Of Mice and Merchants: Connectedness and the Location of Economic Activity in the Iron Age

Jan David Bakker*, Stephan Maurer†, Jörn-Steffen Pischke‡, Ferdinand Rauch§

Abstract

We study the causal relationship between geographic connectedness and development using one of the earliest massive trade expansions: the first systematic crossing of open seas in the Mediterranean during the time of the Phoenicians. We construct a geography based measure of connectedness along the shores of the sea. We relate connectedness to economic activity, which we measure using the presence of archaeological sites. We find an association between better connected locations and archaeological sites during the Iron Age, at a time when sailors began to cross open water routinely on a big scale. We corroborate these findings at world level.

JEL classification: F14, N7, O47. Keywords: Urbanization, locational fundamentals, trade

We thank Juan Pradera for excellent research assistance, Tom Elliott for help with and advice on the Pleiades database, and Rohini Pande, the editor, four referees, David Abulafia, Neeraj Baruah, Tim Besley, Andrew Bevan, Francesco Caselli, Jeremiah Dittmar, Hannah Friedman, Avner Greif, Vasiliki Kassianidou, Damian Kozbur, Carl Knappett, Jeffrey Lin, Andrea Matranga, Guy Michaels, Dennis Novy, Luigi Pascali, Dominic Rathbone, Tanner Regan, Corinna Riva, Susan Sherratt, Pedro CL Souza, Peter Temin, John van Reenen, Ruth Whitehouse, David Yanagizawa-Drott and participants at various seminars and conferences for their helpful comments and suggestions. This research has been supported by a grant from the Economic and Social Research Council [ESRC ES/M010341/1] to the Centre for Economic Performance at the LSE.

*University College London and CEP, j.bakker@ucl.ac.uk
†University of Konstanz and CEP, stephan.maurer@uni-konstanz.de
‡LSE and CEP, s.pischke@lse.ac.uk
§University of Oxford and CEP, ferdinand.rauch@economics.ox.ac.uk.

1 Introduction

We investigate to what degree trading opportunities affected economic development at an early juncture of human history. In addition to factor accumulation and technical change, Smithian growth due to exchange and specialization is one of the fundamental sources of growth. An emerging literature on the topic is beginning to provide compelling empirical evidence for a causal link from trade and market access to growth. We contribute to this literature and focus on one of the earliest massive expansions in maritime trade: the systematic crossing of open seas in the Mediterranean at the time of the Phoenicians from about 900 BC. We relate trading opportunities, which we capture through the connectedness of points along the coast, to early development as measured by the presence of archaeological sites. We find that locational advantages for sea trade matter for the presence of Iron Age cities and settlements, and thus helped shape the development of the Mediterranean region, and the world.

A location with more potential trading partners should have an advantage if trade is important for development. The shape of a coast matters little for how many neighboring points can be reached from a starting location within a certain distance as long as ships sail mainly close to the coast. However, once sailors begin to cross open seas, coastal geography becomes more important: Some coastal points are in the reach of many neighbors while others can reach only few. The shape of the coast and the location of islands matters for this. We capture these geographic differences by dividing the Mediterranean coast into grid cells, and calculating how many other cells can be reached within a certain distance. Parts of the Mediterranean are highly advantaged by their geography, e.g. the island-dotted Aegean and the "waist of the Mediterranean" at southern Italy, Sicily, and modern Tunisia. Other areas are less well connected, like most of the straight North African coast, parts of Iberia and southern France, and the Levantine coast.

We relate our measure of connectivity to the number of archaeological sites found near any particular coastal grid point. This is our proxy for economic development. It is based on the assumption that more human economic activity leads to more settlements and particularly towns and cities. When these expand and multiply there are more traces in the archaeological record. We find a pronounced relationship between connectivity and development in our dataset for the Iron Age around 750 BC, once the Phoenicians had begun to systematically traverse the open sea. We have less evidence whether there was any relationship between connectivity and sites for earlier periods when the data on sites are poorer. Connectivity might already have mattered during the Bronze Age when voyages occurred at some frequency, maybe at more intermediate distances. Our interpretation of the results suggests that the relationship between coastal geography and settlement density, once established in the Iron Age, persists throughout classical antiquity. While our main results pertain to the Mediterranean, where we have good information on archaeological sites, we also corroborate our findings at a world scale using population data for 1 AD from McEvedy and Jones (1978) as outcome.

Humans have obtained goods from far away locations for many millennia. Some of the early trade involved materials useful for tools (like the obsidian trade studied by Dixon, Cann, and Renfrew 1968), as soon as societies became more differentiated a large part of this early trade involved luxury goods doubtlessly consumed by the elites. Such trade might have raised the utility of the beneficiaries but it is much less clear whether it affected productivity as well. Although we are unable to measure trade directly, our work sheds some light on this question. Since trade seems to have affected the growth of settlements even at an early juncture this suggests that it was productivity enhancing. The view that trade played an important role in early development has recently been gaining ground among both economic historians and archaeologists; see e.g. Temin (2006) for the Iron Age Mediterranean, Algaze (2008) for Mesopotamia, Barjamovic et al. (2019) for Assyria, and Temin (2013) for Ancient Rome.

Our approach avoids issues of reverse causality and many confounders by using a geography based instrument for trade. In fact, we do not observe trade itself but effectively estimate a reduced form relationship, relating opportunities for trade directly to economic development. This means that we do not necessarily isolate the effect of the exchange of goods per se. Our results could be driven by migration or the spread of ideas as well, and when we talk about "trade" we interpret it in this broad sense. While we cannot be sure exactly how connectivity mattered, we show that it did not simply proxy for a variety of other geographic conditions. Both our measure of connectedness and our outcome variable are doubtlessly crude proxies of both trading opportunities and of economic development. This will likely bias us against finding any relationship and hence makes our results only more remarkable.

The periods we study, the Bronze and Iron Ages, were characterized by the rise and decline of many cultures and local concentrations of economic activity. Many settlements and cities rose during this period, only to often disappear again. This means that there were ample opportunities for new locations to rise to prominence while path dependence and hysteresis may have played a lesser role compared to later ages. The political organization of the Mediterranean world prior to the Romans was mostly local. The Egyptian Kingdoms are the main exception to this rule but Egypt was mostly focused on the Nile and less engaged in the Mediterranean. As a result, institutional factors were less important during the period we study.

There is a large literature on trade and growth. Canonical studies are the investigations by Frankel and Romer (1999) and Redding and Venables (2004). These papers use distance from markets and connectivity as measured by gravity relationships to capture the ease with which potential trading partners can be reached. However, these measures do not rely purely on geography but conflate economic outcomes like population and output, which are themselves affected by the development process.

The more recent literature has circumvented this by analyzing exogenous events related to changes in trade. Most similar to our study are a series of papers which also exploit new trade relationships arising from discoveries, the opening of new trade routes, and technological change. Acemoglu, Johnson, and Robinson (2005) link Atlantic trade starting around 1,500 AD to the ensuing shift in the focus of economic activity in Europe from the south and center of the continent to the Atlantic periphery. Redding and Sturm (2008) focus on the division and reunification in Germany, which changed the access to other markets sharply for some locations but not others. Similar natural experiments are employed by Feyrer (2009) and by Maurer and Rauch (2019), who use exogenous variation in sea distance created by the temporary closure of the Suez Canal and the opening of the Panama Canal, respectively. Various papers exploit the availability of new transport technologies; Donaldson (2018) and Donaldson and Hornbeck (2016) study railroads, Pascali (2017) steam ships, and Feyrer (2019) air transport. These papers generally find that regions whose trading opportunities improved disproportionately saw larger income growth. That we find similar results for a much earlier trade expansion suggests that the productivity benefits of trade have been pervasive throughout history.

Our paper also relates to a literature on determinants and dynamics of city locations (Davis and Weinstein 2002, Bleakley and Lin 2012, Bosker and Buringh 2017, Hanlon 2017, Michaels and Rauch 2018). Our contribution stresses the role of market access as a locational fundamental. In a world with multiple modes of transport it is typically hard to measure market access and changes of market access of a city. Our measure relates to a world where much long distance trade took place on boats, which makes it easier to isolate a measure related to market access.

Closely related is the paper by Ashraf and Galor (2011a). They relate population density in various periods to the relative geographic isolation of a particular area. Their interest is in the impact of cultural diversity on the development process, and they view geographic isolation effectively as an instrument for cultural homogeneity. Similar to our measure, their geographic isolation measure is a measure of connectivity of various points around the world. They find that better connected (i.e. less isolated) countries have lower population densities for every period from 1 to 1,500 AD, which seems to contradict our result. Our approach differs from Ashraf and Galor (2011a) in that we only look at locations near the coast and not inland locations. They control for distance to waterways in their regressions, a variable that is strongly positively correlated with population density. Hence, our results are not in conflict with theirs.

Our paper is also related to a number of studies on prehistoric Mediterranean connectivity and seafaring. McEvedy (1967) creates a measure of "littoral zones" using coastal shapes. He produces a map which closely resembles the one we obtain from our connectivity measure but does not relate geography directly to seafaring. This is done by Broodbank (2006), who overlays the connectivity map with archaeological evidence of the earliest sea-crossings up to the end of the last Ice Age. He interprets the connections as nursery conditions for the early development of nautical skills, rather than as market access, as we do for the later Bronze and Iron Ages.

Also related is a literature in archaeology using network models connecting archaeological sites; Knappett, Evans, and Rivers (2008) is an example for the Bronze Age Aegean. Barjamovic et al. (2019) conduct a similar exercise for Assyria based on a gravity model. None of these papers relate to the changes arising from open sea-crossings, which is the focus of our analysis. Temin (2006) discusses the Iron Age Mediterranean through the lens of comparative advantage trade but offers no quantitative evidence as we do.

2 Brief history of ancient seafaring in the Mediterranean

The Mediterranean is a unique geographic space. The large inland sea is protected from the open oceans by the Strait of Gibraltar. The tectonics of the area, the African plate descending under the Eurasian one, have created a rugged northern coast in Europe and a much straighter one in North Africa. Volcanic activity and the more than 3,000 islands also tend to be concentrated towards the north. The climatic conditions in the Mediterranean are generally relatively favorable to agriculture, particularly in the north. The Mediterranean is the only large inland sea with such a climate (Broodbank 2013). Its east-west orientation facilitated the spread of agriculture from the Levant (Diamond 1997). The size of the Mediterranean and an uneven distribution of natural resources also implies great diversity. The geography and climate made the region prone to risks such as forest fires, earthquakes, plagues of locusts, droughts, floods, and landslides. Horden and Purcell (2000) stress that the combination of these factors creates ample opportiunties for trade networks to mitigate shocks and exploit comparative advantage. Trade has played a central role since the early history of the Mediterranean.[1]

Clear evidence of the first maritime activity of humans in the Mediterranean is elusive. Crossings to islands close to the mainland were apparently undertaken as far back as 30,000 BC (Fontana Nuova in Sicily), but Broodbank (2006) dates more active seafaring to around 10,000 BC based on the distribution of obsidian (a volcanic rock) at sites separated by water (see Dixon, Cann, and Renfrew 1965, 1968). This points to the existence of active sea-faring of hunter-gatherer societies, and suggests that boats must have traveled distances of 20-35 kilometers around that time. We have no evidence on the first boats but they were likely made from skin and frame or dugout canoes.

[1]The following discussion mainly draws on Abulafia (2011) and Broodbank (2013).

Agriculture around the Mediterranean began in the Levant some time between 9,500 BC and 8,000 BC. From there it spread initially to Anatolia and the Aegean. Signs of a fairly uniform Neolithic package of crops and domesticated animals can be found throughout the Mediterranean. The distribution of the earliest evidence of agriculture, which includes islands before reaching more peripheral parts of the mainland, suggests a maritime transmission channel.

The Neolithic revolution did not reach Iberia until around 5,500 BC. By that time, many islands in the Aegean had been settled, there is evidence for grain storage, and metal working began in the Balkans. Because of the uneven distribution of ores, metals soon became part of long range transport. The first archaeological evidence of a boat also stems from this period: a dugout canoe, about 10 m long, at La Marmotta north of Rome. A replica proved seaworthy and allowed travel of 20 - 25 km per day in a laden boat.

The Levant, home to the first cities, remained a technological leader in the region, yet there is little evidence of sea-faring even during the Copper Age. This changed with the rise of large scale political entities in Mesopotamia and Egypt. Growth in these first states created rich elites, who soon wished to trade with each other. Being at the cross-roads between these two societies, the Levant quickly became a key intermediary.

Two important new transport technologies arrived in the Mediterranean around 3,000 BC: the donkey and the sail. The donkey was uniquely suited to the climatic conditions and rugged terrain around the Mediterranean (better than camels or horses). Donkeys are comparable in speed to canoes. Sailboats of that period could be around 5-10 times faster in favorable conditions, ushering in a cost advantage of water transport that would remain intact for millennia to come. The land route out of Egypt to the Levant was soon superseded by sea routes leading up the Levantine coast to new settlements like

Byblos, with Levantine traders facilitating much of Egypt's Mediterranean trade. Coastal communities began to emerge all the way from the Levant via Anatolia to the Aegean and Greece.

There is no evidence of the sail spreading west of Greece at this time. Canoes, though likely improved into high performance water craft, remained inferior to sail boats but kept facilitating maritime transport in the central and western Mediterranean. The major islands there were all settled by the early Bronze Age. While not rivaling the maritime activity in the eastern Mediterranean, regional trade networks arose also in the west. The Beaker network and the Cetina culture in the Adriatic during the 3rd Millennium BC are examples. Occasional sea-crossings up to 250 km were undertaken during this period.

A drying spell around 2,200 BC and decline in Egypt disrupted the active maritime network in the eastern Mediterranean and the population it supported. The oldest known shipwreck in the Mediterranean at the island of Dokos in southern Greece dates from this period. The 15 meters long boat could carry a maximum weight of 20 tons. The wreck contained largely pottery, which was likely the cargo rather than carrying liquids, and also carried lead ingots. The ship probably was engaged in local trade.

Decline in the eastern Mediterranean soon gave rise to new societies during the 2nd millennium BC: palace cultures sprang up all over the eastern Mediterranean. Minoan Crete and Mycenae in Greece were notable examples but similar cities existed along the Anatolian coast and in the Levant. The palaces did not simply hold political power, but were centers of religious, ceremonial, and economic activity. At least initially, craftsmen and traders most likely worked for the palace rather than as independent agents. Sail boats still constituted an advanced technology, and only the concentration of resources in the hands of a rich elite made their construction and operation possible. The political reach of the palaces at coastal sites was local; larger polities remained confined to inland areas as in the case of Egypt, Babylon, or the Hittite Empire.

An active trade network arose again in the eastern Mediterranean stretching from Egypt to Greece during the Palace period. The Anatolian land route was replaced by sea trade. Some areas began to specialize in cash crops like olives and wine. A typical ship was still the 15 m, 20 ton, one masted vessel as evidenced by the Uluburn wreck found at Kas in Turkey, dating from 1,450 BC. Such vessels carried diverse cargoes including people (migrants, messengers, and slaves), though the main goods were likely metals, textiles, wine, and olive oil. Evidence for some of these was found on the Uluburun wreck; other evidence comes from archives and inscriptions akin to bills of lading. Broodbank (2013) suggests that the cargo of the Uluburun ship was such that it was sufficient to feed a city the size of Ugarit for a year. Ugarit was the largest trading city in the Levant at the time with a population of about 6,000 - 8,000. This highlights that sea trade still largely consisted of high value luxury goods. The Ugarit archives also reveal that merchants operating on their own account had become commonplace by the mid 2nd millennium. Levantine rulers relied more on taxation than central planning of economic activities. Trade was both risky and profitable; the most successful traders became among the richest members of their societies.

Around the same time, the Mycenaeans traded as far as Italy. Sicily and the Tyrrhenian got drawn into the network. While 60 - 70 km crossings to Cyprus or Crete and across the Otranto Strait (from Greece to the heel of Italy) were commonplace, coast hugging still prevailed among sailors during the 2nd millennium BC. After crossing the Otranto Strait, Greek sailors would continue along the coast of the Bay of Taranto, the instep of Italy's boot, as is suggested by the distribution of Greek pottery at coastal sites. Indigenous seafarers from the central Mediterranean now joined these routes, and the sail finally entered the central Mediterranean around 1,200 BC. While there were no big breakthroughs, naval technology also improved in the late 2nd millennium. Better caulking and keels added to sea-worthiness (Abulafia 2011), while brail rigging and double prows improved maneuverability. Most notably, latitude sailing was developed and allowed sailors to steer a straight east-westerly course.

Before these changes could develop their full force, a new period of decline around 1,200 BC reduced the power of Egypt, wiped out cities like Ugarit, and ended the reign of the last palace societies in the eastern Mediterranean. In the more integrated world that the eastern Mediterranean had become, troubles spread quickly from one site to others. The Bronze Age came to an end with iron coming on the scene. Rather than being technologically all that much superior to bronze, iron ore was far more abundant and widespread than copper and hence much more difficult to monopolize. As was the case many times before, decline and change opened up spaces for smaller players and more peripheral regions. Cyprus flourished. Many Levantine cities recovered quickly. Traders from the central Mediterranean also expanded. Traditionally, decline during the Bronze Age collapse was often blamed on the anonymous "Sea Peoples." Modern scholarship seems to challenge whether these foreigners were simply just raiders and pirates, as the Egyptians surely saw them, rather than also entrepreneurial traders who saw opportunities for themselves to fill the void left by the disappearance of imperial connections and networks.

The Levantine city states which had taken in migrants from the central Mediterranean during this period were the origin of a newly emerging trade network. Starting to connect the old Bronze Age triangle formed by the Levantine coast and Cyprus, they began to expand throughout the entire Mediterranean after 900 BC. The Phoenician city states were much more governed by economic logic than was the case for royal Egypt. One aspect of their expansion was the formation of enclaves, often at nodes of the network. Carthage and Gadir (Cadiz) are prime examples but many others existed. At least initially these were not colonies; the Phoenicians did not try to dominate local populations. Instead, locals and other settlers were invited to pursue their own enterprise and contribute to the trading network. The core of the network consisted of the traditional sea-faring regions, the Aegean and the Tyrrhenian. The expanding trade network of the early 1st millennium BC did not start from scratch but encompassed various regional populations. Tyrrhenian metal workers and Sardinian sailors had opened up connections with Iberia at the close of the 2nd millennium. But the newly expanding network not only stitched these routes together, it also created its own, new, long-haul routes.

These new routes began to take Phoenician and other sailors over long stretches of open sea. While this had long been conjectured by earlier writers like Braudel (2001, writing in the late 1960s) and Sherratt and Sherrat (1993), contemporary scholars are more confident. Cunliffe (2008) writes about the course of a Phoenician sailor: "Beyond Cyprus, for a ship's master to make rapid headway west there was much to be said for open-sea sailing. From ... the western end of Cyprus he could have sailed along the latitude to the south coast of Crete ... where excavation has exposed a shrine built in Phoenician fashion. Traveling the same distance again ..., once more following the latitude, would have brought him to Malta" (p. 275-276), a route which became known as the "Route of the Isles." Abulafia (2011) describes their seafaring similarly: "The best way to trace the trading empire of the early Phoenicians is to take a tour of the Mediterranean sometime around 800 BC. ... Their jump across the Ionian Sea took them out of the sight of land, as did their trajectory from Sardinia to the Balearics; the Mycenaeans had tended to crawl round the edges of the Ionian Sea past Ithaka to the heel of Italy, leaving pottery behind as clues, but the lack of Levantine pottery in southern Italy provides silent evidence of the confidence of Phoenician navigators." (p. 71).

These new routes involved crossing 300 - 700 km of open sea. One piece of evidence for sailing away from the coast are two deep sea wrecks found 65 km off the coast of Ashkelon

(Ballard et al. 2002). Of Phoenician origin and dating from about 750 BC, the ships were 14 meters long, and each carried about 400 amphorae filled with fine wine. These amphorae were highly standardized in size and shape. This highlights the change in the scale and organization of trade compared to the Uluburun wreck with its diverse cargo. It also suggests an early form of industrial production supporting this trade.

An unlikely traveler offers a unique lens on the scale of the expansion of seafaring and the density of connections which were forged during this period. The house mouse populated a small area in the Levant until the Neolithic revolution. By 6,000 BC, it had spread into southern Anatolia before populating parts of north eastern Africa and the Aegean in the ensuing millennia (there were some travelers on the Uluburun ship). There were no house mice west of Greece by 1,000 BC. Then, within a few centuries, the little creature turned up on islands and on the mainland throughout the central and western Mediterranean (Cucchi, Vigne, and Auffray 2005).

The Phoenicians might have been at the forefront of spreading mice, ideas, technology, and goods all over the Mediterranean but others were part of these activities. At the eve of classical antiquity, the Mediterranean was constantly criss-crossed by Greek, Etruscan, and Phoenician vessels as well as smaller ethnic groups. Our question here is whether this massive expansion in scale led to locational advantages for certain points along the coast compared to others, and whether these advantages translated into the human activity which is preserved in the archaeological record.

3 Data and key variables

For our Mediterranean dataset we compute a regular grid of 10×10 kilometers that spans the area of the Mediterranean and the Black Sea based on a coastline map of the earth from Bjorn Sandvik's public domain map on world borders.[2] We use a Lambert Azimuthal Equal Area projection, with the coordinates 39N, 18.5E as reference point, which is close to the center of the area we study. No projection avoids distortions completely but this one works well for the study of a limited geographical area. The distances of the edges of our 10×10 km grid are close to the true distances: Even at points furthest from the reference points, such as Gibraltar in the west and Sinai in the east, measurement error of both vertical and horizontal lines remains within less than 2 percent of true distances.

We define a grid-cell as coastal if its centroid is within 5 km of a coastline. Grid-cells whose centroid is more than 5 km away from a landmass are classified as sea, the remaining cells are classified as land. Our estimation dataset consists of all coast cells and all land cells within 50 km of a coast cell. Each cell is an observation. There are 12,013 cells in this dataset of which 3,352 are coastal.

We compute the distance between coastal point i and coastal point j moving only over water d_{ij}.[3] Our key variable in this study, called c_{di}, measures the number of other coastal cells which can be reached within shipping distance d from cell i. Destinations

[2]We use version 3, available from `http://thematicmapping.org/downloads/world_borders.php`.

[3]For this computation, we use the *cost distance* command in ArcGIS. This tool calculates least-cost paths between points based on a cost raster that assigns travel costs to the area in between the points. In our case, the cost raster consists of a regular grid of 10×10 kilometers of cells that are either over water or coastal. We assign the same cost value to every grid cell, so that the cost-distance calculation boils down to finding the shortest distance between points via the cost raster cells (i.e. water or coast). We then treat one coastal cell as origin and calculate the minimum distance from this origin cell to all other coastal cells. We repeat this exercise using each of our coastal cells as origin cell to obtain the full matrix of pairwise distances.

may include islands but we exclude islands which are smaller than $20km^2$. We also create separate measures, one capturing only connectedness to islands, and a second measuring connectedness to other points on the mainland coast. While we use straight line or shortest distances, we realize that these would have rarely corresponded to actual shipping routes. Sailors exploited wind patterns and currents, and often used circular routes on their travels (Arnaud 2007). Our measure is not supposed to mimic sailing routes directly but simply capture opportunities.[4]

Figure 1 displays the measure c_{500} for a distance of 500 km; darker points indicate better connected locations. Measures for other distances are strongly positively correlated and maps look roughly similar. The highest connectedness appears around Greece and Turkey partly due to the islands, but also western Sicily and the area around Tunis. The figure also highlights substantial variation of the connectedness measure within countries. The grid of our analysis allows for spatial variation at a fine scale.

We interpret the measure c_d as capturing connectivity. Of course, coastal shape could proxy for other amenities. For example, a convex coastal shape forms a bay, which may serve as a natural harbor. Notice that our 10×10 km grid is coarse enough to smooth out many local geographic details. We will capture bays 50 km across but not those 5 km across. It is these more local features which are likely more relevant for locational advantages like natural harbors. Our grid size also smooths out other local geographic

[4]We do not attempt to use wind patterns to calculate sailing times. Leidwanger (2013), combining modern data on wind speeds and prevailing directions with the sailing logs from sea trials with the replica of a 3rd century BC wreck on a Piraeus to Cyprus route, is an attempt to do this for a small area a few hundred kilometers across off the Turkish coast. He discusses shortcomings and problems with this approach. His work illustrates how far away we still are from being able to extend an exercise like this to an area like the entire Mediterranean.

features, like changes in the coastline which have taken place over the past millennia, due, for example, to sedimentation. The broader coastal shapes we capture have been roughly constant for the period since 3,000 BC, which we study (Agouridis 1997).

Another issue with our measure of connectivity is whether it only captures better potential for trade or also more exposure to external threats like military raids. Overall, it was probably easier to defend against coastal attacks than land-based ones (e.g. Cunliffe, 2008, p. 447) so this may not be a huge concern. But at some level it is obvious that openness involves opportunities as well as risks. In this respect we measure the net effect of better connectivity.

We also compute a global dataset based on a global grid, using a Cylindrical Equal Area projection. We increase the cell size to 50 $\times$ 50 kilometers. This is for computational convenience, but also our outcome variable at the global level varies only at the country level and thus spatial precision is less relevant than in the Mediterranean dataset. While we define our global connectedness measure for the whole world, our analysis focuses on the part of the world between -60 degrees and 60 degrees latitude, as units outside that range are unlikely candidates for early urbanization for climatic reasons. In the Southern Hemisphere there is no landmass apart from the Antarctic below 60 degrees, while in the Northern Hemisphere 60 degrees is close to Helsinki, Aberdeen, and Anchorage, well north of climatic conditions particularly favorable to early settlement. We again compute the distance from each coastal grid point to each other coastal grid point by moving only over water. Figure 2 shows the global connectedness measure c_{500}. The most connected coastal points are located again near Greece, but also in Southeast Asia, Chile, Britain, and Northern Canada, while Western Africa and Eastern South America have few well connected coastal points.

We measure economic development by counting archaeological sites of settlements. Historians and archaeologists have long debated to what extent the material evidence that has been discovered is representative of actual historical conditions. On one end of the spectrum are warnings like that of Manning (2018, p. 64) that "archaeological evidence, especially for settlement history, is extremely uneven for the first millennium BCE." The idea of a "positivist fallacy" of "making archaeological prominence and historical importance into almost interchangeable terms: in equating what is observable with what is significant" goes back to at least Snodgrass (1987, p. 38). At the other end are optimists such as Broodbank (2013), who concludes that "only a single imbalance is so devastating that it threatens to undermine the integrity of the overall study of the Mediterranean. This is the dearth of information on the early societies of the Mediterranean North Africa" (p. 37). We deal with the North African exceptionalism by showing results excluding the North African coast. But Broodbank concludes that "the low archaeological profile of much of Mediterranean North Africa may not entirely be due to a lack of prospection ... In the coming chapters we shall encounter several indications that this was indeed the case" (2013, p. 39).

Whether the archaeological record is representative of history is one issue, another is to obtain a quantitatively useful snapshot of the archaeological record. Our data on settlements for our period of investigation come from the Pleiades Project, an electronic database (Bagnall et al. 2014) at the University of North Carolina, the *Stoa Consortium*, and the *Institute for the Study of the Ancient World* at New York University maintained jointly by the *Ancient World Mapping Center*.[5] The Pleiades dataset is a gazetteer for ancient history. It draws on multiple sources to provide a comprehensive summary of the current knowledge on geography in the ancient world. The starting point for the database is the *Barrington Atlas of the Greek and Roman World* (Talbert 2000); but it is an open

[5]Available at `pleiades.stoa.org`. We use a version of the dataset downloaded in September 2017.

source project and material from multiple other scholarly sources has been added.[6]

The Pleiades data consists of three different databases of which we use the "pleiades-places" dataset. It offers a categorization as well as an estimate of the start and end date for each place. We only keep units that have a defined start and end date, and limit the dataset to units that have a start date before 500 AD. We use two versions of these data, one more restricted (which we refer to as "narrow") and the other more inclusive ("wide"). In the narrow one we only keep units that contain the word "urban" or "settlement" in the categorization. These words can appear alongside other categorizations of minor constructions, such as bridge, cemetery, lighthouse, temple, villa, and many others. In the "wide" measure, we include any man-made structure, excluding only natural landmarks (e.g. rivers) and administrative units.[7] Figure 1 displays the sites that appear in the narrow dataset in 750 BC as circles. The figure gives a first glimpse as to the relationship between connectedness and the presence of sites.

Some of the entries in the Pleiades dataset are located more precisely than others. The dataset classifies the confidence into the location as precise, rough, and unlocated. We only keep units with a precisely measured location.[8] For both datasets, as we merge the Pleiades data onto our grid we round locations to the nearest 10×10 kilometers and are thus robust to some minor noise.

Since the Pleiades data is originally based on the *Barrington Atlas* it covers sites from the classical Greek and Roman period well and adequate coverage seems to extend back

[6]Various historians have assured us that the *Barrington Atlas* is probably the most representative source for the period we are studying.

[7]The raw Pleiades dataset contains some sites that are duplicates and/or have been moved to the errata section of Pleiades. We drop those sites from our analysis.

[8]An exception to this are roads and canals, which typically cannot be interpreted as a single point, and where we therefore also include rough locations.

to about 750 BC. Coverage of older sites seems much more limited as the number of sites with earlier start dates drops precipitously. For example, our wide dataset has 1,565 sites in 750 BC and 5,707 in 1 AD but only 142 in 1,500 BC. While economic activity and populations were surely lower in the Bronze Age, there are likely many earlier sites missing in the data. As a consequence, our estimation results with the Pleiades data for earlier periods may be less reliable.[9]

Our measure of urbanization for a given cell is the number of sites that exist at time t and fall into that cell. We prefer a count of sites over an indicator given that it is scale invariant with respect to the grid size. The maximum number of sites in a cell for the narrow Pleiades measure is 5 but for 98.5% of the cells the value is either 0 or 1.

For our global results, we have only a single early outcome measure: population in 1 AD from McEvedy and Jones (1978). This is the same data as used by Ashraf and Galor (2011b) for a similar purpose. Population density is measured at the level of modern countries, and our sample includes 122 countries.

4 Specification and results

We run regressions of the following type:

$$u_{it} = \beta_{dt} c_{di} + X_i \gamma_t + e_{it}, \tag{1}$$

where u_{it} is the urbanization measure for grid point i, c_{di} is the log of the connectivity measure for distance d, and X_i is a vector of grid point control variables. For coastal cells,

[9]In the online appendix we present some alternative estimates based on the much earlier *Archaeological Atlas of the World* (Whitehouse and Whitehouse 1975), which is more focused on the pre-classical era but has problems of its own.

connectivity is simply the connectivity of the respective coastal cells. For inland cells, we assign the connectivity level of the closest coastal cell. We only measure connectivity of a location, not actual trade. Hence, when we refer to trade this may refer to the exchange of goods but could also encompass migration and the spread of ideas. u_{it} measures the number of archaeological sites in each cell and year, which we view as proxy for the GDP of an area. Growth manifests itself both in terms of larger populations as well as richer elites in a Malthusian world. We would expect that the archaeological record captures exactly these two dimensions.

We start by using only linear variables for latitude and longitude as control variables. Latitude captures climatic variation due to the north-south gradient of the region. Climatic conditions also vary in the east-west orientation since proximity to the Atlantic moderates weather variability (Manning 2018, p. 85), and the longitude variable controls for this. Since some of our cells are up to 50 km inland, we also consider distance to the coast as an additional control variable, as well as distance to the Fertile Crescent. The latter may be important because agriculture spread from the Fertile Crescent throughout the Mediterranean Basin, and various authors have linked the timing of the Neolithic Revolution to later development (Diamond 1997; Hibbs and Olsson 2004; Comin, Easterly, and Gong 2010). We explore dropping the Aegean, to address concerns that our results may be driven exclusively by developments around the Greek islands, by far the best connected area in the Mediterranean. We also show results dropping North Africa to address concerns that there may be fewer archaeological sites in North Africa due to a relative lack of exploration. This may spuriously correlate with the fact that the coast is comparatively straight. We cluster standard errors at the level of a grid of 200×200 km following Bester, Conley and Hansen (2011). Using a 400×400 km grid as cluster variable results in very similar standard errors. Kelly (2019) warns against spurious inference resulting from spatially correlated but coincident variation on the left and right of spatial regressions but clusters of that size should largely guard against this.

Our measure of connectedness depends only on coastal and maritime geography and therefore is plausibly exogenous. However, it might be correlated with other factors that affect early growth, such as agricultural productivity, topographic conditions, or rivers, which provide inland connections. Those factors are hard to measure precisely. Hence, instead of including them on the right-hand side of our regression equation as control variables, we follow the suggestion of Pei, Pischke and Schwandt (2019) and show that they are not systematically related to our measure of coastal connectivity.

The results of these balancing regressions are shown in table 1. In the first row, we relate connectedness to agricultural productivity, which we construct using data from the FAO-GAEZ database and following the methodology of Galor and Özak (2016): We convert agroclimatic yields of 48 crops in $5' \times 5'$ cells under rain-fed irrigation and low levels of input into caloric yields and assign the maximal caloric yield of the closest $5' \times 5'$ to our grid cells. In the second row, we use Nunn and Puga's (2012) measure of ruggedness, averaged over our 10×10 km cells. Both ruggedness and agroclimatic conditions are standardized to have mean 0 and standard deviation 1. The third row looks at distance to the nearest river. For this, we used Wikipedia to create a list of all rivers longer than 200 km and geocoded their paths from FAO Aquamaps, dropping tributaries. We then calculate the distance from each cell to the nearest river, capping it at 50 km. To make the interpretation easier, we then take the negative of this measure, so that a positive coefficient on connectedness would mean that well-connected cells are closer to rivers. We use distance to the nearest mine, using data from the OXREP Mines Database (2017), coding distance in the same way as for rivers. For wind, we use the AMI Wind on ERS-1 Level 4 Monthly Gridded Mean Wind Fields provided by the Centre de Recherche et d'Exploitation Satellitaire (CERSAT), at IFREMER, Plouzané (France). This dataset contains monthly average wind speeds over oceans on a 1x1 degree grid. We average wind speed over the sailing period from March to October, using data for 1993. Each coast cell is then assigned the value of the closest wind grid cell. For the sixth row, we constructed a measure of land connectedness that mimics our sea connectedness. Specifically, for all the cells in our sample, we calculated how many other cells in our dataset on the same landmass can be reached within 500km, going only over the land or coast cells in our sample.

Column (1) in table 1 starts by showing the results of balancing regressions just controlling for latitude and longitude. Column (2) also adds controls for distance to the Fertile Crescent and distance to the coast. Neither agricultural productivity, ruggedness, nor distance to rivers or mines, nor land connectedness have a large association with our measure of connectedness once we control for the distance to the coast and the Fertile Crescent. The exception is wind speed, which correlates positively with connectedness.

Columns (3) and (4) show that dropping the Aegean from the sample sometimes leads to bigger associations but also impairs precision. When we control for distance to the coast and Fertile Crescent in the sample without the Aegean, associations between the balancing variables and connectedness tend to be small and insignificant, including for wind speed. The only exception is distance to rivers but this relationship is very imprecise. Outside of North Africa, a slight negative association between connectedness and agricultural productivity arises with controls. We are comforted by the fact that our measure of connectedness does not appear to be related to the six variables examined in the table in a systematic way across subsamples. This is especially true once we control for distance to the coast and the Fertile Crescent. As a result, we will use all of latitude, longitude, and distance to the coast and Fertile Crescent as controls in the analyses that follow.[10]

[10]In table A.1 in the online appendix we additionally add these variables as control variables to the main specification, and find that the coefficient does not change significantly with this inclusion.

4.1 Basic results

In panel A of table 2, we start by showing results for connections within 500 km and the settlement counts in 750 BC. At this time, we expect sailors to make extensive use of direct sea connections, and hence the coefficients β_{dt} from equation (1) should be positive. This is indeed the case for all specifications. We find stronger results in the wide Pleiades data, and the association is highly significant. The magnitude of these estimates is large. Increasing the connectedness of a cell by ten percent increases the number of archaeological sites by around 0.02. The coefficients are larger than the means of the dependent variables, also reported in the table, suggesting an elasticity above one. The coefficient is slightly lower for the narrow site definition but so is the mean of the site count. Coefficients decrease in magnitude when we drop the Aegean in column (2), but they remain positive and substantial, indicating that the Aegean alone was not driving the results in column (1). Dropping North Africa in column (3) makes little difference compared to the original results.[11]

A potential concern with our results might be that we are not capturing growth and urbanization, but simply the location of harbors. To address this, panel B of table 2 repeats the analysis of panel A, but drops coastal cells themselves from the sample. Here we are investigating whether a better connected coast gives rise to more settlements further inland. The results are similar to those from the previous panel, indicating that the effects we observe are not driven by coastal locations but also manifest themselves in the immediate hinterland of the coast. This bolsters the case that we are seeing real growth effects of better connections. The same is true when we exclude short connections within 100 km from the connectedness variable in panel C of table 2. This is important

[11] We find very similar results using a measure of eigenvector centrality instead of our connectedness variable, which adds weighting to connecting cells, but it is very highly correlated to the original connections measure.

as we are primarily interested in the longer range connections which opened up with open sea crossing.[12]

Coastal points are only a proxy for market access. A more direct measure would be to measure how many settlements a ship can reach, rather than how many coastal points. In table 3 we use such a more direct measure of market access by counting the number of sites within distance d. To account for the endogenous location of settlements we instrument this market access measure with the connectedness variable, both in logs. The first stage F-tests we report show that connectedness is strongly correlated with market access. The magnitude of the 2SLS effect is similar for all these specifications to the one seen in the connectedness estimation.[13] This effect is large compared with existing estimates of the impact of market access. For example, it is about twice as large as the estimate for the land value elasticity in Donaldson and Hornbeck (2016). This may reflect the relatively long time scale over which these effects would have materialized. It may also reflect the greater importance of connections in the Iron Age Mediterranean, where there were few other pre-existing long range trading possibilities other than sea routes, compared to a USA without railroads. It may also show that in a less technologically advanced economy, market access mattered more relative to other fundamentals.[14]

[12]The results in panel C of table 2 are unchanged if we separately control for short connections up to 100 km, as we show in table A.1 in section 1.3 of the online appendix. This further strengthens the case that we are not simply picking up some other effects of coastal shape.

[13]Table A.3 in the online appendix contrasts these estimates with an OLS estimator. Magnitudes are similar when we exclude the Aegean. Otherwise the 2SLS estimates are larger.

[14]Our results so far pertain to connections within a 500 km radius. In the online appendix we also show results for other distances, which tend to look fairly similar.

Our regressions relate the location of sites to geographic connectedness or market access. We do not directly observe the channels through which connections might lead to growth, like trade, migration and the spread of ideas. Why should we be confident that urbanisation arose because of these channels rather than something else, or that the association is merely spurious? While connectedness is clearly related to other geographic features of an area, we find no systematic lack of balance with respect to other measurable factors. We find that it is longer range connections which seem to matter most, which is exactly the type of connections which became important for sea travel during the Iron Age. The historical literature on the period is adamant that longer range trade expanded massively during this period, as suggested by the analysis of the origins of particular archaeological artefacts (Abulafia, 2011, Braudel, 2001, Broodbank, 2013, Sherratt and Sherratt, 1993). In section 1.7 in the online appendix, we also provide suggestive evidence that connectedness is related to a proxy for the interaction between locations. In particular, we show that better connections are associated with lower genetic distance around 1500 AD (as measured by Spolaore and Wacziarg, 2018) at the world level. This holds on the bilateral level, connected locations are less genetically distant, and on average, better connected locations have lower genetic distance to the rest of the world. While each of these pieces of evidence might be merely suggestive, they point in a consistent direction.

A somewhat different concern might be that connections are indeed associated with the presence of sites, maybe because of trade, but the locations of the sites come about because individuals settled at favored localities. In the absence of good connections, sites might have simply arisen in some other place. Our cross-sectional data cannot rule out this alternative explanation. However, this was a period of relatively rapid growth in population (Scheidel, 2007) and social development (Morris, 2010, figure 3.8). Maybe this too was just coincidental. But this seems like a convoluted story: people moved towards locations conducive to trade but not because trade was productive. At the same time, some other factor did cause growth, which we observe manifesting itself in the trading locations. Occam's razor seems to favor an explanation where connections and trade are the driving force behind development and settlement patterns.

4.2 Timing and persistence

So far we have shown that connectedness is related to the presence of archaeological sites in 750 BC. This relationship should have first emerged around this time but should be absent in 1000 BC or earlier. Furthermore, the period from the Iron Age until the decline of the Roman Empire was one of relative continuity; centres of gravity in the Mediterranean might have shifted but there were no further disruptions like the Bronze Age collapse. Trade and seafaring kept expanding during this period until the height of the Roman Empire. As a result, we expect that the relationship between connectivity and settlement density remained intact or grew even stronger. Settlements existing in 750 BC should have continued (and possibly grown) while more intense trade should have spurred the establishment of additional sites at similar locations in the coming centuries.

In order to investigate these ideas, Figure 3 shows results from the narrow data set over time using the 500 km connectedness measure. The total number of sites differs by year. To enable comparison over time, we divide the left hand side by the average number of sites per cell in each year, turning the estimates effectively into elasticities. The figure has various features. Elasticities are positive and sizable but insignificant during the 2nd millenuim BC. They increase in 750 BC, consistent with the Iron Age expansion of open sea routes. From 500 BC, the effects of connectivity decline continually until no effect is left by the end of the Roman Empire. The results for the period before 750 BC are roughly in line with our expectation but the ones for the subsequent period are not.

In figure 3 the relationship between settlements and connections first emerges during the middle Bronze Age around 2000 BC. This may reflect the earlier trade networks that existed during this period, particularly in the eastern Mediterranean. However, estimates are noisy for this period. This is a result of the fact that there are relatively few sites in the Pleiades dataset for the period before 750 BC. Moreover, given the way the database was constructed, coverage in the earlier periods is less complete, and the earlier sites are largely ones that happened to have persisted into the classical period. This selection could mean that the results for the earlier period are just an attenuated image of the later ones. Therefore, we don't want to over-interpret these findings.

The decline in the elasiticy between site density and connectivity after 500 BC is not consistent with our expectations. A large literature in urban economics and economic geography has studied the dynamics of city locations and largely found substantial persistence, sometimes across periods of major historical disruption (Davis and Weinstein 2002, Bleakley and Lin 2012, Bosker and Buringh 2017, among others). An exception is Britain after the fall of the Roman Empire, which saw a substantial reorientation of the location of its cities during the Middle Ages (Michaels and Rauch 2018). However, the latter case is characterised by both a major disruption of the entire urban network in Britain, as well as a change in transportation modes. Given the relative continuity in the Mediterranean after 500 BC and the further expansion of seafaring, we would not expect such a drastic change in our setting. Instead, we would expect the locations of new cities to be driven by the same forces as the previous ones.

One possible explanation for the observed pattern could be that the role of maritime connectivity declined – for example, if sailors and ships got better and distance played less of a role, or other modes of transport, such as on Roman roads, became cheaper. But these were marginal changes and the cost advantage of water transport remained intact for the following millenia.

We suspect that the real explanation is a different one, and has to do with site density in our data growing too much, so that our grid cells are becoming saturated with archaeological find spots. In 750 BC there are 1,565 sites in the wide dataset and this number increases to 5,707 in 1 AD at the height of the Roman Empire.[15] There are only 12,013 cells in our dataset. As a result, our grid quickly fills up with sites after the start of the Iron Age. This eliminates a lot of useful variation given our lack of an intensive margin measure: By the height of the Roman Empire many grid points will be the location of archaeological sites.

A distinct and possibly complementary explanation is that the first sites may be concentrated in the best-connected locations. New settlements after 750 BC, on the other hand, might have arisen further away from existing cities in unoccupied locations, which are slightly less well connected. This is consistent with the results of Bosker and Buringh (2017) for a later period, who find that having a previously existing city close by decreases a location's chance of becoming a city seed itself. In order to investigate this, we split the sites in the Pleiades data into those which existed already in 750 BC but remained in the data in subsequent periods and those which first entered at some date after 750 BC. Figure 4 shows results for the period 500 BC to 500 AD. As in figure 3, we show coefficients divided by the mean number of sites in the period. The solid line shows the original elasticities for all sites. The line with long dashes shows elasticities for sites present in 750 BC which remained in the data while the line with short dashes refers to sites that have newly entered since 750 BC. The elasticity for remaining sites is more stable (it only falls because site density rises), while the relationship between connectedness and the location of entering sites becomes weaker and even turns negative towards the end of the period. Because the new entrants make up an increasing share of

[15] See table A.5 in the online appendix for more details on the numbers of sites in each dataset and time period.

the total over time, the total coefficients (solid line) are being dragged down by selective site entry towards the end of the Roman era.

4.3 Results for a world scale

Finally, we corroborate our findings for the Mediterranean at a world scale. While Mediterranean trade is very well documented, there were several other prehistoric trade networks around the world. Paine (2013) describes substantial trade on the Arabian Sea, Persian Gulf, and the Red Sea and between the Mediterranean world, East Africa, and India. India also traded with Southeast Asia, and evidence suggests long-distance trade from Ecuador to Guatemala and Mexico, as well as trading relationships in the Caribbean and between South-eastern Alaska and the Strait of Juan de Fuca.

For our global analysis, we use population in 1 AD from McEvedy and Jones (1978) as outcome variable. Population density is measured at the level of modern countries, and the sample includes 122 countries. Recall that we compute connectivity for coastal cells based on a grid of 50 x 50 km cells for this exercise.

We aggregate coastal connectivity to the level of countries, which is the unit at which the dependent variable is measured anyway.[16] Figure 5 is a scatter plot of c_{500} against log population density at the country level. The weights in this figure correspond to the number of coastal grid points in each country. The line in the figure comes from a standard bivariate regression and has a slope of 1.30 (1.02). This estimate is very similar to the implied elasticity for the Mediterranean in table 2, although the nature of the dependent variable is different. Note that many Mediterranean countries can be found

[16]We drop Fiji from this analysis. Our projection does not allow travel across the 180th Meridian, and at a 500km radius, Fiji is the one country that is affected by this, as its coast cells are close to, but on both sides of this meridian.

in the upper right quadrant of this plot, highlighting how exceptional connectivity in the basin may have contributed to the early development of this region.

Additionally, we regress log population density in 1 AD on log 500km connectedness, controlling for absolute values of latitude and its square and again weighting by the number of coastal grid points in each country.[17] This results in a point estimate for connectivity of 2.35 with a standard error of 0.72.

5 Conclusion

We argue that connectedness matters for human development. Some geographic locations are advantaged because it is easier to reach a larger number of neighbors. We exploit this idea to study the relationship between connectedness and early development around the Mediterranean. We argue that this association should emerge most potently when sailors first started crossing open seas systematically. This happened during the time when Phoenician, Greek, and Etruscan sailors and settlers expanded throughout the Mediterranean between 800 and 500 BC. Barry Cunliffe (2008) calls this period at the eve of classical antiquity "The Three Hundred Years That Changed the World" (p. 270).

This is not to say that sea trade and maritime networks were unimportant earlier. We find clear evidence of a significant association between connectedness and the presence of archaeological sites for 750 BC. Our results are more difficult to interpret as to whether this relationship began to emerge at that period because the data for earlier periods are more shaky. Once locational advantages emerged, the favored locations mostly retained

[17] East-west orientation and distance from the Fertile Crescent are not particularly meaningful covariates for the world scale. Unlike for the Mediterranean, there were various centers of early development around the world. The squared term is introduced to capture potential non-linearities of absolute latitude.

their urban developments over the ensuing centuries, in line with a large literature on urban persistence.

References

[1] Abulafia, David, *The Great Sea: A Human History of the Mediterranean*, London: Penguin; New York: Oxford, University Press, 2011.

[2] Acemoglu, Daron, Simon Johnson, and James Robinson, "The Rise of Europe: Atlantic Trade, Institutional Change, and Economic Growth", *American Economic Review* 95 (2005): 546-579.

[3] Agouridis, Christos, "Sea Routes and Navigation in the Third Millennium Aegean", *Oxford Journal of Archaeology* 16 (1997): 1-24.

[4] Algaze, Guillermo, *Ancient Mesopotamia at the Dawn of Civilization. The Evolution of an Urban Landscape*. Chicago: Chicago University Press, 2008.

[5] Arnaud, Pascal, "Diocletian's Prices Edict: The Prices of Seaborne Transport and the Average Duration of Maritime Travel", *Journal of Roman Archaeology* 20 (2007): 321-336.

[6] Ashraf, Quamrul, and Oded Galor, "Cultural Diversity, Geographical Isolation, and the Origin of the Wealth of Nations", NBER Working Paper 17640 (2011a).

[7] Ashraf, Quamrul, and Oded Galor, "Dynamics and Stagnation in the Malthusian Epoch" *American Economic Review* 101 (2011b): 2003-2041.

[8] Bagnall, Roger et al. (eds.), *Pleiades: A Gazetteer of Past Places*, `http://pleiades.stoa.org` (2014).

[9] Ballard, Robert D. Lawrence E. Stager, Daniel Master, Dana Yoerger, David Mindell, Louis L. Whitcomb, Hanumant Singh, and Dennis Piechota, "Iron Age Shipwrecks in Deep Water off Ashkelon, Israel", *American Journal of Archaeology* 106 (2002): 151-168.

[10] Barjamovic, Gojko, Thomas Chaney, Kerem A. Coşar, and Ali Hortaçsu, "Trade, Mechants, and the Lost Cities of the Bronze Age", *Quarterly Journal of Economics* 134 (2019): 1455-1503.

[11] Bester, C. Alan, Timothy G. Conley, and Christian B. Hansen, "Inference with Dependent Data Using Cluster Covariance Estimators", *Journal of Econometrics* 165 (2011): 137-151.

[12] Bleakley, Hoyt, and Jeffrey Lin, "Portage and Path Dependence", *The Quarterly Journal of Economics* 127 (2012): 587-644.

[13] Bosker, Maarten, and Eltjo Buringh, "City Seeds: Geography and the Origins of the European City System", *Journal of Urban Economics* 98 (2017):139-157.

[14] Braudel, Fernand, *The Mediterranean in the Ancient World.* London: Penguin Books, 2001.

[15] Broodbank, Cyprian, "The Origins and Early Development of Mediterranean Maritime Activity", *Journal of Mediterranean Archaeology* 19.2 (2006): 199-230.

[16] Broodbank, Cyprian, *Making of the Middle Sea*, London: Thames and Hudson Limited, 2013.

[17] Comin, Diego, William Easterly, and Erick Gong, "Was the Wealth of Nations Determined in 1000 BC?", *American Economic Journal: Macroeconomics* 2 (2010): 65-97.

[18] Cucchi, Thomas, Jean Denis Vigne, and Jean Christophe Auffray, "First Occurrence of the House Mouse (Mus musculus domesticus Schwarz & Schwarz, 1943) in the Western Mediterranean: a Zooarchaeological Revision of Subfossil Occurrences", *Biological Journal of the Linnean Society* 84.3 (2005): 429-445.

[19] Cunliffe, Barry, *Europe Between the Oceans. 9000 BC - AD 1000.*, New Haven: Yale University Press, 2008.

[20] Davis, Donald, and David Weinstein, "Bones, Bombs, and Break Points: The Geography of Economic Activity", *American Economic Review* 92 (2002): 1269-1289.

[21] Diamond, Jared M., *Guns, Germs, and Steel: The Fates of Human Societies*, New York: W. W. Norton, 1997.

[22] Dixon, John, Johnston R. Cann, and Colin Renfrew, "Obsidian in the Aegean", *The Annual of the British School at Athens* 60 (1965): 225-247.

[23] Dixon, J. E., J. R. Cann, and Colin Renfrew, "Obsidian and the Origins of Trade", *Scientific American* 218.3 (1968): 38-46.

[24] Donaldson, Dave, "Railroads of the Raj: Estimating the Impact of Transportation Infrastructure", *American Economic Review.* 108 (2018): 899-934.

[25] Donaldson, Dave, and Richard Hornbeck, "Railroads and American Economic Growth: a "Market Access" Approach", *Quarterly Journal of Economics* 131 (2016): 799-858.

[26] FAO/IIASA, "Global Agro-ecological Zones (GAEZ v3.0)"FAO, Rome, Italy and IIASA, Laxenburg, Austria, 2010.

[27] Feyrer, James, "Distance, Trade, and Income– The 1967 to 1975 Closing of the Suez Canal as a Natural Experiment", NBER Working Paper 15557 (2009).

[28] Feyrer, James, “Trade and Income–Exploiting Time Series in Geography”, *American Economic Journal: Applied Economics*, 11 (2019): 1-35.

[29] Frankel, Jeffrey A., and David Romer, “Does Trade Cause Growth?”, *American Economic Review* 89 (1999): 379-399.

[30] Galor, Oded, and Ömer Özak, “The Agricultural Origins of Time Preference”, *American Economic Review* 106 (2016): 3064-3103.

[31] Hanlon, W. Walker, “Temporary Shocks and Persistent Effects in Urban Economies: Evidence from British Cities after the U.S. Civil War”, *Review of Economics and Statistics* 99 (2017): 67-79.

[32] Hibbs, Douglas A. and Ola Olsson, “Geography, Biogeography, and Why Some Countries Are Rich and Others Are Poor”, *Prodeedings of the National Academy of Sciences* 101 (2004): 3715-3720.

[33] Horden, Peregrine, and Nicholas Purcell, *The Corrupting Sea: a Study of Mediterranean History.* Oxford: Wiley-Blackwell, 2000.

[34] Knappett, Carl, Tim Evans, and Ray Rivers, “Modelling Maritime Interaction in the Aegean Bronze Age'—rq, *Antiquity* 82 (2008): 1009-1024.

[35] Kelly, Morgan, “The Standard Errors of Persistence”, CEPR Discussion Paper 13783 (2019).

[36] Leidwanger, Justin, “Modeling Distance with Time in Ancient Mediterranean Seafaring: a GIS Application for the Interpretation of Maritime Connectivity”, *Journal of Archaeological Science* 40 (2013): 3302-3308.

[37] Manning, J.G., *The Open Sea. The Economic Life of the Mediterranean World from the Iron Age to the Rise of Rome*, Princeton, Oxford: Princeton University Press,

2018.

[38] McEvedy, Colin, *The Penguin Atlas of Ancient History*, Hamondsworth: Penguin Books Ltd, 1967.

[39] McEvedy, Colin, and Richard Jones, *Atlas of World Population History*, Hamondsworth: Penguin Books Ltd, 1978.

[40] Maurer, Stephan, and Ferdinand Rauch, "Economic Geography Aspects of the Panama Canal", CEPR Discussion Paper 13820 (2019).

[41] Michaels, Guy, and Ferdinand Rauch, "Resetting the Urban Network: 117-2012", *Economic Journal*, 128 (2018): 378-412.

[42] Morris, Ian, *Why the West Rules–For Now: The Patterns of History and What They Reveal about the Future*, Farrar Straus Giroux, 2010.

[43] Nunn, Nathan, and Diego Puga, "Ruggedness: The Blessing of Bad Geography in Africa", *Review of Economics and Statistics* 94 (2012): 20-36.

[44] OXREP Mines Database, "The Oxford Roman Economy Project", downloaded from http:oxrep.classics.ox.ac.ukdatabasesmines_database in December 2017 (2017).

[45] Paine, Lincoln, *The Sea and Civilization: A Maritime History of the World*, New York: Knopf, 2013.

[46] Pascali, Luigi, "The Wind of Change: Maritime Technology, Trade and Economic Development", *American Economic Review* 107 (2017): 2821-2854.

[47] Pei, Zhuan, Jörn-Steffen Pischke, and Hannes Schwandt, "Poorly Measured Confounders Are More Useful on the Left than the Right", *Journal of Business and Economic Statistics* 37 (2019), 205-216.

[48] Redding, Stephen J., and Daniel M. Sturm, "The Costs of Remoteness: Evidence from German Division and Reunification", *American Economic Review* 98 (2008): 1766-97.

[49] Redding, Stephen, and Anthony J. Venables, "Economic Geography and International Inequality", *Journal of International Economics* 62 (2004): 53-82.

[50] Scheidel, Walter, "Demography", in: *The Cambridge Economic History of the Greco-Roman World*, eds. Walter Scheidel, Ian Morris, and Richard Saller, Cambridge and New York: Cambridge University Press, 2007, 38-86.

[51] Sherratt, Susan, and Andrew Sherratt, "The Growth of the Mediterranean Economy in the Early First Millennium BC", *World Achaeology* 24 (1993): 361-378.

[52] Snodgrass, Anthony M., *An Archaeology of Greece: The Present State and Future Scope of a Discipline*. Berkeley: University of California Press, 1987.

[53] Spolaore, Enrico, and Romain Wacziarg, "Ancestry and development: New evidence", *Journal of Applied Econometrics*. 33 (2018): 748-762.

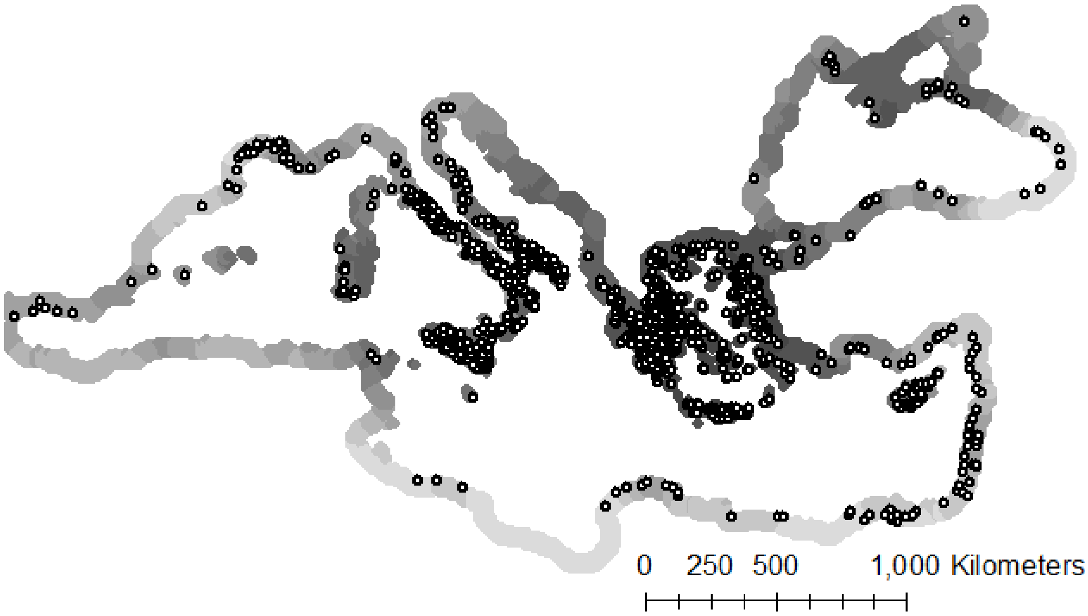
[54] Talbert, Richard JA, ed., *Barrington Atlas of the Greek and Roman World: Map-by-map Directory*. Princeton, Oxford: Princeton University Press, 2000.

[55] Temin, Peter, "Mediterranean Trade in Biblical Times"in Ronald Findlay et al., eds. *Eli Heckscher, International Trade, and Economic History*. Cambridge: MIT Press, 2006, 141-156.

[56] Temin, Peter, *The Roman Market Economy*. Princeton: Princeton University Press, 2013.

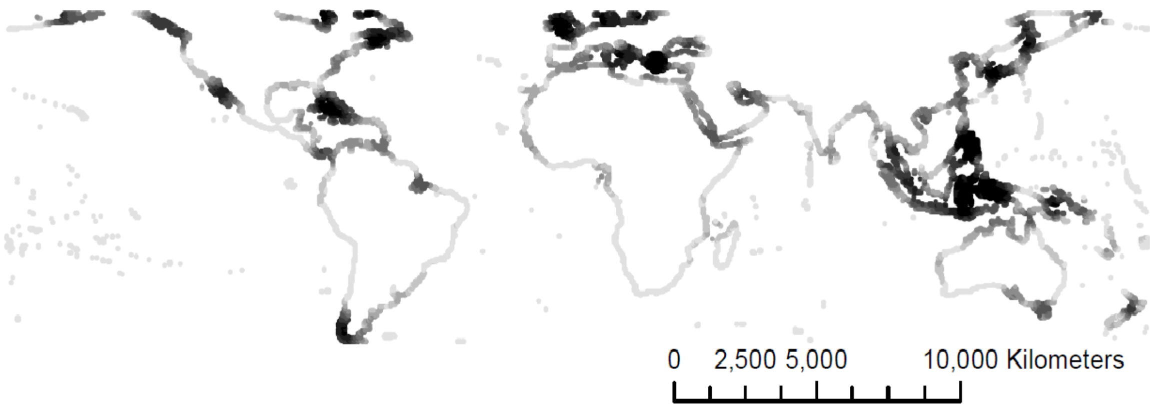
[57] Whitehouse, David, and Ruth Whitehouse, *Archaeological Atlas of the World*. London: Thames and Hudson, 1975.

Figure 1: Connectedness for 500 km distance and Pleiades narrow sites in 750 BC



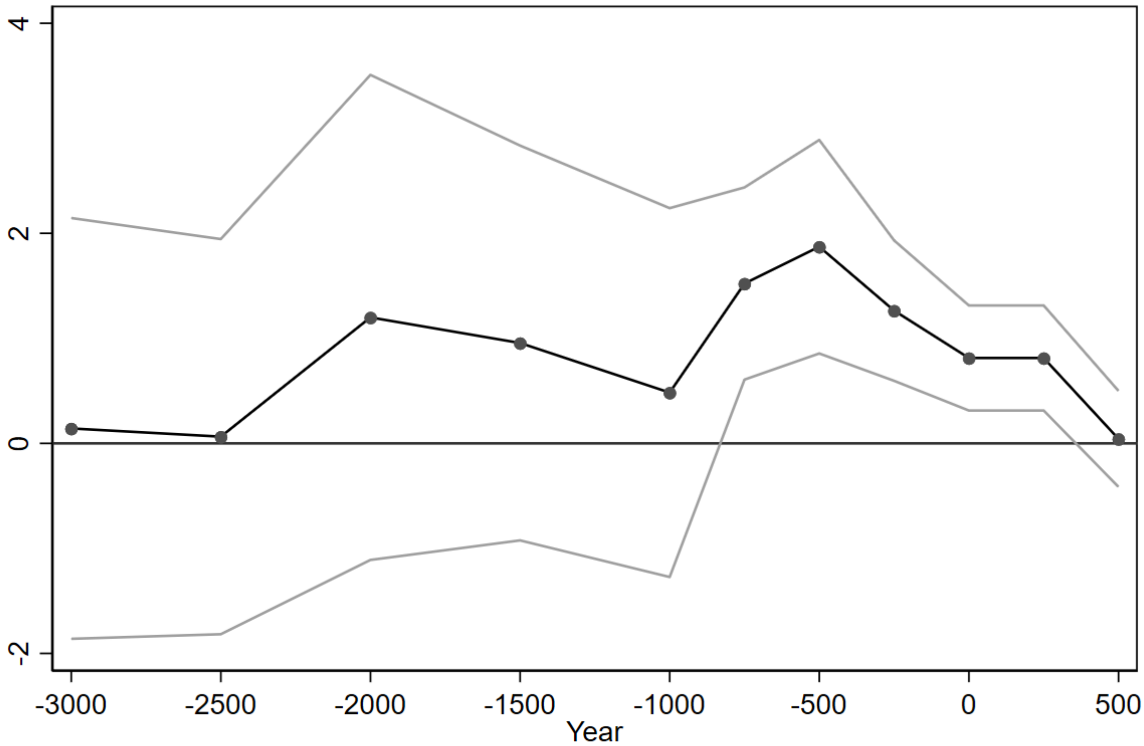
The different shades of gray indicate deciles of the connectedness distribution. Darker points show better connected areas. The circles display archeological sites for 750 BC from the Pleiades narrow definition.

Figure 2: Connectedness in the world for a 500 km distance measure



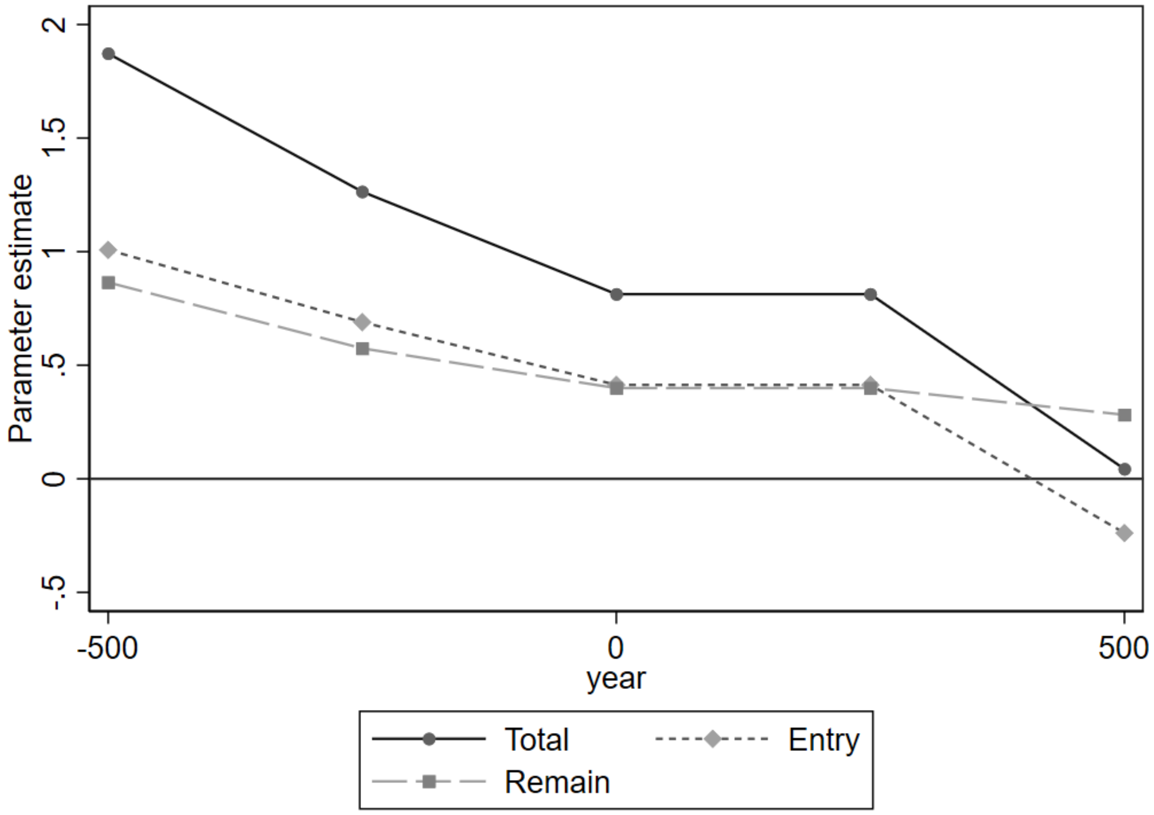
The different shades of gray indicate deciles of the connectedness distribution. Darker points show better connected areas.

Figure 3: Scaled coefficients for different years



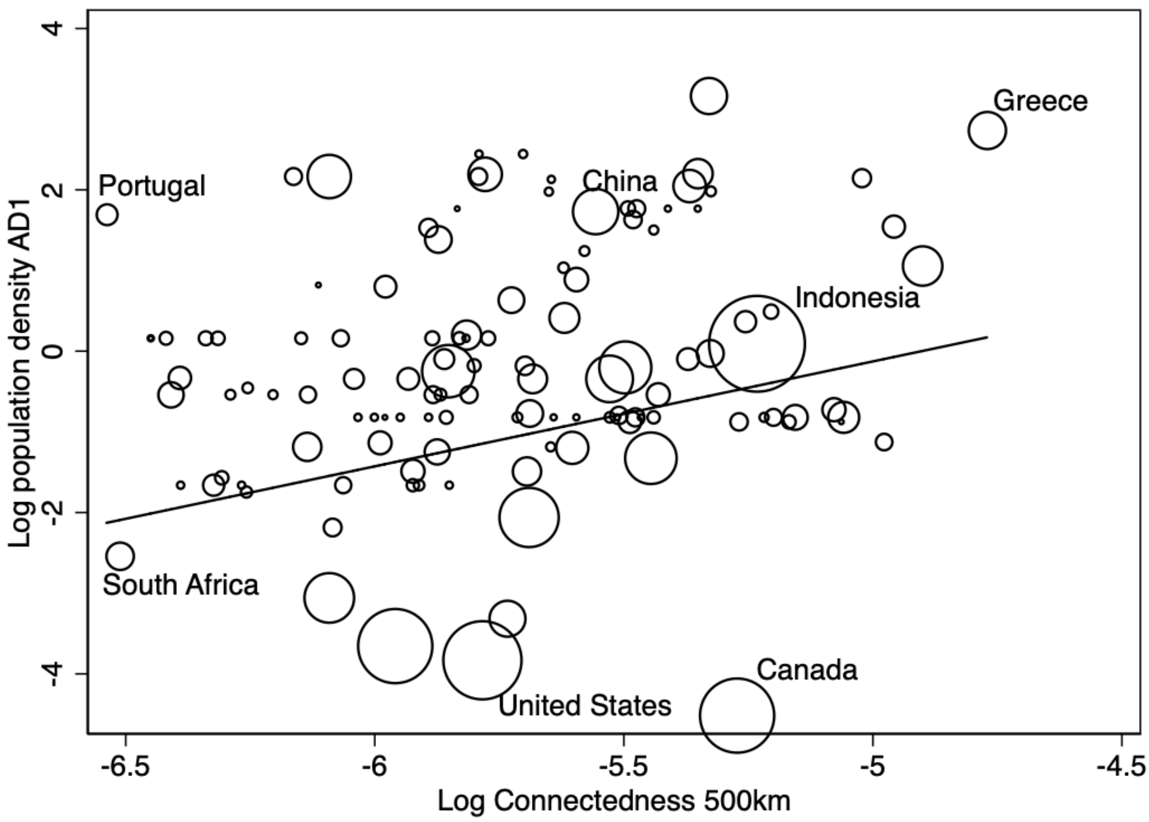
This plot shows the main coefficient of our regression (equation 1) for narrow Pleiades sites and 95 percent confidence intervals for different years. In these regressions, the left hand side variable is the number of sites in each cell divided by the average number of sites in each period to allow for a comparison over time. The right hand side variable is log connectedness computed for a distance of 500 km. The regressions include controls for latitude, longitude, distance to the coast, and distance to the Fertile Crescent. Standard errors are clustered at the level of 200×200 km cells.

Figure 4: Scaled coefficients for narrow Pleiades sites: Total, existing, and new entry



This plot shows the main coefficient of our regression (equation 1) for narrow Pleiades sites divided by the average number of sites in a cell and 95 percent confidence intervals for different years. Entry refers to sites which are present in a year but weren't present in 750 BC. Remain refers to sites which were also present in 750 BC. Total refers to all sites. The regressions include controls for latitude, longitude, distance to the coast, and distance to the Fertile Crescent.

Figure 5: Connectedness and population density around 1AD at the world scale



The graph shows a scatter of log population density in 1 AD against log connectedness at 500 km. The weights reflect the length of the coast of countries. The slope coefficient is estimated to be 1.30, with a standard error of 1.02. The figure omits Bermuda, which is an outlier in terms of connectedness. The weighted slope (robust standard error) with Bermuda is 1.28 (1.00). When we include a control variable for the absolute latitude and its square the slope becomes 2.35 (0.72) with Bermuda and 2.40 (0.73) without it.

Table 1: Balancing checks

Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)
Agricultural productivity	0.46	0.00	0.54	0.07	0.16	-0.17
(following Galor and Özak (2016))	(0.08)	(0.10)	(0.14)	(0.16)	(0.11)	(0.09)
Ruggedness	0.19	0.14	0.06	-0.05	-0.29	-0.13
(following Nunn and Puga (2012))	(0.14)	(0.19)	(0.29)	(0.28)	(0.16)	(0.16)
River proximity	-3.00	-2.90	-4.32	-3.82	-2.45	-2.99
	(1.72)	(2.14)	(2.96)	(3.33)	(2.09)	(2.19)
Mines proximity	-0.37	0.10	-0.14	0.40	-1.96	-0.04
	(0.37)	(0.74)	(1.22)	(1.48)	(0.74)	(0.67)
Wind	0.31	1.05	-0.53	0.24	0.67	1.20
	(0.16)	(0.23)	(0.30)	(0.34)	(0.17)	(0.22)
Land connectedness	-0.43	-0.30	-0.30	-0.04	-0.24	-0.24
	(0.22)	(0.24)	(0.15)	(0.16)	(0.24)	(0.24)
Observations	12013	12013	10064	10064	9464	9464
Controls:						
Longitude and latitude	X	X	X	X	X	X
Distance to coast and Fertile Crescent		X		X		X
Dropping Aegean			X	X		
Dropping North Africa					X	X

Each coefficient in this table is from a different regression. For each row a different dependent variable is regressed on the log connectedness measure for 500km, with controls as indicated at the bottom of each column. Standard errors are clustered at the level of 200×200 km cells, in parentheses.

Table 2: Main results

Dependent variable	Dep. var. mean	(1)	(2)	(3)
Panel A: Basic results				
Pleiades wide 750BC	0.130	0.208	0.103	0.204
		(0.056)	(0.044)	(0.056)
Pleiades narrow 750BC	0.103	0.156	0.075	0.156
		(0.048)	(0.035)	(0.048)
Observations	12013	12013	10064	9464
Panel B: Results excluding coastal cells from outcome definition				
Pleiades wide 750BC	0.100	0.176	0.095	0.184
		(0.063)	(0.048)	(0.062)
Pleiades narrow 750BC	0.081	0.131	0.073	0.140
		(0.053)	(0.041)	(0.053)
Observations		8661	7567	6647
Panel C: Results excluding short connections				
Pleiades wide 750BC	0.130	0.201	0.103	0.197
		(0.052)	(0.042)	(0.053)
Pleiades narrow 750BC	0.103	0.152	0.076	0.152
		(0.045)	(0.034)	(0.045)
Observations		12013	10064	9464
Controls		X	X	X
Dropping Aegean			X	
Dropping North Africa				X

Coefficients from regressions of the number of sites on 500 km log connectedness and controls. Controls include longitude, latitude, distance to the coast, and distance to the Fertile Crescent. The dependent variable counts the number of sites in a cell based on either the wide or the narrow Pleiades measure. Panel B excludes coastal cells from the sample, and panel C uses log connectedness from 100 to 500 km as main regressor.

Table 3: 2SLS regressions for market access instrumenting with connectedness

Dependent variable	(1)	(2)	(3)
Pleiades wide 750BC	0.225	0.100	0.251
	(0.056)	(0.038)	(0.064)
First-stage F statistic	32	17	37
Pleiades narrow 750BC	0.178	0.074	0.214
	(0.050)	(0.031)	(0.060)
First-stage F statistic	30	16	32
Observations	12013	10064	9464
Controls:			
Longitude and latitude	X	X	X
Distance to coast and Fertile Crescent	X	X	X
Dropping Aegean		X	
Dropping North Africa			X

Coefficients from a 2SLS regression of the number of sites in a cell, computed for either the wide or narrow Pleiades measure as indicated, on log market access computed for the 500km connectedness measure. In the first stage market access is instrumented using 500 km log connectedness. Standard errors clustered at the level of 200x200 km cells, in parentheses.