Systemic Risk and Resilience: The Bronze Age Collapse and Recovery

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Abstract In this chapter we apply the concepts of resilience theory and systemic risk to the Bronze Age Collapse. We contend that this was a case of synchronous failures driven by both long-term trends in interconnectedness and inequality, as well as external shocks such as climate change, warfare (including from hostile migration), rebellion, and earthquakes. This set off a chain reaction as the loss of key cities destabilised the trade-network and undermined state revenue, leading to further rebellion, migration, and warfare. Eventually, enough cities were destroyed to undermine the economic, cultural, and political fabric that held the Bronze Age together. Many states recovered and displayed resilience through the Bronze Age systems collapse. No two states were alike in their resilience. The Neo-Assyrians persisted by moving from a strategy of trade to conquest. The surviving Hittites in northern Syria, in contrast, relied on the modularity of their semi-feudal structure. Systemic risk and resilience are helpful lens for viewing the Bronze Age collapse and recovery, as well as taking lessons for the modern globalised world. It at least provides historical grounds for believing that synchronous failures can happen and can be lethal to states.

Keywords Resilience theory · Systemic risk · Synchronous failure · Bronze Age · Collapse

Introduction

Systemic risk may be a ubiquitous danger for complex systems, whether they be in an age of bronze or silicon. We define systemic risk as the ability for a single disruption, or a series of individual disruptions, to cascade into a systems wide failure. This often occurs as a 'critical transition' in which there is a relatively rapid change

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from one state to another (Scheffer et al. 2012). Critical transitions are well studied for ecosystems (the typical term here being 'regime shifts'), including pollinator communities and coral reefs (Bellwood, Hughes, and Folke 2004; Holbrook et al. 2016), and financial systems (Haldane and May 2011; Acemoglu, Ozdaglar, and Tahbaz-Salehi 2015; Beale et al. 2011). Far less research exists for the modern world system (Helbing 2013; Keys et al. 2019), or historical state systems. Yet there are significant fears that the current globalised world is self-organising towards a state susceptible to systemic crises (Centeno et al. 2015; Nyström et al. 2019).

The Bronze Age State System is one of the most well-known and studied historical cases of a gradual systems collapse. The Bronze Age collapse involved the fragmentation and loss of multiple states that were deeply culturally, politically, and economically interconnected. The collapse coincided with multiple shocks hitting cities throughout the system within the space of approximately a century (Cline 2014, 2021).

In this article we apply key concepts in the systemic risk and socio-ecological resilience literature to the case of state collapse and recovery in the Bronze Age system. Was the decline of the Bronze Age a case of contagion, a domino effect due to the dropping of a key state or city (critical node loss), or the terrible misfortune of multiple shocks that reinforced each other? Or was it all three? Did recovering states exhibit any key attributes of resilience?

Systemic Resilience and Risk in Societies

Resilience

Resilience generally refers to the ability for a system to withstand and recover from different perturbations without losing its fundamental identity (Gunderson and Holling 2002; Walker, Salt, and Reid 2012; Folke et al. 2016; Cumming and Peterson 2017). It is the ability for a system to be robust to different shocks, recover from damage, and resist fundamental change to a new system state (the three Rs) (Grafton et al. 2019). Antifragility is a similar, but subtly different concept. It is not simply the ability to withstand random shocks, but to actively benefit from them (Taleb 2014). The idea is already used in several fields, including in biology through hormesis: the ability for biological systems to gain from small doses of toxins or stress, but damaged by sufficiently large quantities. Antifragility can be roughly thought of as resilience (persisting through stress) in combination with learning and adaptation (changing system structure based on learning).

In applying resilience, we need to ask "resilience for what and to what"? In this chapter we are focusing on the resilience of political and economic systems (primarily states) in the Bronze Age from both internal and external stressors. Resilience is agnostic. It says nothing about whether the system is moral and worth sustaining. Our analysis is agnostic too, but there are reasons to question whether many of the

Table 1 Principles of socio-political resilience

Principles	Description
Adaptive capacity	The ability for a society to change existing behaviour based on observation and (social and organizational) learning to better fit the environment
Diversity	Diversity refers to the variety of elements in a system, the balance between different elements and their disparity (how much elements differ from one and other)
Interconnectedness	The number and intensity of linkages between different elements of a system. This can range from information (social connections, sharing of administrative data) through to material (trade) flows
Modularity	Modularity measures how densely connected 'hubs' within a network can be decoupled. A network is usually more robust if a key node can be destroyed with little impact on the remaining network
Redundancies	Repeated and replicated components within a system. Like kidneys, if one fails, another can take over

states of the Bronze Age were worth preserving. It did, after all, contain empires of domination that were dependent, at least in part, on stratification and slavery.

There is no universally accepted set of resilience principles. Nor is there any agreement on how and in what contexts different principles should be applied (Grafton et al. 2019). This is especially true for states, as most of the resilience literature has been applied to either engineering or socio-ecological systems more broadly. There have been a few attempts to provide a set of key principles or considerations for resilience (Walker, Salt, and Reid 2012; Grafton et al. 2019; Biggs et al. 2012; Yu et al. 2020; Ungar 2018). These tend to both overlap and diverge. There remains neither full consensus nor agreement on which principles can be fruitfully applied to states. Importantly, the evidence for some commonly cited principles for resilience, such as leadership or experimentation, are mixed (Biggs et al. 2012). In Table 1 we have summarised several of the key principles of resilience. These include diversity, interconnectedness, modularity, redundancies, and adaptive capacity (response abilities). These are based on the existing proposals for resilience principles, but with an eye to those which are both applicable to states and can be potentially observed or measured for the Bronze Age.

Systemic Risk

Systemic risk first became a subject of interest due to stock market flash crashes and contagions in the financial system. It was originally intended to explore the possibility that the loss of a single company could cause the destabilization of an entire market or even economy. There is now increasing acknowledgement that systemic risk is relevant across a wide range of areas, ranging from ecology to politics. Systemic risk challenges traditional notions of risk by placing greater emphasis on the vulnerability

of a system over the threats it faces. Ultimately, systemic risk is as much a product of structure as shocks.

Many structural features operate as 'tipping points' when it comes to systemic risk. That is, they can operate in a threshold manner in which a certain amount is beneficial for resilience, but too much creates fragility. There is a pernicious and uncertain threshold beyond which features like interconnectedness and diversity can become harmful rather than helpful to a system. This is similar to, but subtly different from, the notion of 'hypercoherence': that as a society becomes more complex and interdependent it also becomes more liable to collapse and disaggregation (Dark 2016).

Any such threshold is unlikely to be a simple matter, but also hinge on the challenges that a system is facing. Interdependence, for instance, may be a blessing during times of stability, but an Achilles heel if there is a large enough shock. In one study of financial networks, Acemoglu et al. (2015) put forward the case that densely connected financial networks tend to buffer against small disturbances, but perpetuate sufficiently large ones. There is broader evidence for this trade-off, in which greater interconnectedness and scale tends to mean resilience against local disruption and more vulnerability towards systemic failure (Scheffer et al. 2012). The system can shift resources to cover small, local losses, yet a large enough shock is more likely to be amplified. There is an unknown tipping point past which a shock goes from being locally bearable to systemically spread. In short, the conditions for resilience can, under different circumstances, become the seeds of systemic risk.

Systems which are dependent on a few key nodes tend to be more vulnerable than those with a more distributed structure. Systems can typically be thought of as 'fat-tailed' or 'random'. Random networks are characterized by a roughly equal distribution of connections between nodes. A typical example is the US road system. The opposite to random networks are 'scale-free' arrangements in which connections have a power-law distribution. Yet such systems with a complete power-law distribution are rare in both human and natural systems (Broido and Clauset 2019; Stumpf and Porter 2012). We opt for the more telling and practical designation of 'fat-tailed': whether linkages tend to be dominated by a few nodes. The network of flights in the US is an archetypal example, with a few hubs such as the John F. Kennedy airport in New York having an order of magnitude more activity than the average airport (Homer-Dixon 2008; Ferguson 2018). Many human networks exhibit such a skew. Industries characterized by network externalities, such as social media platforms, are particularly prone to these 'winner takes all dynamics' (Schilling 2002). These are rarely natural occurrences, but are reinforced by economic and political positive feedback loops. For example, banks that have been labelled as 'too big to fail' have not shrunk since the 2008 Global Financial Crisis, due to consolidation, lobbying, and (unchanged) favourable regulations (Ioannou, Wójcik, and Dymski 2019). Indeed, wealth in general appears to follow a pattern of becoming increasingly fat-tailed and unequal, due to high returns on capital and the ability for the rich to politically reinforce their position. Natural systems can also have such patterns. Disease mortality, for instance, appears to follow a fat-tail distribution throughout

history (Cirillo and Taleb 2020). Such systems, whether biological or social, tend to become more susceptible to systemic risk.

Systemic risk appears to have multiple failure modes: contagion, synchronous failures, and critical node loss. Contagion involves an initial shock and its effects being transmitted to the rest of the system. Financial contagion is one of the clearest examples of this. It is most likely to occur in highly interconnected, homogenous and tightly-coupled systems. Critical node loss also occurs in more interdependent, fat-tailed systems. It entails the loss of a key node(s), radically disrupting system functioning. This can happen for electricity networks in which the loss of a key transmitter can cause a region-wide blackout. Synchronous failure is an overarching framework in which multiple, reinforcing stressors cause different, interacting systemic crises which combine to create larger intersystem crises (Homer-Dixon et al. 2015). These tend to be composed of long-term growing vulnerabilities leading to disasters ('long-fuse, big-bang') coinciding with simultaneous stresses, and then culminating in self-reinforcing crises. The 2008 Global Financial Crisis, which was driven by long-term trends in market deregulation and inequality leading to the US sub-prime mortgage crisis and its contagious spread into other markets, as well as an oil price surge, is one example. These different failure modes are not mutually exclusive. Synchronous failures are indeed likely to occur through both critical losses leading to a process of contagion (or, vice versa).

There is some emerging evidence of scale impacting the speed in which a critical transition can occur. One analysis of 42 ecosystems found that regime shifts occurred disproportionately more quickly in larger systems (Cooper, Willcock, and Dearing 2020). Why this is the case is unknown, but logically could be linked to mechanisms of systemic risk. Further study is needed and whether this can be applied to state systems is unclear. When combined with ideas of systemic risk and the presence of a threshold effect for connectivity, there are grounds for believing that the larger and more interconnected a system is, the more susceptible it is to a catastrophe and the quicker and more complete will be its eventual disaggregation.

The Bronze Age

In this section, we will briefly map both the interconnected nature of the Bronze Age state system and the different shocks involved in its slow demise. It should be noted that we are focused here on what can be considered as the 'core' of the Bronze Age, meaning the urban consumers as well as economic and state elites. Our analysis rarely touches upon the more populous 'periphery', namely the largely rural communities that provided raw materials including grain and ores. This is a necessity due to the limited nature of the historical data, which may be common across most historical collapses. We have a high-resolution image for elites and urban areas, but far less for the rural periphery and non-elites at the end of the Bronze Age in the Aegean and Eastern Mediterranean as well.

System Interconnectivity: Economic, Political and Cultural

It is difficult to describe in just a few words the extent of the economic, political, and cultural interconnectivity among the various societies and civilizations in the Bronze Age Aegean and Eastern Mediterranean, among whom we can count the Mycenaeans, Minoans, Hittites, Cypriots, Canaanites, Egyptians, Mitanni, Assyrians, and Babylonians (Cline 2014, 2021). Suffice it to say that we are looking here at a Small World Network, in Social Network Analysis (SNA) terms, wherein even if one of the civilizations was not in direct contact with one of the others, it was in indirect contact though one or more of the others. If there are less than three such "hops" required to connect all members of the network, then it qualifies as a Small World Network, which this does. This is simply a mathematical way of saying that this was an international and globalized world system, for its time and area.

The interconnectedness of the Bronze Age to facilitate trade in metals, particularly copper and tin, was a defining characteristic of the time. It was facilitated by both the demand for such metals, as well as new long-distance mobility technologies such as sail and the chariot, and shared traditions of traders (Kristiansen 2016).

That such economic, political, and cultural interconnectivity was all intertwined is clear from both textual evidence and the archaeological record. For instance, we can see that the various societies were not completely self-sufficient, but rather were dependent to a certain extent upon each other for items ranging from raw materials such as gold, silver, copper, and tin to finished goods and even basic supplies such as grain and dried fish.

We read this, for instance, in letters dating to the eighteenth century BCE found at the site of Mari in ancient Mesopotamia. These mention the importation of finished goods such as gold daggers inlaid with lapis lazuli and leather shoes sent from Minoan Crete (referred to as "Caphtor" in the texts) as well as the arrival of raw tin from Afghanistan and its subsequent exportation onward to the site of Ugarit in what is now coastal northern Syria, where it was traded to Minoan merchants and sent on to Crete. Many of these traded goods were critical. Tin, an essential component of bronze, after which the age was named, was as essential to their world as oil (petroleum) is to ours today (Bell 2012).

The archive of royal letters dating to the time of Pharaohs Amenhotep III and his son Akhenaten in the fourteenth century BCE, found at the site of Amarna in Egypt in 1887, similarly document substantial economic activity at the highest levels. These mention the shipments of tons of raw copper and large quantities of gold in addition to tremendous numbers of finished goods, all couched in the guise of "gift giving" between the Great Kings of Egypt, Assyria, Babylonia, and Mitanni, as well as extensive (and expensive) dowries for the weddings of royal princesses sent by those kings to marry the Egyptian pharaohs (Cline and Cline 2015). We also find similar discussions and lists of exchanged goods between royal elites in the archives of the Hittites at their capital city of Hattusa, as well as in the archives maintained by private merchants working on behalf of the palace in the city of Ugarit, mentioned above, dating to the fourteenth through twelfth centuries BCE.

These exchanges at the highest levels likely masked the vast majority of economic transactions which were doubtless being conducted at a much lower level, perhaps under the cover of the elite exchanges. This is much like the Trobriand Islanders who were participating in the so-called Kula Ring in the South Pacific, whom Malinowski studied in the 1920s. There, while the chiefs of each island ceremonially exchanged valued armbands and necklaces made of shells, the crewmembers of the canoes who had transported the chiefs were busy trading with the locals on the beach for food, water, and other necessary staples of life. Such commercial transactions were the real economic motives underlying the ceremonial gift exchanges of the chiefs, just as the merchants and diplomatic messengers of the Egyptian and Near Eastern kings traveled with caravans containing more mundane but necessary staples of life alongside the royal gifts (Cline 2014, 2021).

Shocks and Interconnections

This interconnected world came to a surprisingly sudden end just after 1200 BCE. Within a matter of a few decades, and one to two generations at most, the populations of these areas were devastated and the economic, political, and cultural ties between the various societies and civilizations destroyed. The shocks suffered by the various societies and civilizations were many and varied. Climate change was especially impactful, manifested in the form of a severe mega-drought lasting between 150 and 300 years in an area stretching from what is now northern Italy across modern Greece and Turkey to Cyprus, the Levant, Egypt, and even as far to the east as Iran and Iraq. The evidence is now undeniable, coming from all of the above-named countries as a series of proxy data derived from studies of lake sediments, stalagmites in caves, and coring from lakes and lagoons. While significant, the local impacts of this climatic shift varied substantially across time and space (Riehl et al. 2014; Finné et al. 2017). Still, it appears to have played a key role, with agent-based modelling exercises already suggesting that it was a primary driver towards the Greek Dark Ages (Vidal-Cordasco and Nuevo-López 2021).

There are also indications of wide-spread famine, as recorded specifically and plaintively in texts found in the archives of the merchants in Ugarit as well as the royal Hittite archives at Hattusa. Societal inequality may have come into play here, as one text from an Ugaritic official says to the king: "grain staples from you are not to be had! (The people of) the household of your servant will die of hunger! Give grain staples to your servant!" (Cohen 2021; Cline 2021). Possible internal uprisings, hypothesized at sites ranging from Hazor in Canaan to Mycenae on mainland Greece, may also have been an additional direct result of both the famine and social inequality at the time.

The mega-drought is most likely the driving factor underlying the migrations of specific groups of people across the region at this time, apparently moving from the western Mediterranean across to the Aegean and thence to the eastern Mediterranean. Some were hostile, such as the so-called Sea Peoples who are featured in the records of

the Egyptian pharaohs Merneptah and Ramses III in 1207 and 1177 BCE respectively, as well as unnamed invading forces mentioned in newly published texts from Ugarit. Others were perhaps more peaceful and assimilated with the local population, as indicated archaeologically at sites like Ashkelon, located in modern-day Israel.

There were also natural disasters, such as a series of earthquakes over a fifty-year period (known as an "earthquake storm"), which factored into the overall collapse, with evidence for such at sites ranging from Mycenae to Troy and elsewhere (Nur and Cline 2000). These undoubtedly contributed to the overall Collapse, but also may have contributed to events such as internal rebellions at some of the cities.

Not to be left out, but without conclusive evidence for it yet, is the fourth Horseman of the Apocalypse: pestilence. It has long been known that an epidemic wiped out most of the members of the royal Hittite family ca. 1350 BCE, including the ruling king Suppiluliuma I, and that a later Egyptian pharaoh, Ramses V, apparently died from smallpox ca. 1140 BCE. There is currently no indication yet of any sort of epidemic contributing to the actual Collapse. There are, for instance, no mass graves that have been found and there are no mentions in the contemporary texts. Yet such an additional catastrophe cannot be discarded out of hand. Epidemics do not often leave a clear archaeological trace and disease has frequently accompanied other calamities throughout history. Given that trade and war are two of the key conduits of disease (Scott 2017), there is a non-trivial chance that this played a role during the collapse.

Mapping the Systems Collapse

It is difficult to actually map the systems collapse in real time, for it is nearly impossible to accurately date the demise and fall of each city and/or civilization. While it seems likely that Ugarit fell by ca. 1185 BCE, and Troy by approximately 1180 BCE, even these are just estimates based on a variety of different factors and sources. Even the destruction of Megiddo at the end of the Bronze Age, which now has dozens of radiocarbon dates from the relevant levels, is still the subject of active debate, for possible suggestions range from ca. 1177–1130 BCE or even later for the termination of Stratum VII at the site.

Complicating matters even more is that life did not necessarily come to a complete halt on a particular day even in cities which fell, unlike Pompeii which was buried in a matter of hours or days by Mt. Vesuvius in 79 CE and never occupied again. Hattusa in Anatolia, for instance, is now thought to have been abandoned by the royal family well before the date of its final destruction. Mycenae on the Greek mainland may have been occupied by squatters, and there may have even been a substantial number of surviving inhabitants in the case of Tiryns, perhaps for decades after the cities' elite and most of the citizens were killed or fled for their lives.

Nevertheless, we can certainly say that life as they knew it in the interconnected and globalized Small World Network of the Late Bronze Age Aegean and Eastern Mediterranean essentially came to end shortly after 1200 BCE. By 1100 BCE, their world was quite different, and by 1000 BCE it was so different as to be almost

unrecognizable to a former occupant of Mycenae, Tiryns, Troy, Hattusa, or Ugarit. Now many of those cities lay empty and abandoned; some, such as Ugarit, would not recover for centuries.

Is there any evidence that what happened in the Bronze Age was a case of systemic risk? We cannot with any strong confidence suggest that this was a critical node loss. Nor can we provide a quantitative analysis of whether there was a threshold in interconnectivity that undid the Bronze Age. The lack of a clear time series means that for now we cannot model or know if the loss of a critical city destabilized the entire network. Yet, there are signs of other systemic risk archetypes being at play. We can reasonably conclude that the different hazards were not independent. In fact, it may even be somewhat misleading to simply call the Bronze Age collapse a 'perfect storm,' since to many that implies a chance convergence of independent different shocks. Instead, there are good reasons to view the Bronze Age Collapse as a systems disaster in which certain shocks reinforced others, rather than being unrelated. It was, in the language of systemic risk, more likely to be, and perhaps more accurately described as, a case of 'synchronous failures'.

Figure 1 depicts one way of viewing this interconnected crisis in the Bronze Age. To put it briefly, as cities—the key economic and political nodes in the Bronze Age Network—were lost, the remaining urban centers became more vulnerable and new threats worsened. Climatic change appears to have not only decreased crop yields in key areas, but it also likely drove both benign and hostile migration, which in turn threatened trade-routes and further stressed the food system. As different cities failed, they would have likely triggered greater scarcity in the remaining network,

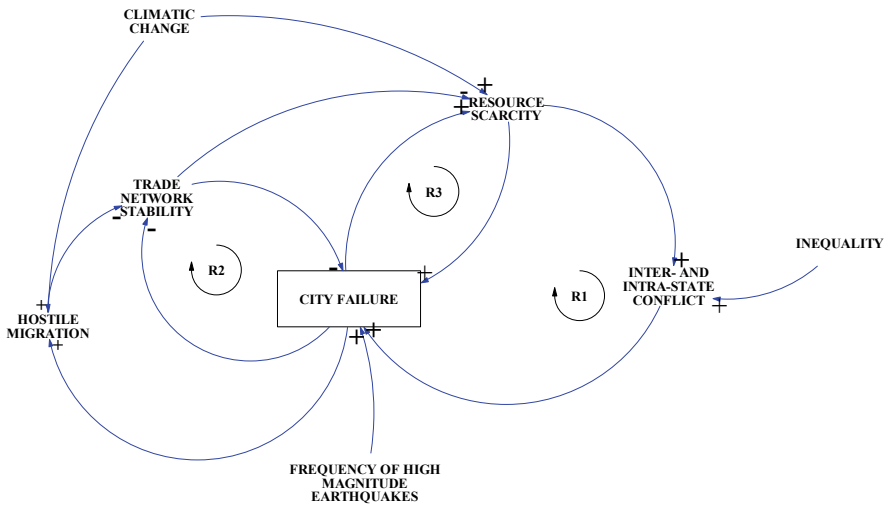

Fig. 1 A causal-loop diagram of the bronze age collapse

creating an impetus for competition (warfare) and worsening underlying vulnerabilities (debt crisis and inequality triggering rebellion), including to other shocks such as earthquakes.

We identify three key reinforcing synchronous failures. The first is resource scarcity, driven by decreasing crop yields, driving conflict. This will not have been unique to the Bronze Age, of course; in the modern world, decreasing food security and resource scarcity has been linked to socio-political violence stretching from Egypt to Syria (Natalini, Bravo, and Jones 2019), to give just one example. Modern case studies and literature have provided evidence that shocks to food security can influence emigration, conflict, and natural mortality rates (Richards, Lupton, and Allwood 2021). Moreover, the decrease in grain yields likely led to higher rates of slavery and debt peonage as peasants failed to repay loans measured in wheat or barley (Graeber 2011). Factors such as debt (Graeber 2011), declining economic opportunity (Lawson 2019), and inequality (Wilkinson and Pickett 2010) have all been linked to social friction and even rebellion. Ancient regimes were also notorious for demanding too much of farmers and peasants during difficult times, causing flight or fights, as was the case for the Third Dynasty of Ur (Scott 2017). We also know that in the period leading up to the systems collapse, inequality was worsening in the Bronze Age world (Scheidel 2017). Thus, cities and states faced a potent mix of factors that made them ripe for either violent upheaval or for turning towards conflict to secure scarce resources in an increasingly chaotic situation. In addition, the transport of grains, metal (particularly tin), and other goods would have been disrupted as cities fell, worsening resource scarcity.

The second synchronous failure is hostile migration and piracy driven by city failure. The initial burst of migration likely came from movements by those whom we have come to call the Sea Peoples. Piracy within the Bronze Age network likely drew upon these migrants, as well as peasants from the Mediterranean, mercenaries, disillusioned warriors, and workers (Hitchcock and Maeir 2014, 2016). The multicultural marauders settled among existing peoples, but also preyed upon the already fraying trade network. As more cities fell, the number of peasants, workers, mercenaries, and others looking for alternative work grew. Thus, piracy was likely driven to a certain extent by the loss of cities. And, as such sea-borne skirmishers increased, the trade network was further destabilised. If disease was also an active part of the Bronze Age crisis, then the emigration of citizens whether it be through piracy or more traditional mobility could have also acted as a disease vector. Microbes often spread alongside chaos.

Third, the loss of trade links and increasing food scarcity would have undermined the revenue sources of both cities and their overarching governments. As grain supplies shrunk, so too did government coffers. This would have likely led to further restrictions in trade, as well as higher unemployment, and hence driven both the adoption of piracy and further migration.

Each of these synchronous failures relies on the interconnectedness of the Bronze Age acting as a conduit for chaos. The reliance of cities on the trade network for strategic resources such as tin, as well as grain, provided a buffer against most perturbations, but likely became a liability during the combination of megadrought

Table 2 Synchronous failures in the bronze age

Causal loop	Explanation
R1	Conflict (both inter-state war and intra-state rebellion) due to resource scarcity from drought further undermines grain stockpiles
R2	Piracy and hostile migration undermine cities as well as the overall trade network. As cities fall, further migration and piracy spreads
R3	The failure of trade networks due to the loss of key cities and the presence of piracy and invaders. This leads to economic decline in surviving hubs

and conflict. We have, for example, cities and states requesting grain and aid from others during the Bronze Age collapse, as demonstrated by a recently translated text from Ugarit which quotes the king of that city beseeching the Egyptian pharaoh: "May my lord save [the land of Ugarit], and may the king give grain to save my life…and to save the citizens of the land of Ugarit" (Cohen 2021; Cline 2021). Similarly, the proximity and easy maritime connections provided a highway for diplomacy and trade, but also eventually for invaders, migrants and pirates.

These different shocks had varying timeframes and severities. Inequality, increasing interconnectivity, and reliance on trade can be thought of as 'long-fuse, big-bang' phenomena. They took decades or centuries to build-up, but eventually the pressure erupted. These coincided with 'simultaneous stresses' including climate change, migration, disease, and earthquakes, which unfolded over the space of decades, years, or even days. The 'reinforcing' crises were then the warfare, piracy, and the other maladaptive and misbegotten responses to disaster. Vulnerability festered in the Bronze Age system, before it was revealed by a few ill-timed disasters (Table 2).

Bronze Age Recovery

It is easier, in some ways, to detail how the different societies and civilizations did or didn't recover from the collapse, and how the world system changed. But it is a complicated scenario to document which states collapsed, which ones recovered or transformed, and which ones were superseded by new entities that arose in the aftermath of the Collapse.

For instance, some, like the Neo-Assyrians and the Egyptians, were able to hold on longer than the others, maintaining the position of the king/pharaoh and his retainers, the trappings of the elites surrounding them, the administrative structures of the state, and even such basics as the ability to write and continue to record the transactions and activities of their society. Eventually, however, even the Neo-Assyrians succumbed for almost two hundred years to the ravages of continued drought, famines, and the encroachment of new enemies such as the Arameans. It would not be until the ninth century BCE that they were able to reassert and re-establish themselves, replacing the trade of the Late Bronze Age with military campaigns and warfare to get the basic

supplies that they needed to survive. The Egyptians, meanwhile, also beset with drought and problems with the Nile, devolved into rival factions and, occasionally, rival Pharaohs, especially during the Twenty-First and Twenty-Second Dynasties. Yet, the strong embedded ideological structure of Egypt, combined with its lesser exposure to drought, ensured that there was some degree of continuity despite internal struggle.

Others, like the Mycenaeans and Minoans in the Aegean, the Hittites in central Anatolia, and most of the small Canaanite kingdoms in the central and southern Levant, collapsed quickly and almost entirely, never to rise in its original form again. In each case, however, the key word is "almost," for in every instance, some segment of the society managed to survive, by transforming and adapting to the new reality.

The Phoenicians, for instance, apparently were able to take advantage of the chaos and thrive in the sudden absence of Ugarit, such that they now began venturing out into the waters of the Mediterranean virtually unopposed and eventually re-establishing the links to the Aegean and western Mediterranean. Similarly, the rump state of Carchemish, located in northern Syria and ruled by a member of the Hittite royal family, survived alongside of other small city-states and kingdoms, to collectively take part in the new societal order as the Neo-Hittites, known from the Hebrew Bible as well as from Neo-Assyrian records. In Greece, the surviving population slowly rebuilt their society from the ground up, although they had lost almost everything, including writing, and took longer than any of the other societies to make their way back out of the Dark Age in which they had suddenly found themselves.

Although we cannot be sure, it looks like the previous interconnectivity of the Bronze Age Small World Network did not necessarily aid in the recovery of the key societies and states, for not all survived the centuries after the Collapse. While trade networks did persist, albeit by breaking down into smaller networks, many of the recovering states did not rely on trade for their rejuvenation. However, overall, we may still probably utilize Holling's 'Adaptive Cycle' for at least portions of the network, such as the transformation of the surviving Canaanites into the Phoenicians on the coastal regions of what is now Lebanon. Some, especially those who argue that the Collapse is actually more of a transformation, might even argue that the 'Adaptive Cycle' as a whole can be seen in the eventual reconnection of this entire region, even though the culmination of the cycle took at least four long centuries, until the end of the eighth century BCE, to come to fruition (see also Newhard and Cline, this volume).

Notably, there is no evidence that these states or peoples collectively realized that they were in a collapse. There are, however, indications that some of the individual entities were aware that they were facing a disaster. For instance, the Egyptian administration in Canaan bred heartier cattle and increased their grain production during the beginning of the arid period. They extended dry farming in the Southern and Eastern fringes of the Levant to supply food to the harder hit area of the northern Near East (Finkelstein et al. 2017). Clearly the Egyptians were not blind to their predicament; they were aware of the drought and were taking adaptive steps. They, however, could not have been aware of the severity or duration of the drought, nor the wider context of the unfurling transformation.

As noted, none of the collapses seem to have been total. While there was undoubtedly multiple site destruction, the loss of particular forms of writing, and the severing of many trade networks, both settlements and governance lived on in some more decentralized form. Collapse in the Bronze Age was frequently a process of political disaggregation (Scott 2017). This can also be seen as a triumph of modularity: in lieu of the previous larger, overarching networks of trade and governance, in the aftermath of the Collapse, smaller entities now took on a prominent role in carrying forward culture and populations. However, this should not detract from the genuine human and cultural loss that apparently accompanied the collapse of the Bronze Age.

Each state appears to have relied on a different principle or attribute of resilience to aid in its recovery from the Bronze Age collapse. The Hittites had an almost semi-feudal structure[48] which provided some basis for modularity. The rump states that continued on in the absence of the Hittite empire had enough of a cultural and political connection to carry on into the Neo-Hittites, but were modular enough to ensure that they did not fall apart alongside the Empire. The Neo-Assyrians, in contrast, appear to have relied on a more sinister approach of adaptation from trade to conquest. As trade proved to be an insufficient and unpredictable source of capital for the state, it instead adopted a more reliable and lucrative strategy of warfare. This may have been spurred by the adoption of iron weaponry and the annexing of crucial iron ore mines, though this remains to be further investigated (Mann 1986).

The Neo-Assyrians proved to be not only resilient, but sinisterly anti-fragile. On the other hand, as noted, Egypt suffered a prolonged period of political fragmentation and conflict after the Collapse. However, it likely avoided a far worse fate by having sufficient diversity in ecology such that areas less exposed to drought were able to provide coverage for those that suffered greater losses. Overall, both the Canaanites/Phoenicians and Neo-Assyrians exhibited anti-fragile properties as they gained significantly in the aftermath of the collapse. The Neo-Assyrians grew beyond the borders of the previous Assyrian Empire, while the Phoenician city-states found tremendous commercial success and left a long legacy, including the alphabet. In ecology there is the notion of a 'niche': the position of a species in its ecosystem and the conditions to which it is adapted. The Phoenicians essentially expanded their niche in the absence of Ugarit, as did the Neo-Assyrians due to the vulnerability of their neighbors.

These different approaches to resilience can be broadly thought of as evolution or involution. Evolution (adaptive change through competition) was clearly key to the militaristic rise of the Neo-Assyrians. 'Involution,' i.e., adaptive change through cooperation, communication and symbiosis (Hustak and Myers 2012), was far more apparent in the trade-based growth of the Phoenicians. Hence not all forms of resilience for one state are equally beneficial for their neighbors or the wider system (Table 3).

Table 3 Examples of different strategies of resilience in the iron age recovery

State	Process	Primary resilience strategy
Neo-Hittites	Continuity	Modularity through semi-feudal structure
Neo-Assyrians	Expansion	Adaptation through conquest (niche construction)
Egyptians	Recurring fragmentation	Diversity and differing exposure
Canaanites/Phoenicians	Transformation	Adaptation through expansion overseas in the absence of Ugarit

Conclusions: Parallels to the Modern Globalised World System

The modern world has an intriguing number of echoes with the Bronze Age State System. First, like the Bronze Age, it is deeply politically and economically interconnected despite the presence of multiple competing and cooperating states. Second, in both systems there was one particularly essential item of trade which drove the world system. For the Bronze Age, it was tin imported primarily from Afghanistan; for the Modern World, it is oil coming from a handful of key exporters. Third, many of the hazards faced by the two world systems are surprisingly similar. The world of the Bronze Age had drought brought on by climatic variation, while we have modern anthropogenic global warming. The Bronze Age was an unequal age marked with rebellion at its end. Similarly, intra-country inequality has surged persistently over the past decades (Piketty and Goldhammer 2017).

We note, however, that there are a number of obvious differences, which may be either good or bad. For instance, on the plus side, oil doesn't face the same bottlenecks as tin likely did in the Bronze Age. On the other hand, however, there are deep concerns over the declining quality of oil and its energy return on energy invested (EROI).

Furthermore, the modern world appears to have the same long fuses as the Bronze Age in terms of its interconnectedness and inequality. It also has many of the same impending shocks by way of climate change and migration stemming from environmental disruptions. The key difference lies, hopefully, in adaptive capacity. The modern world has far greater potential for adaptation and learning since it can foresee oncoming crises, rely on better technical capabilities, and learn from the past. Hopefully it can adapt without replicating the bloody path of the Neo-Assyrians.

It is also reasonable to point out that the modern world system is likely both more densely interconnected and far faster operating than the Bronze Age World System. Such modern systems, when paired with a world of random shocks, may be simply prone to failure. This idea of 'normal accidents' has already been put forward for complex, tightly-coupled systems such as nuclear power plants. In such systems, disasters are both inevitable and unforeseeable (Perrow 1999). There may similarly be a phenomenon of 'normal collapse' at play for densely connected networks of states. Thus, if the wrong events transpire and conspire in another 'perfect storm' or

series of 'synchronous failures', we could quite easily end up replicating the Bronze Age Collapse—modernized and updated, but with the same outcome for all intents and purposes.

Overall, however, the Bronze Age Collapse will likely always be mired in some fog of societal failure. We may never have precise enough data to confidently assert what kind of network failure occurred, what were the most impactful threats, or why some states recovered while others did not. Nonetheless, the existing data and theories concerning systemic risk and resilience can give us the ground for informed estimates. For example, the Bronze Age does appear to be an example of synchronous failures, with the loss of cities driving an economic downturn, trade destabilization, war, privacy, and rebellion, stimulating the further loss of urban centers. This was spurred by climatic change as well as long-term trends in increasing inequality and interconnectedness. It was an example of 'long fuses, big bangs', simultaneous stresses and reinforcing failures (Homer-Dixon et al. 2015), combining together to form the crash.

While the fall of the Bronze Age societies had commonalities in risk, the stories of recovery all vary. Each land was unique in how it did, or didn't, navigate the challenges of the collapse. Some, such as the surviving remnants of the Hittites, relied on existing patronage and semi-feudal networks to ensure that some political and cultural unity was carried forward. Others, such as the Neo-Assyrians, took a more brutal approach of abandoning trade with its decreasing yields, and taking up arms to prey on its weakened neighbors.

Worryingly, many of the vulnerabilities and threats present in the Bronze Age echo through to today. The difference is that their scale and intensity is heightened, with a vastly more interconnected world armed with nuclear weapons, dependent on oil and facing extreme climate change. There are other differences, most importantly in our technology and knowledge of both oncoming crises and past systems collapse. Whether these prove to be enough for resilience remains to be seen. Importantly, the kind of resilience matters. A modern state with nuclear weapons taking a Neo-Assyrian approach to recovery is far from desirable.

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