001) all reveals how randomly placed long-distance links can influence social diffusion processes. Structural properties affect communication in (Albert *et al.*, 1999); and (Dodds *et al.*, 2003). Influence dynamics across virtual networks are discussed in (Backstrom *et al.*, 2006).

<sup>7</sup>Designating clear lines of dynastic succession became an essential contribution to the formation of durable regimes and therefore to the scaling up of social complexity. In Kokkonen and Sundell (2014) primogeniture is more stable than

This sets both systems apart from the Roman, Ottoman, and Mughal empires, among the many historical meta-regimes that failed to codify the rules for hereditary kingship.<sup>8</sup> In Rome, for example, while there was a general inheritance to male heirs, emperors typically chose a successor – usually a family member, sometimes an adopted heir – and the symbolic consent of the Senate and the generals was a critical factor. Neither an emperor nor his heir acquired an intrinsic ‘right’ to rule, opening the door to contestation (Keith, 2009). The rules of succession became one of the reasons that China, from late medieval through modern times – i.e., from Mongolic Yuan (1206–1368) up to 1840s of the early Manchurian Qing – was able to sustain a complex state-based social capacity that far exceeded the longevity of the Mongol, Ottoman, or Mughal empires found in the center of Eurasia, in which disputes among distant relatives were more likely to end in civil war or invasion by a rival power.

In both China and Western Europe, lordship succession was usually via agnatic, or patrilineal, primogeniture. In Europe, primogeniture stabilized the feudal system and facilitated its spread during the 11th century from the polities of the former Carolingian empire, then eastward in the 12th and 13th centuries.<sup>9</sup> Shielding the estates of feudal lords from fragmentation, the primogeniture system also bolstered their ability to fulfill their military obligations to the king. Inevitably this geopolitical security came at the price of perpetuating their wealth, power, and social standing.<sup>10</sup> It also made state building and capacity dependent upon the cooperation of noble families, enabling their rights to be memorialized in constitutional settlements that constrained the scope of royal discretion. Democracy sprang from these compacts between elites and rulers. In China, there were treatises on morality and ethics, such as the *Ancestral Injunctions* (1375), but these were not constitutions, nor was there any institutionalization of formal consultative procedures with noble families. As potential sources of intra-elite conflict, noble lineages were more likely to be viewed as threats to the incumbent imperial line.

Because European royals often failed to produce male heirs, hereditary lordship did not eliminate every category of disputed succession for Europe’s feudal rulers. For example, in a chapter of history made famous by William Shakespeare, when the English King Henry V invaded France in 1415, it was on the basis of a dynastic claim to the throne of France through the female line. The Church had its own rules and tolerated neither divorce nor concubinage; nor did it recognize illegitimate offspring. This made royal lineages vulnerable if there was no male heir and created a category of contention – female-line heirs with competing claims – that triggered frequent succession disputes and wars.<sup>11</sup> By contrast, when an imperial dynasty collapsed in China, it was usually not for

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alternative succession arrangements in a sample of contemporary authoritarian regimes. The introduction of automatic hereditary succession in an autocracy limits the number of coups conducted by challenger in Kurrild-Klitgaard (2004).

<sup>8</sup>While imperial rule has a 4000-year history in China, the successful usurpation by contesting lines ended after the Song dynasty (960–1279); from that point onward, dynastic succession followed clear rules.

<sup>9</sup>Over the course of medieval history, the former regions of the Carolingian Empire, including Aragon, Austria, Bavaria, the Duchy of Milan, Florence, France, Navarre, and Prussia, adopted primogeniture.

<sup>10</sup>The Western Church also recognized nonroyal primogeniture, thereby strengthening these elite lineages. In *An Inquiry into the Nature and Causes of the Wealth of Nations*, Adam Smith explains the political economy logic of primogeniture: ‘When land was considered as the means, not of subsistence merely, but of power and protection, it was thought better that it should descend undivided to one. In those disorderly times, every great landlord was a sort of petty prince. His tenants were his subjects. He was their judge, and in some respects their legislator in peace and their leader in war. He made war according to his own discretion, frequently against his neighbors, and sometimes against his sovereign. The security of a landed estate, therefore, the protection which its owner could afford to those who dwelt on it, depended upon its greatness. To divide it was to ruin it, and to expose every part of it to be oppressed and swallowed up by the incursions of its neighbors’ (Smith, 1776: 306).

<sup>11</sup>A smooth leadership transition reduces conflicts that place existing institutional and social balance at risk with harmful effects on economic development (Acharya and Lee, 2019). The Norman kingdom of Italy owes its decline to an inability to produce male heirs. The Hundred Years’ War (1337–1453) between England and France was precipitated by a dispute over female inheritance. Most succession conflicts were generally short affairs until the Wars of Religion (1562–98), which ruptured the Church and raised the stakes of obtaining the throne, adding another dimension to the quest for power, since it gave royals more control over the appointment of bishops within their jurisdiction, as well as greater sway over confessional matters.

lack of a male heir. Emperors could amass extensive harems to breed male successors. Concubinage contributed to intermediate regime durability, reducing the danger of a succession crisis.<sup>12</sup> As a result, crises of dynastic succession were less frequent in China, which enabled stability and prosperity over a large territory and longer periods.

European succession conflicts, although more frequent than in China, did not threaten the wider network of intermarried royal lineages that crisscrossed the continent and undergirded the stability of the system at large.<sup>13</sup> In many instances, disputes resulted in new alliances between the lineages that had advanced rival claims to the unoccupied throne. Even when failure to produce an heir resulted in the extinction of an entire lineage, connectivity among the remaining royal houses would simply reroute, preserving the macro-level continuity of the system. These important differences in the system-level properties of stability and resilience in the state development of each will be discussed in a subsequent section.

### *2.3 Patterns of interconnectivity create system-level variation*

The philosophy of imperial governance constant throughout much of Chinese history was for the core–periphery connectivity to pass through a single monarch. The emperor sought to deter regional hubs from challenging imperial control by building networks of connectivity with one another that could segment the polity. Since hierarchical structures do not guarantee that information will flow in both directions, the Imperial authority faced the dilemma that the policies designed to prevent rival elites from forming also prevented information from flowing from the regions to the center. Chinese rulers addressed this vulnerability by the development of an administrative mechanism that was unique in world history.

Beginning with the Sui dynasty (581–618), the throne established a state system of Confucian officialdom. The mandarin, a civil service that was eventually recruited by an imperial examination system and which made important official appointments and managed systemwide feedback, was the mechanism created to transport information from one point to the next across the far-flung empire. The mandarin enabled Chinese rulers to engage in strategies of state making and to acquire a lead in technological and scientific innovations that took Europe hundreds of years to overcome.

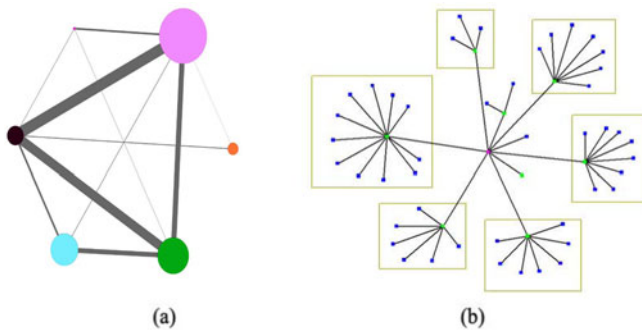
Although the goal was always for the central node to guide network growth in accordance with principles that enhanced its supervision over all the other nodes, in practice the emperor could never achieve anything that resembled absolute political centrality. The top-down distribution of imperial administration allowed for rapid diffusion of approved innovations but lacked adequate resources to manage the moral and material welfare of local communities, thus compelling a coalescence of state officialdom with local lineage orders. This weakness, embedded systemically and organically in China's network structure of political authority.

The continental network of international royal houses in Europe secured system durability and enabled economic and legal change to occur within a common context. [Figure 1.2](#) charts the marriage network of the European royal houses from the 14th century, the Late Medieval Period, through the 20th century. The small-world network of royal families constituted the core–periphery network for over six centuries, yet their alliances through marriage also caused the segmentations that account in large part for the identities and national boundaries of European states. Despite this segmentation into national identities, Europe retained the property of a 'nearly decomposable system.'<sup>14</sup>

<sup>12</sup>The longevity of Chinese rulers exceeded that of their European counterparts, providing stability and prosperity over a large territory (Wang, 2018).

<sup>13</sup>Royal families connected by ties were less likely to fight wars (Benzell and Cooke, 2021).

<sup>14</sup>Western Europe meets Herbert Simon's criteria of a 'nearly decomposable' system (1962) in which each unit is a subunit of a potentially higher level of organization. Should the system break apart, it would not have to be reassembled from scratch. Each unit would revert to its last sub-assembly level. The advantage a system gains from being nearly decomposable is that overall fitness will increase at a faster rate than systems without this quality.



**Figure 1.** Structure of core-periphery connectivity in European and Chinese royal networks: Western Europe developed small-world connectivity (a) while growing a distributed network structure, with some nodes growing into hubs as they attracted more connections. This concentration of connections in a few hubs simplified relationships between power clusters. The node size represents betweenness centrality, or how often a given node falls along the shortest path between any two other nodes. Line thickness is proportional to the number of marriages between two houses. By contrast, in China's starlike network structure (b), the emperor and court at the center control whether or not to share information originating from other hubs, thus reducing, although not eliminating, the prospects for alliances among the subunits.

Figure 2 illustrates how the connectivity of periphery nodes to the core nodes follows discrete patterns that produce cohesion throughout the entire network. The network exhibits mixed features of small-world, a short average path length and a high clustering coefficient with a few large hubs that are highly connected with the smaller nodes across the system, (Figure 3). Some royal lineages were more successful at accumulating webs of influence by increasing their ties with other lineages, but the multiple great families that formed kept the others in check, preventing any one from swallowing up all the others and arresting the evolution of the system, as occurred in China.

This kind of distributed network actually gained stability by adding new nodes. Kings had to acquire the skill to assemble a patchwork of multiple jurisdictions with pledges to protect administrative, fiscal, legal, and linguistic liberties from challengers. This way of attracting potentially useful allies led to a forbearance of subsidiary connectivity, preserving a diversity of local economic contexts. Throughout medieval and early-modern European history, this process of preferential node attachment differentiated the network growth of the interconnected royals from that in China, in which social groups were prevented from establishing autonomous zones independent of the state.

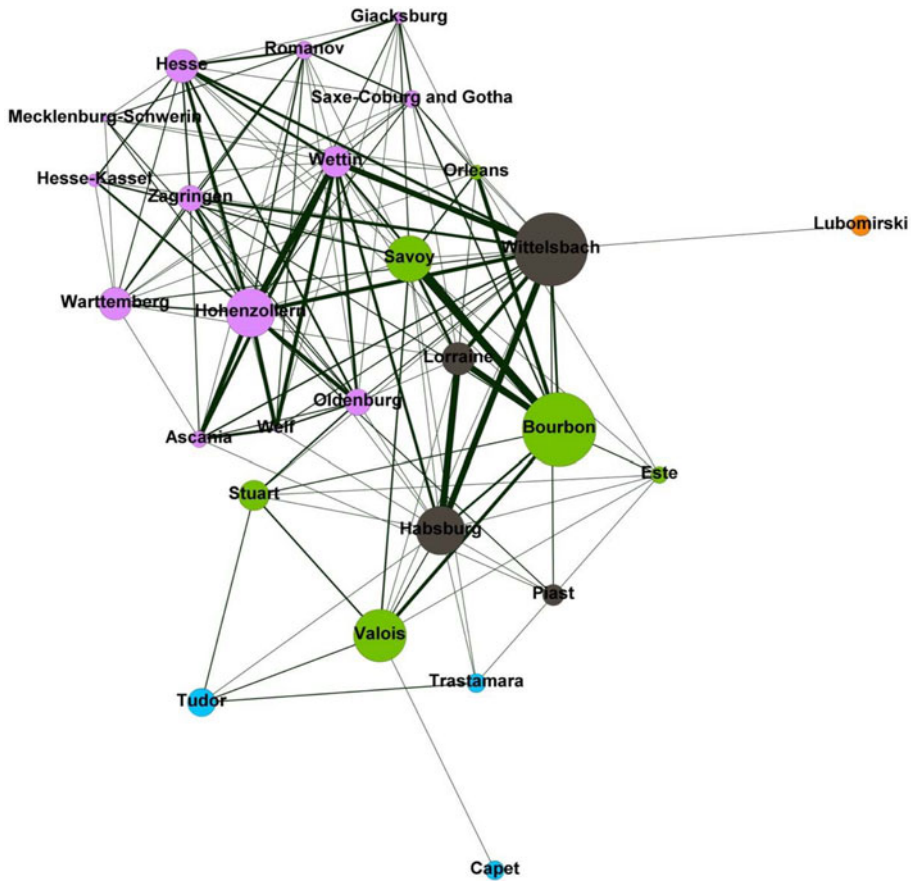
In sum, the European sovereigns depended more on partnering with autonomous institutions and increased their central power by working with traditional elites and integrating those elites into the state's growing orbit. Not until the 17th century did the European royals start to recruit sufficient administrative staffs to create dedicated systems of local public administration, and it was not until the 19th century that these systems began to professionalize with their own educational curriculums. Royal lineages in Scandinavia, the United Kingdom and the Netherlands that worked with representative bodies of elites often had greater longevity than those in southern and central Europe which opposed or repressed them (Van Zanden *et al.*, 2011).

#### 2.4 Network structure, information diffusion and disruptive innovation in Europe

Both Europe and China shared the small-world properties of high local connectivity and relatively short average path length, but because Europe comprised many hubs with their own highly skewed degree distributions, monarchs there faced constraints that Chinese emperors were able to avoid.<sup>15</sup> In the former, the topologies that facilitated information flow via private universities, guilds, courts, trade, monasteries, and religious confraternities from one part of the continent to others left Europe's monarchs powerless to stem the spread of disruptive ideas and innovation, or to control systems of production and ensure the state's grip over the economy.

<sup>15</sup>Short paths are defined in relationship to the size of the network. The average path length is short if it grows slowly with the size of the network.



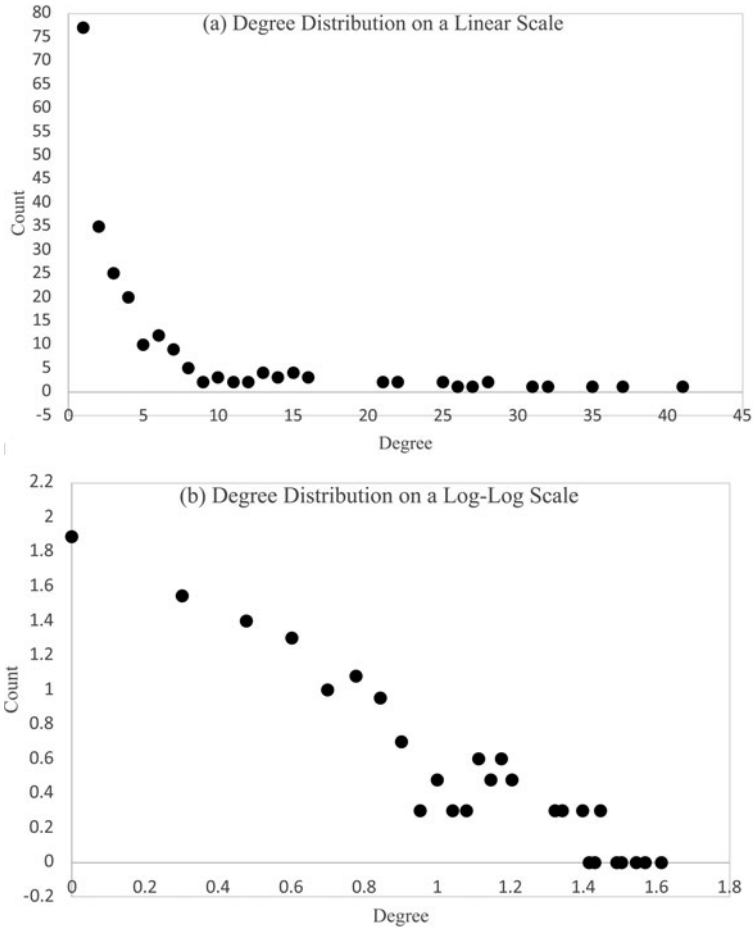


**Figure 2.** The marriage network between European royal houses from the fourteenth through the 20th centuries: An edge is established when there is a marriage between two royal houses. The thickness of edges represents the number of marriages between two royal houses (1–92). The size of a node represents its degree, the degree of a node is its number of links, which in this case refers to the number of houses with which it has a marriage relationship (ranging from 0–41). The network includes 239 nodes and 622 edges, excluding self-loops (marriages among members in the same house). The nodes also include nobility, popes, bishops, and electors. Some bishops and popes overlooked their vows of celibacy and had children in order to establish alliances. Royals needed linkages with aristocratic families and the Church, as well as with each other. Genealogists kept precise records of these marriages, and considerably more elucidation of their significance is possible. The marriage network resembles a small-world network.<sup>16</sup>

Instead, European royal lineages became proficient at harnessing technologies as well as alliances to their particular advantage. To this end, royal patronages endowed institutions and supported channels of communication that crisscrossed the continent to foster innovation and link knowledge creation on statecraft, law, culture, music, architecture, engineering, science, and military organization.<sup>17</sup> The major cultural transformations in European history – the Italian Renaissance of the 15th century, the Reformation of the 16th century, the Enlightenment of the 18th century, industrialization of the 19th century, and socialism, secularism and democratization of the 20th century – all arose from endogenous sources, spreading from one corner of the continent to another, often with the

<sup>16</sup>Using Python, 100 random networks with the same number of nodes and edges are generated, and the clustering coefficient and the average shortest path are calculated for each simulated network. The European network has the average shortest path length of 3.3857, comparable to that of a random network of 3.4844, but with a much higher clustering coefficient of 0.2010, in comparison with 0.0218 of a random network.

<sup>17</sup>Continent-wide news reporting during the old regime, its regularity and increasingly public character have been studied by (Würgler, 2012).



**Figure 3.** The degree distribution of the European marriage network between royal houses (a) on a linear scale, and (b) on a log-log scale: The marriage network attained right-skewed distributions with a small number of nodes possessing a large number of links, but their distribution does not indicate that a relative change in the degree of one network would be proportional to a change in the quantity of links in another.

help of institutions that were endowed by the royal families. The ability of the hierarchical hubs, the interconnected royals, to sustain their linkages while accommodating rapid changes at lower, subsystem levels enabled the spread of network-wide vitality from those cultural movements and revolutions, which sprang from communities with similar interests or functions in science, law, technology, trade, and religion. Creating something new and different, each of these movements started in one part of Europe, strengthening some nodes while eliminating others. It did not matter to the durability of the overall structure if one of Europe's interconnected governing elites failed to survive waves of cultural, institutional, technological, or social disruption. The hubs repositioned themselves into new configurations, retaining the context of a shared European tradition (Berman, 1983: 19).

The network comprising alliances between royal houses and the Church created yet another unique feature of Western Europe's imperial tradition. Europe's appetite for overseas expansion can be attributed to its network structure. There were limited possibilities for achieving growth by the accumulation of adjacent territory, as occurred in the Roman, Ottoman, and Mughal empires, so outward, overseas expansion became a favored option for regime aggrandizement. China followed the more conventional pattern, expanding into contiguous territories.



Europe's technological and economic expansion had to match its imperial aspirations, cementing the link between the global ambitions of statecraft and the Industrial Revolution. European states had to develop institutions to exploit new possibilities, and to move more swiftly and effectively than their rivals into the acquisition of new technological capabilities. A pursuit of static efficiency was not a viable option in a system in which endogenous change processes could unleash cascades of socially transformative innovations. Maintaining adaptive fitness required investments in human capital, opening education and providing physical mobility to ever larger segments of the population. It meant creating new sectors of the economy in metallurgy, chemistry, mass transport, logistics, accounting, and energy that required teaching, enfranchising, and providing a financial opportunity to greater numbers of the citizenry. It was this combination of government policies and incentives that drove the endogenous processes of change that ultimately led to World War I, and the demise of the system of monarchy as a source of social order and collective identity.

### *2.5 Network structure, information diffusion and disruptive innovation in China*

European monarchies may have lacked the institutional mechanisms to suppress disruptive innovation, but this is not to say that Europe was more innovative than China. Many of the keynote technologies that made European expansion possible in fact appeared much earlier in China but were suppressed there as threats to the unity of imperial command. This was the fate of gunpowder weapons and the printing press. China's Dragon fleets might have dominated the western and southern oceans; between 1405 and 1433 they undertook seven massive expeditions going as far east as the coast of Africa. Yet the Ming dynasty emperor mandated voluntary withdrawal from the marine trade, and the legacy of the chief naval officer, Zheng He, was erased from the imperial history books. Domestic security, disputes among court factions and a long series of disasters, as well as fear that rivals to the emperor might obtain resources to incite internal rebellion, motivated this retreat.<sup>18</sup> Being able to accomplish suppression across an empire is a measure of how effectively Chinese emperors directed their own system of up- and down communication. Institutional innovations in China, including the Song and Ming dynasty reforms of the examination system that brought greater social mobility through meritocracy, enabled regime officials to contain or eliminate the spread of institutions, ideas, and technologies that would dilute central authority.

In Imperial China, where systemwide connectivity emanated from the central hub, unwanted innovation was discouraged because it could foster potential new hubs, such as merchant organizations or aristocratic clans that could gain leverage over local institutions.<sup>19</sup> Merchant guilds, charitable confraternities, and other local civic communities rarely gained institutional autonomy either; formal institutions not created for the express purpose of supporting the emperor had a low probability of surviving. A persistent theme of Imperial governance was to prevent the formation of subnetworks with independent institutional claims to a local authority or that entitled members of subnetworks to acquire an institutional voice of their own.

The imperial court exerted its control over the mandarinates via the classical curriculum, in which candidates for the civil service were educated from an early age. This was the curriculum in which they were examined and the system that determined to which regions they would be posted upon selection. It has often been noted that this system produced an elite averse to taking risks unless instructed to do so, in which critical ideas did not arise or spread organically. Yet Chinese dynasties do exhibit a capacity to either block or disseminate technology. For example, the late Qing dynasty had a capacity for technology absorption from the West and after the British invasion and opium wars there was considerable incorporation of financial and managerial methods from Europe. Key technological innovations such as railway and telegraph lines, as well as monetary innovations that enabled domestic

<sup>18</sup>From the collapse of China's last dynasty, we can presume that the fear of gunpowder weapons falling into the hands of local elites might bring the downfall of the state, was well founded.

<sup>19</sup>Intermarriage was common among prominent administrative families, but as a group their status depended upon the continuity of the imperial system. Many leading merchant families also depended upon ties to the imperial center.

financial markets to integrate, were of Western influence (Palma and Zhao, 2021). Other ideational drivers of Chinese societal development since the end of the Qing dynasty (1636–1912) have come primarily from external sources. Virtually all initial Chinese modern hospitals and universities are the fruits of Western making, particularly of Christian organizations and missionaries. Even after the examination system was abolished, external catalysts inspired intellectual trends, e.g., France for literature and revolutionary treatises; the UK for literature and a streak of utilitarianism in Chinese philosophy; Germany in science and technology; and Russia for communist governance.

Here then is a pattern in Chinese history that seems to exhibit continuity with the late Imperial period. Since the late 1850s, socioeconomic reforms that underlie China's transition into a global economic power arose via exogenous prompting, whereas European transitions in ideologies, beliefs, social norms or technologies arose primarily endogenously. Post-revolutionary China continues to exhibit a capacity for technological assimilation, although like prior dynasties, cultural or institutional absorption from external sources is limited.<sup>20</sup> This is further indication that the network for technological diffusion and those for cultural or social behavior are not the same. System-spanning networks can facilitate technological diffusion, but cultural and behavior change depends more on local networks. In the next section, we will explore the networks of local connectivity and how they coevolved with the imperial system.

### 3. The organization of cooperation in local networks

We have observed that system-spanning networks are sufficient to either encourage or discourage technological diffusion. But behavioral diffusions, those changes involving moral frameworks or ethical values, depend more upon the connectivity of subnetworks at lower levels, i.e., among local nodes. In this section, we will see how differences in local network design influenced variations in the diffusion of interpersonal trust, cultural norms, and moral protocols. We will also see that ramifications for patterns of connectivity and information flows at lower levels had feedbacks that reached back to affect the macro system itself.

#### 3.1 Europe's micro-level networks

In Europe, the network of intermarried royal families provided one such structure for system-spanning connectivity; it also supported the institutional strengthening at subnational levels in several ways. We previously noted the desire in each royal house to avoid compression into a network dominated by a single lineage; the Church, upon which they depended for royal legitimacy, was in turn always mindful to protect its own power and autonomy, and thus served as a barrier to the emergence of a single secular hegemon.<sup>21</sup> The royals also shared an interest in grounding the population's overarching unity upon a common faith, and this paved the way for the pervasive role of the Church as a locally grown source of a shared continent-wide identity. This network, emanating across the village parishes, gave the Church an extensive role in managing cultural evolution, and was to have important consequences for the creation of organizations held together by generalized trust. It enabled Europeans to build organizations with system-spanning connectivity in parallel with the state.

It was at the micro levels where the system-spanning role of the Church was to reinforce innovative behaviors of social coordination, including across community groups, that require intersecting bonds,

<sup>20</sup>Much of what makes China modern, both materially and in its way of life, is inspired by the Western world. The NYSE and NASDAQ inspired the Chinese stock exchanges, German and French civil law has profoundly influenced the new Chinese civil law, eBay inspired Alibaba, Uber inspired Didi, Tesla inspired the groundswell of indigenous electric automakers. China's business schools seek AACSB business accreditation standards and EQUIS accreditations and are reshaping their curricula in compliance with U.S. and EU ISO certification. Certified Public Accountant certifications are all directly copied. China acknowledges this debt of inspiration and copycat absorption but is now set upon innovating within a Chinese context.

<sup>21</sup>Charlemagne's anointment as Holy Roman Emperor by the pope occurred at a time when Christendom needed leadership to stand up to invasions from the south and east.

or *bridge wideners* (Centola, 2018: 133).<sup>22</sup> Such pathways of social cooperation that enable behavioral change to become durable required significant investments in institutional infrastructure (Centola, 2021: 95–109). Throughout Europe’s Medieval Period, in a wide range of local-level bridge wideners, the Church proved instrumental, both as an institution and a system of beliefs, in building cultural foundations to reinforce ad hoc groups formed for the common benefit. Common-interest organizations require a generally accepted moral system in order to thrive, which underscores the role of Christian humanism in building the civil society of early medieval towns. The networks of voluntary societies that Christian humanism inspired helped accelerate the spread of new behaviors. The ethical norms that prescribed fairness toward strangers underpinned the common ideal of medieval cities as moral communities (Rubin, 2020).

Christian humanism shaped attitudes and played a role in how towns dealt with migration and migrants, enabling strangers and foreigners to obtain rights, and making the government of medieval towns different from pre-Christian Greece and Rome, in which every family and community worshiped its own gods. European civil society differed also from that of Chinese cities, which were organized around lineages. Generalized trust grounded in Church doctrine of brotherly love, or *caritas*, helped voluntary associations, such as guilds and monastic orders, build webs of organized cooperation beyond kinship. The impact of this foundation for the diffusion of generalized trust expanded especially after the periods of massive migration and population replacement following the Black Death (1346–48) and enabled the towns to become seedbeds of innovative behaviors, creating economic opportunity in a decentralized environment.

Centola’s bridge wideners were the multiple voluntary associations and common-interest organizations that built their own institutional infrastructures, such as the merchants’ practice of law known as the *Lex mercatoria*; and the assurances they provided reduced the uncertainty of exchange with strangers so that groups of people who had no prior relationships could pool resources and build private firms and markets.<sup>23</sup> The Church’s institutional reach extended down to the parish, another bridge widener, where general morality became a widely disseminated cultural norm among populations whose overarching unity derived from a common faith. *Caritas* and other moral frameworks, as well as cultural practices, like the ban on cousin marriages or the permitting of marriage on the basis of spousal consent, gave Europe a cumulative advantage in organizational skills needed to sustain cooperation grounded in contractual rights among individuals that did not share bloodlines. Because of this implicit capacity, the centralizing state in Europe modernized with close ties of interdependence with civil society.

### 3.2 Song dynasty innovativeness and exceptionalism

Scholarship on imperial China widely accepts that during the Song dynasty (960–1279) exceptional technological dynamism occurred (Jones, 1981). Examples of this dynamism are knowledge dissemination made possible by the introduction of moveable-type printing, an increase in the use of money as currency, stimulating commerce and leading to the introduction of a national currency, and the organization of the civil bureaucracy of the Chinese state was improved. Administrative changes made recruitment to the civil service more meritocratic creating a more open society, more representative of the wider population and less based on intermarriage, or residence in the capital. The newly recruited cadre did not have vested interests in protecting older technologies and were eager to disseminate innovations. Differences with prior regimes were compounded by schism of the Northern and Southern Song (1127–1279). According to Hilde De Weerd, the Northern Song continued to promulgate the concept of governance as emanating from the emperor and his senior court officials alone,

<sup>22</sup>Social diffusion in large, complex societies may depend on socially ‘intermediate’ groups that bind socially remote groups together’ (Centola, 2018: 34–62). In Europe’s distributed system, such intermediate groups were agreement-based, voluntary civic associations. In China intermediate groups were lineage-based. That their ties might scale into region-wide clans was only a remote possibility; nevertheless, fear of regional segmentation along clan lines made officials wary of regional identities.

<sup>23</sup>Rural European villages were self-governed without a lineage system. In many regions, local public goods were managed by village assemblies under the auspices of the local lord or parish friar.

while the Southern Song promoted a new vision of the imperial body politic as encompassing ‘local officials, retirees, exiles, and scholars’ (2016: 100–101). Her evidence of an active interchange between the central court and multiple flourishing hubs of local culture, reinforces Robert Hartwell’s notion of a localist turn championed by the activism of the Southern Song literati (1982). Sukhee Lee’s findings support the notion of the localist turn of the Southern Song. Weakened by the constant threat from the Jurchens that ruled in the North, the Southern Song, appeased the local literati by accepting their claims to various ‘customary privileges’ and their leadership in local society (Lee, 2014: 205). S. Chen tells us ‘the growing importance of locality in elite social life’ made the Southern Song ‘more willing to recognize the legitimacy of private interests and more capable of finding ways to accommodate them’ creating ‘space’ for local innovations that responded to local exigencies (2017). Beverly Bossler, contrasts the marriage patterns of grand councilor families of the Northern Song in which ‘the network appears to have had a single center, a single point of convergence in the capital,’ while among the Southern Song ‘that center had disappeared’ and the network had reverted to numerous regional nodes (1998: 93).<sup>24</sup> Hence the network structure of political authority of the Southern Song bears a striking resemblance to that of the European Renaissance in which civil order sprung from a collective vision of elite members of local society. However, after the re-unification of the empire, S. Chen reports, the Yuan (1271–1368) ‘jealously defended the state’s monopoly of control ... over the literati, refusing to grant them any fiscal, legal, or social privileges that might help them build up their own power base in local society, thereby continuing a Chinese political tradition dating back to the Qin dynasty’ (2017: 142). Features of local society that could strengthen local autonomy once again were viewed suspiciously as potential sources of political schism that caused warfare and other ills. The renewed curbs on the activism of local officials also constrained the cultural and political potential for innovation.

While historians continue to debate the state-and-society relationships underpinning China’s technology leap, they universally agree China’s superior innovativeness begins to wane around 1300, at the very time that Western Europe became more innovative. The seeming increase in European innovativeness stems from the advantage it was able to reap from the construction of long-lasting agreement-based civic and exchange-based groups. These advantages accrued slowly because of the social capital required to continually recruit new members through persuasion. Although greater aggregate up-front investment of resources is needed to sustain trust in the organizations, an inherent longer-term advantage exists in partnerships that recruit members from a broader population.

### 3.3 China’s lineage persistence and authoritarian centralization

Just as Christianity helped promulgate the formation of certain types of subnetworks whose properties are distinctive to the European context, China’s characteristic pattern of cooperative organization can also be traced to longstanding historical patterns that created a nexus of moral constraints to sustain interpersonal trust. But that nexus depended less upon formal institutions and was primarily limited to groups that shared lineage ties or were under the authority of prominent lineages. This abundance of certain types of subnetworks, or cliques that formed a deeply embedded subnetwork of nodes, are referred to by China scholars as *guanxi*, a deeply embedded system of particularism, i.e., a preference for trusting and dealing solely with one’s relatives and acquaintances. The high moral obligations inculcated within such parochial groups, rather than in generalized, longstanding common interests, rarely extended to external dealings, either with the government or more generally with strangers.<sup>25</sup> Lineage formed the template from which relationship-based *guanxi* networks evolved.<sup>26</sup>

<sup>24</sup>Beverly Bossler observes, ‘Whereas in the Northern Song the highest level of the political elite was effectively skimmed off the top of local society and concentrated in the capital, in the Southern Song that political elite remained much more part of the local society from which it had come’ (1998: 94).

<sup>25</sup>The CAF World Giving Index (Charities Aid Foundation, 2019) ranks China lowest of all 128 countries on willingness to help a stranger, donate money, or volunteer time.

<sup>26</sup>Chang (2011) considers the evolution of *guanxi* networks from the traditional to the modern economy.

One reason for the pervasiveness of *guanxi* was the absence of religious thought in China that might induce individuals to trust in social ties beyond those of parochial origin, i.e., the family, village, or network of personal acquaintances. Nor was there any institution like the parish that devolved from a central place and could affect or direct the sociological and moral instruction of the population. The Western Church's extensive role in managing cultural evolution did not have an institutional analog in China's history. The program for local order inspired by Confucian ethics did not call for an explicit role for central administrators to effect behavioral change among local groups. Kinship was elevated as the basis of self-sponsored, self-help action by communities to solve local problems because it did not offer an institutional capacity for locals to voice their interests against those of the state.<sup>27</sup> In short, the formation of formal institutions to sustain cooperation or assistance via voluntary civic organization among individuals, families, and groups sharing common interests was stymied by the imperial administration, which relied instead on ancient Confucian moralism and upon village elders to provide problem-solving capacity at the local levels. The village worship association was adopted as early as the Yuan dynasties as the basic unit of rural administration and continued to evolve during the Ming to take on a broader range of public responsibilities. The expansion of its sphere of activity in the self-governance of rural society continued through the Qing dynasty.

By working with lineage groups, the state advanced its coercive authority without acknowledging individual rights or corporate privileges. Even during the late Qing dynasty of the early 20th century, this was accomplished with only 1,300 county magistrates spread over a vast country. Allowing the lineage to serve as the pivot for the interaction between local society and the central state had effectively limited administrative costs. The enjoyment of high-quality selective benefits also induced a loyalty dividend. Was the minimalist size of bureaucracy a deliberate design intended to increase the costs of defection? Did the emperor pay off its supporters by allowing them to reap the benefits of nepotism? This arguably was the implicit strategy, although never explicitly acknowledged.

Copious records exist illustrating how the lineage power structures in villages were instrumental to the bureaucracy of imperial China in helping to overcome the organizational limits of the imperial state. Contrary to the European experience, where states modernized by creating stronger public roles for civil society activism, the reliance of the Chinese state on lineage increased over time and it deserves special mention that even as the Qing dynasty undertook efforts to modernize the society, the influence of lineage groups increased.<sup>28</sup> Lineage leaders were tapped to provide community services, enforce social regulation, organize economic activities, and help households with their tax obligations, making their presence felt in education, in charity, in surveillance, and in organizing the militia, granaries and public projects, and at the national level in the management of financial and industrial organization.<sup>29</sup>

However, as lineages and village worship associations gained material and organizational resources from the state's efforts at modernization, continuing dependence on lineage leaders had negative effects on governance functions, ranging from tax collection to irrigation management (Chen *et al.*, 2020; Esherick and Rankin, 1990; Kung and Ma 2018). Such negative effects – embezzlement, tax avoidance by the wealthy, bribery of government officials, kickbacks, and concessions awarded to

<sup>27</sup>Chinese elite families diversified their kin into government service but unlike European elites were denied corporate status. Throughout Chinese history rulers risked military vulnerability rather than allowing military commanders to achieve independent bases of power.

<sup>28</sup>Contemporary research on China continues to find that the 'most important social groups in Chinese villages' share patrilineal ancestry (Cohen, 1990; Duara, 1988; Fei, 1946; Freedman, 1958; Hsu, 1948; Tsai, 2007; Watson, 1982). Xu and Yao (2015) report that when 'one of the two largest family clans in a village' are in charge, 'local public investment will increase'; but just as in imperial times, it comes at a price – the clans line their own pockets while colluding with local officials. In Greif and Tabellini (2017) lineage organizations influence the resolution of civil and commercial disputes as well as the provisioning of welfare, securing of property rights, protecting locals from official abuse, and from contributing to public projects.

<sup>29</sup>Bin Wong discusses the state's growing reliance on lineage groups in local governance as it became modern (1997: 124). The lineage's ascendancy in village level organizational activities in Ming Huizhou is researched by McDermott (1999), and in 20th-century, South-Eastern China (Fukien and Kwangtung), by Maurice Freedman (1958, 1966).



relatives – were not unique to Imperial China. Assessments of kinship-intensive governance throughout the world and in contemporary settings have found that when lineage leaders hold predominant roles in community organization, an inhospitable environment for behavioral innovations and cultural inertia results. Greater kinship intensity correlates with less attention to universal morality and less generosity for those outside the group; this strengthens loyalty to family members, even when they break covenants with society at large (Henrich, 2020: 196; Schulz *et al.*, 2019). Strong in-group loyalty and a sharp distinction between in- and out-groups contribute to a general distrust of strangers, with negative impacts on the quality of governance (Akbari *et al.*, 2019; Schulz, 2022).

With the creation of the People's Republic of China in 1949, lineages were officially divested of their role in local governance in favor of the local party secretary. Rules guaranteeing lineage representation on village councils were invalidated, lineage property was seized, and genealogies were burned. Constraints on participatory and representative forums of local government were implemented with the goal of strengthening central control over rural society.

Nevertheless, once Deng Xiaoping removed the prohibitions on lineage organizations in 1979, the cultural sway of kinship ties over the norms of socialization quickly resurfaced. In addition, Deng's pro-market reforms inadvertently rehabilitated lineage networks that once again were called upon to supplement weak legal institutions, a role they have played in China's market organization since imperial times. Private firms today are often lineage businesses, maintains Peng (2004), who records 'a strong and significant correlation of village-level kinship with the number of private enterprises.' Foltz *et al.* (2020) demonstrate that lineage connections help increase migration and public goods creation in fast-growing newly populated areas. He *et al.* (2018) report that 'lineage-homogenous villages are more likely to engage in reciprocal behavior with their lineage members,' and to contribute to the 'provision of public goods jointly shared across lineages' than with people living in lineage-heterogeneous villages. Tsai (2007) holds that 'village-wide lineage groups are significantly correlated with the provision of public goods and with holding public officials accountable.' Mattingly (2019) has documented how lineage groups in villages continue to abet central control, reduce the threat of resistance, and facilitate the implementation of unpopular state mandates.<sup>30</sup>

All told, contemporary scholarship demonstrates that reliance on informal institutions of lineage groups solves collective action problems, but at the risk of collusion and corruption, and with a negligible impact on local-government accountability. Yet China has not found itself mired in economic and cultural inertia like other kinship-intensive societies. Its meritocratic and relatively inclusive civil service system, which has few parallels in world history or among developing nations today, has enabled China to outperform other regimes that have similarly depended upon lineage organization to sustain cooperation among the wider population.

Confucian ethics promoted strong relational ties to lineage within homogenous communities but reinforced cooperative barriers, in the form of weak moral obligations, between communities. The Chinese subnetworks, unlike the European ones, could not organize in parallel to the state. This parochialism limited the spread of behavioral innovation between communities and instead created a 'village' ethos in which relationship-based solutions continue to preside over anonymous market exchanges (Bowles and Gintis, 2004).<sup>31</sup> It also facilitated authoritarian centralization by eliminating institutionally enabled challenges to centralized imperial control.

Scholars still debate the role of *guanxi* in the country's development. A common view in the economic growth literature that is supported by the work of economic historians is that private-order institutions can substitute for public-order ones in enabling markets to function (Greif, 1989, 2006; Milgrom *et al.*, 1990; North, 1981; North and Thomas, 1973). In contrast to this view, a multi-level perspective reveals that neither networks of personal relations nor local private-order institutions

<sup>30</sup>In (Mattingly, 2019) local Communist Party officials ended up manipulating the lineage organizations after failing to eliminate them.

<sup>31</sup>Interpersonal trust can be divided into parochial and civic trust: The former denotes trust in one's family or group, the latter contributes to trust in institutions.



are by themselves sufficient for societal development. For cooperation to scale, there must be networks that span the entire system, and *guanxi* does not provide an adequate basis for this. If it did, then Chinese enterprise development and participation in the global economy would have been less dependent on foreign direct investment and state-owned enterprises.

Here then is the key trade-off in terms of efficiency from the variations in the formation of social capital: interpersonal trust based on lineage ties is more readily mobilized than trust reliant on agreement-based organizations. Greater upfront investment is required to build successful formal institutions that are agreement-based. But there is a long-run payoff: once established, those institutions can elicit interpersonal trust more broadly from the wider population, creating aggregate long-term social capacity needed for sustaining private markets and citizen-based governance. While the Confucian clan added to society's risk-sharing capacity, it left many potential markets unrealized, which does not make it a perfect financial market substitute for private or public-order institutions that are agreement based.

#### 4. Conclusion: the political-economy consequences of network structure

We have used network analysis to build a theory for the development of societies and states from endogenous mechanisms of social change. We have explored the influence of network topology over the larger organizational structures of society to offer a thesis about how different patterns of network connectivity shape innovation and diffusion, linking the emergence of institutions to the properties of a network's overall structure.

We have highlighted those distinctive aspects of European history that enabled it to become a society that 'innovates' in connectiveness, allowing subnetworks to develop in parallel to networks of the state. We have observed how variations in the diffusion of interpersonal trust – cultural norms that stem from moral protocols at the local levels – have feedbacks that reach back to affect the macro system itself. Being able to anonymize market transactions at local levels allowed the macro structure of European society to transition into what (North *et al.*, 2009) define as an 'open access order.'

In contrast to other authors, we have argued that networks of personal relations are *not* substitutes for public-order institutions and that the flexibility of the European network structures facilitated a complementarity of formal and informal institutions that is not observable in the Chinese case. The analog for China is a more 'natural state' built on kinship ties or personalized markers of trustworthiness, but which froze the network structure and prevented additional connections. This thwarted the path to potentially disruptive technological change and created a dependency on relationship-based financing, while impeding the formation of autonomous civil-society institutions.

This paper has probed how the structural properties of networks impact the diffusion of innovations in technology and behavior, with consequences for institutional evolution at both macro and micro levels. It confirms that identifying the topologies within a large-scale network is key to understanding the dynamics of how technological change spreads, but moral diffusion depends upon connections among local nodes. The network for technological diffusion and those for cultural or social behavior are not the same. System-spanning networks can facilitate technological diffusion, but local networks have greater influence over cultural and behavioral change. Understanding institutional differences that are embedded in network dynamics that have unfolded over long periods should help us to contextualize how China's rivalry with the West will pose challenges for globalization for generations to come.

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