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SOMMARIO

FORUM ARTICLE

THE WESTERN STRING IN THE LATE MBA AND LBA I-II: POPULATIONS AND ACCOUNT BALANCES

Donald W. Jones

Summary

Three Aegean islands – Melos, Thera, and Kea – between Crete and the eastern mainland of Greece have been singled out as composing the Western String principal trade route during the Bronze Age (Fig. 1). Each has a single town and at least the remains of a good harbor, and the towns have the archaeological evidence of out-of-the-ordinary wealth: fortification walls, at least one monumental building, sophisticated fresco wall paintings in some of the buildings, and high-value imports. My question is: How did such small islands with so few productive resources and populations, get so rich? My answer is that they charged for port services, earning something like monopoly profits off their natural harbor facilities. I test this hypothesis with the interruption of commercial shipping following the destruction of the middle island – Thera – by a volcanic explosion around 1630 BCE. As the shipping through the remaining two islands tapered off, partly due to reduced demand from Crete and partly due to emergence of new, work-around shipping routes, so did those two islands' ability to sustain the monumentality of architectural structures as earthquakes required repairs that increasingly came out of savings and shipping income dwindled. Eventually the towns were abandoned.

Much of the literature on the islands of the Cycladic Western String – Melos, Thera, and Kea – has been devoted to questions of their relationships with Crete during the late MBA and LC I/LM I periods: colonization, with and without Cretan political domination; Cretan emigrants, possibly craftspeople; emulation in search of prestige; and even ordinary trade, either under official sponsorship or privately undertaken. The results of these research programs have been largely indeterminate, generally because of difficulties in identifying unambiguous archaeological indicators of these phenomena (Broodbank 2004). One of the more enduring, if somewhat more restricted, interpretations of the evidence for late MBA and LC I external relations among the Western String islands themselves is that the islands offered way-stations in a maritime trading nexus between Crete and the mainland (Davis 1979; Schofield 1982a; Cherry, Davis 1982; Graziadio 1998, 37-38; Sherratt 2000, 20-23), although Georgiou (1993; 1998, 213-14) has expressed a vigorous case for wider Cycladic island participation in shipping between Crete and the mainland. Several themes have emerged as corollaries to the primary theme: the presence of Cretans on the islands (*e.g.* Schofield 1984; Wiener 1984); the proper interpretation(s) of the appearances of affluence in at least some of the major buildings of the principal towns on the islands; political relations between Crete and the islands (Davis 1978; Branigan 1981; Poursat 1990; Niemeier 2009; Nikolakopoulou 2009, 37); the interpretation of Minoan artifacts on the islands (*e.g.* Knappett, Nikolakopoulou 2008) and Cycladic artifacts on Crete (MacGillivray 1984); and the role of metallurgical activities and the metals trade in the external relations of the islands (Gale, Stos-Gale, Davis 1984; Warren 2009, 264).

To date, these topics generally have been addressed separately, although not necessarily in competition with one another, as explanations of the economic prehistory of the Western String. To my thinking, a mystery lurking throughout these topics, one which I cannot find called out in the literature, is how these three islands came into the wealth observed on them. They were too small to have had large enough populations for skimmings from their production to account for it. This paper develops and explores a model that focuses on this mystery and in so doing unites the topics noted above, showing them to be, to a great extent, different aspects of a single, unified

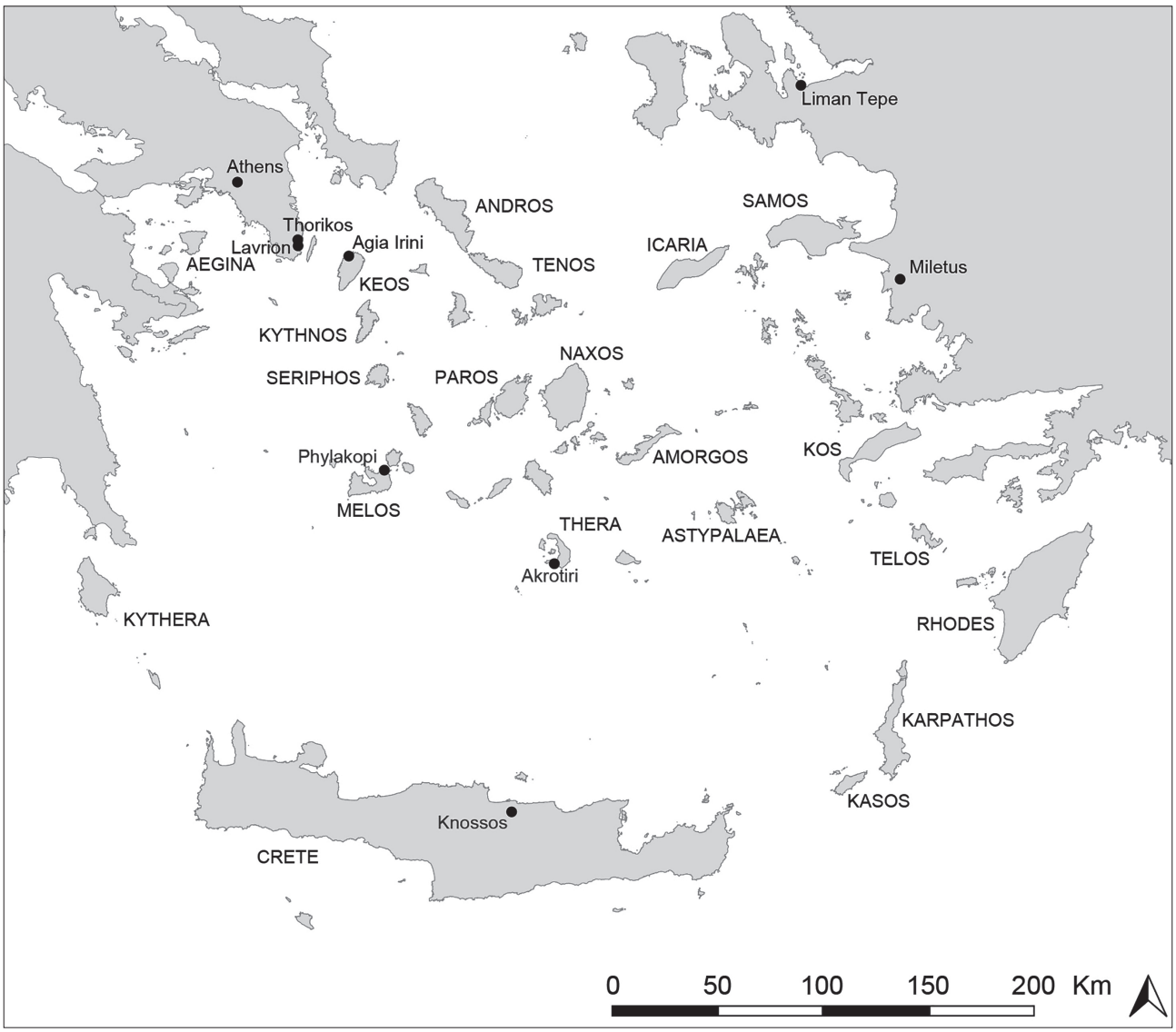

Fig. 1. The Aegean islands.

explanation, or hypothesis, regarding the evidence of economic activity on those islands. In this unified explanation, a change in some part of the system causes changes elsewhere in the system, commonly in places where they would not ordinarily be sought. For example, a change in, say, Crete's demand for Attic metals would affect food imports into the islands. The increase of Cypriot copper on Crete later in the Late Bronze Age (Gale, Stos-Gale 2008, 389) might serve as such a change in demand for Attic metals, or at least copper; or the earlier Thera eruption precipitated the drastic reduction in evidence of Cretan shipping activity at Phylakopi and Agia Irini during LM IB (Mountjoy, Ponting 2000, 172-174; Mountjoy 2000, 399, 402). The setting of this model relies on some demographic matters, so several issues revolving around population and demography are logically prior and are dealt with in the section after next.

Recent and current research on the Cyclades and their inhabitants' relationships with Crete and various mainland regions has turned away from macro-scale study of 'Minoanization' and toward detailed study of community- and individual-level mechanisms of cultural change (*e.g.* papers in Gorogianni *et al.* 2016). Advances in the

physical science analysis of ceramics have begun to yield quite detailed insights into ancient production techniques that have been unavailable heretofore. These two recent developments in Aegean archaeology have dovetailed in the application of agency notions in efforts to get closer to the minds and actions of ancient individuals in the Cyclades. Berg (2007a, 72) has expressed this intellectual movement eloquently by comparing its aims with perceived shortcomings of previous research which "[…] represent[ed] the different Cycladic communities as one undifferentiated 'Minoanised' entity (cf. also Western String, 'community colonies'), thus denying the islanders their individuality in dealing with outside cultures and failing to acknowledge the diversity of the material record." Malcolm Wiener's "Versailles effect" is included in this list of de-individualizing theories and concepts. Vlachopoulos (2016, 122) goes so far as to contend that the earlier opinion, that the Western String theory was "selective and obsessive with regard to its island components, and dismissive with regard to the role of most islands of the Cyclades in their participation in corresponding networks of contacts and reciprocal influences, is vindicated" by results of recent excavations of MBA Cycladic sites. Some scholars may think that these ideas from the 1970s through the early 2000s have given all the insights they have to offer. Others may disapprove rather than offer disproof.

A good deal of this Cycladic cultural change research has involved differences in production techniques applied to different shapes and sizes of vases at different locations, to a great extent with material from Agia Irini, Phylakopi, and to a somewhat lesser extent from Akrotiri – the towns of the three Cycladic islands that have been most extensively excavated. Inferences have extended to community identity, social competition, taboos on production of particular vase shapes with new techniques, and to elite display of certain vase types in socially charged situations (Berg 2007a, 2007b; Davis, Gorogianni 2008; Hilditch 2014; Abell, Hilditch 2016; Gorogianni 2016). My interest in this paper is more restrictive than the encompassing topic of cultural change. I want to convince the reader how these three towns, or at least some of their residents, got as rich as their material remains indicate they did. Minoanization, in the large or in the small, while interesting, is outside the scope of my investigation. That field is being heavily tilled by other scholars. I take a mixed approach to the large and small differences among these three islands and their residents. In developing the model of the mechanisms that I think were responsible for the observed wealth, I have applied simplifications that some archaeologists may think drastic, possibly too drastic. In testing the model empirically, I bring back into the analysis some of the differences among the islands as controlling factors in the interpretation of evidence. Agency is present in my model and analysis, but it is directed to economic choices rather than to cultural ones although there may be overlap between these two scholarly categories. I am skeptical that the activities whose remains have been found along the Western String islands were unique. As for a 'special relationship' between Crete and these islands, all relationships are 'special,' possibly leaving none of them special. Recent research on evidence of Cretan overseas activities has extended eastward to the Dodecanese and the west coast of Anatolia as well as northward, so clearly any relationship between Crete and the Western String islands was not unique (*e.g.* papers in Macdonald *et al.* 2009).

Trade through these islands, between Crete and the mainland, is not in doubt. It is well accepted. My question is: How did trade make the residents, or at least some of them, as affluent as the remains suggest they were? – By selling their own products or someone else's? Melos with its obsidian was the only one of these islands with an extractable resource, and obsidian was cheap and also was probably an open-access resource on Melos. The only exploitable resources these islands had were their locations. To anticipate the conclusions, the small populations of the islands would have precluded their autarkic creation of the affluence inferred from the plethora of luxurious artifacts found at Phylakopi, Akrotiri, and Agia Irini, which puts the spotlight on trade, but on what aspects of trade? Since they could not have produced much in the way of merchandise to sell with their small labor pools, certainly not in sufficient quantity to generate the observed affluence, service exports in the form of shipping and related supporting services, including eventually financing, a notoriously lucrative activity, come to the fore as a potential explanation. Allocating labor time to shipping services would have drawn islanders' working time out of agriculture, requiring the islands to import part of their food supplies, incidentally diversifying their food sources. Using the concept of a trade balance – the value of exports must equal the value of imports (in the absence of a capital account) – we also can infer that the value of these port towns' shipping services well exceeded the value of their food imports.

The paper proceeds as follows. After the preceding outline of the problem, but before embarking on the analysis itself, it is helpful to place the traffic patterns of the Western String model (or hypothesis) in the broader context of maritime patterns in the south and central Aegean, remembering that my principal goal is to explain the apparent wealth of the three island towns rather than shipping routes per se, although the two are clearly related. Following this positioning of the problem, I address the populations of the three Western String islands, Crete, and the Bronze Age mainland. Demonstration of relative population sizes is necessary to document the empirical soundness of a major structural feature of the model. Next, characteristics of Bronze Age ships and shipping are brought to bear on the rationale for considering the Western String to be an analytically meaningful unit, scratching somewhat more deeply into the mechanism underlying the original Western String hypothesis. Having confirmed that rationale, the model of the islands' connectivity and relations with Crete and the mainland is developed. The section following the model tests the model. The final section reviews what has been found and considers its significance.

AEGEAN SHIPPING ROUTES OUTSIDE THE WESTERN STRING

As rescue excavations, surveys, and occasional, sustained excavations such as that at Mitrou, have expanded reports of ceramic material originating from outside its find spot, some interpretations of the Western String model have declared it somewhere between morbidly anorexic and dead (Vlachopoulos 2016; Hilditch 2019, 454-455). In fact, Scholes' survey of reports of Bronze Age Cycladic pottery made apparent that mainland-island and island-island exchanges existed throughout that period, if not necessarily to the extent that would be known a half-century later (Scholes 1956, 15-16, 23, 27-31). Morgan (2020, 19-20) summarizes the network of shipping interactions throughout the southern Agean which excavations have revealed over several recent decades. My focus on the three islands of the Western String is on the processes of their enrichment, not the exclusivity of the shipping routes through them, although there is surely a relationship through the concept of monopoly, or at least oligopoly: the more competing ports along a shipping route, the smaller the site rents any port should be able to extract from shippers.

Accordingly, it is useful to survey the alternative shipping routes between Crete and the mainland through the Cyclades and other island-hopping routes such as through Kythera. I do not deal with the more recently named 'Eastern String,' from Crete, through Karpathos, Rhodes and Kos and on to the west coast of Anatolia. In this section I survey what is known about external contacts of, and possible shipping through, Cycladic islands outside the Western String, the route from Crete to the southern and western Peloponnese via Kythera, and the potential competition or complementarity between Aegina and the Western String islands in shipping to mainland destinations.

Since the period that involves my hypothesis about port-town wealth tapers off after LM IA/LH I-II/LC I-II in most cases, evidence for external contacts and possibly shipping activities in LH III is generally of little relevance. That said, the emergence of new port facilities dating to LB III could reflect work-arounds from the disappearance of Thera from the Western String near the end of LM IA, but they only indirectly would affect the test of my hypothesis that uses the LM IA eruption as the natural experiment. The adjustments of shipping routes thereafter would affect the post-eruption activity on the remaining Western String islands, as appears especially in the case of Melos and its port town, Phylakopi, and as such are very much a part of Aegean prehistory. But those developments involve a number of emerging forces: the rise of Mycenaean civilization on the mainland and the mechanisms of at least its cultural spread to the Cyclades, growing interaction with the Levant, and the subsequent decline of the Mycenaean palatial society and polities and the corresponding adjustments evident in LH IIIC. And that's all another story.

A number of studies have produced valuable maps of probable Aegean shipping routes and the environmental forces helping to shape them, from the Neolithic through the end of the Bronze Age. Surprisingly or not, the results converge by and large. Agouridis's map for third millennium routes shows the route that would later be called the Western String route, with links to both central and east Crete (Agouridis 1997, 10, fig. 5). Janko's map

is distinguished from the others by the absence of a direct route from Crete to Melos and on through the rest of the Western String, although that is not his comment on the Western String model (Janko 2008, 579, fig. 14.6). Papageorgiou's map of Neolithic and EBA routes is less easy to interpret, as her maps do not show the major shipping routes she designates as A through F. Route F is what would be called the Western String in the late MBA and early LBA, although she stops at the end of the EBA (Papageorgiou 2009, 210, fig. 4). But the different maps show the routes from western Crete to southern Laconia at Agios Stephanos and other sites along the Laconian Gulf, to sites in Messenia, and to sites leading up the Argolic Gulf to Lerna and other northeastern Peloponessian sites. Some of these maps, particularly Janko's, point to other sites in the Laconian Gulf that most likely would have been important stopping points, if not necessarily major ports, but have experienced major subsidence/sea-level changes which have changed their Bronze Age configurations beyond ready recognition. Marthari maps a trade route between Thera and Crete, extending on through Melos to the Gulf of Argos, with its ports at Lerna, Tiryns, and Asine (Marthari 1993, 252, fig. 3). Considering Aegean trade routes from the MH through LH IIIC periods, Alberti (2013, 23) envisions "trade activities […] carried out through segmented geographical circuits, mainly north-south oriented […] by a restricted number of major leading centres, while other sites and areas play a decidedly more secondary role". In her map of the central Cycladic circuit, she includes Kea and Thera, does not include Melos and Crete, but does include Amorgos. Alberti subsequently maps Aegean trade routes and circuits from the MBA to LB I Early (LM IA) (Alberti 2016, 280, fig. 11.1). It includes a route along the Western String from Crete to Kea, although it doesn't extend to Lavrion in Attica, even if that extension may be implicit. It also has a route from western Crete through Kythera to the southern Peloponnese, but there is no route from Crete through the more central to northern Cyclades – through Naxos, Paros, Mykonos, Tenos and Andros, etc. Most of the scholars who have suggested maps of trade routes in the Aegean overlap considerably with one another in their visions, and no matter what segment of the full Bronze Age is concerned.

Cyclades beyond the Western String: Blue Highways (Country Roads) behind the Interstates (the Autobahn)[1]

The maritime commerce forming the basis of the apparent wealth of the three Western String islands began in the MBA, possibly early in that period, since wealth takes time to accumulate and depends on decisions made regarding the disposition of net income over many years. After extensive archaeological evidence of inter-Cycladic maritime contacts during the EBA, many of the Cycladic islands appear to have gone silent during the earliest MBA. An exception, Paroikia on Paros maintained contact with Kea, several other Cycladic islands, and the mainland – likely via Kea – into the middle of the MBA, although the site's remains show no evidence of direct contact with Crete (Rubinsohn 1901; 1917, 34-37; Overbeck 1982, 1989b). The harbor there has experienced subsidence, putting potentially extensive prehistoric remains well underwater, even beneath underwater Byzantine architecture (Evelpidou *et al.* 2018, which contains extensive archaeological references).

Surface survey at the promontory site at Mikri Vigla on the west coast of Naxos has revealed an interesting settlement climbing up a steep slope overlooking a dual harbor, dating from the MBA into LB I (Barber, Hadjianastasiou 1989; Hadjianastasiou 1993). Cretan influence is substantial, primarily in the form of roughly made terracotta figurines. The remains of the large building high up on the site have yielded some painted plaster in several colors. The figurines led Sakellarakis to suggest at least the top of the site as a Minoan-style peak sanctuary, to be sharply contradicted by Vlachopoulos (Sakellarakis 1996; Vlachopoulos 2016, 119). That issue appears to favor Sakellarakis' judgment, on the basis of details of some of the figurines, such as the tilted-back heads and on one figurine a penis sheath (Sakellarakis 1996, 95 n. 159; Barber, Hadjianastasiou 1989, 118-119, no. 517, fig. 26, pl. 25). No excavation

1 'Blue Highways' is a term for the older, secondary roads in the United States made obsolete by the Interstate Highway System. The Autobahn is, of course, the German restricted-access highway system, comparable to the American Interstate system. I use the terms here to distinguish between shipping routes that served proportionally more short-distance destinations from routes that appear to have borne more, and probably higher-value cargoes between more distant origins and final destinations. Tartaron (2013) has emphasized the importance of archaeologically overlooked short-distance sailing to local, Mycenaean communities, as contrasted with the long-distance voyages that are the subject of the Western String hypothesis.

of the sandy beach below the populated promontory has been undertaken to assess the existence of a sea-level portion of the town, but the existence of probably Hellenistic bench quarries about 100 m offshore indicates probable subsidence which could have added to beach-sand cover over such a site. Olga Hadjianastasiou, one of the archaeologists surveying Mikri Vigla, has inferred the existence of another harbor on the southern end of Naxos sending shipping to Thera and thence to Crete during the late MBA/early LBA, on the grounds of imported sherd reports from nearby Ios, but no targeted exploration has been conducted. Subsidence – sometimes called sea level rise – has been demonstrated more thoroughly around the site of the LH I (and possibly earlier) site of Grotta on the west side of the island, a little north of center. Sfyroera offers a map of the MBA and LBA sites around the present city of Naxos, and Vlachopoulos offers a map of Bronze Age sites throughout the island (Sfyroera 2018, 329, fig. 1; Vlachopoulos 2016, 121, fig. 7.4). Underwater Mycenaean town remains have been found some 30 m off the present shoreline. Excavations of LH I housing remains at Grotta have been stymied by limitations on pumping out seawater (Welter 1930; Kontoleon 1958, 1967, 1970; Lambrinoudakis 1985, 1988; Hadjianastasiou 1989, 1993; Cosmopoulos 1998; 2004, 198 n. 22; Evelpidou *et al.* 2018). It may be possible that an episodic subsidence associated with the Theran volcanic explosion was responsible for the sinking of an early Mycenaean town, with a late MC town beneath it. Michael Cosmopoulos's publication of earlier rescue excavations at Grotta reports the houses uncovered by rescue excavations to date to LH IIIA, although some sherds found either at bedrock or in mixed strata date to LH IIA/LC II/LM IB (Cosmopoulos 2004, 195-197). Imported pottery includes 14 Minoan sherds dating to LM IB and four possibly Melian Red and Black sherds with comparanda from MC/MM III to LH IA/IB, although the largest group is Helladic (Cosmopoulos 2004, 208-209). The wealth of MC and early LC material at Mikri Vigla, the absence of that period's material from Grotta, and the decline of Mikri Vigla about the time settlement appears at Grotta leads Cosmopoulos to suggest that Mikri Vigla was the earlier major port on Naxos, and that a shift from Minoan to mainland commerce could have been responsible for the shift from a south-central west coast site to a north-central west coast site, from which sailing time to the mainland was shorter (Cosmopoulos 2004, 213-214, n. 76).

Marisa Marthari long ago emphasized the interaction between Thera and the mainland, beginning with Theran material in the burials of Grave Circle B at Mycenae and the longstanding characterization of much Theran ceramics on the mainland as 'Cycladic.' She offered a map of a likely route from Thera through Melos to the port towns in the Gulf of Argos – Lerna, Tiryns, Asine (Marthari 1993, 249-250, 252, fig. 3) – noting a particularly close relationship with the northeast Peloponnese. She observed that pottery containers at Akrotiri came from "all over the Aegean" while the origins of the ceramic forms imported for themselves rather than their contents – drinking cups – were restricted to Crete and the mainland (Marthari 1993, 253). Irene Nikolakopoulou's recent publication of the pillar pits from Akrotiri greatly expanded upon Papagiannopoulou's early report on those excavations. It adds substantially to our understanding of both the originality of Theran ceramic and wall painting and the external contacts Akrotiri enjoyed with other Cycladic islands, the mainland, and locations as far east as the Dodecanese during the MC period (Nikolakopoulou 2019; Papagiannopoulou 2008). Naxian sherds were quite numerous in some of the pillar pits, as identified by a pilot analytical study using QEMSCAN® on LB I pottery, which identified 5 of 12 pots as Naxian (Knappett *et al.* 2011). In the later MC Phase C of the pillar pits, Naxian vessels outnumbered Cretan vessels in all but one pillar pit that Jill Hilditch studied. However, Naxian fabrics exhibited considerable variation, indicating not a single production center, as the geology of the island varies considerably. Maybe a number of smaller ceramic production sites were in contact with Akrotiri on a more local basis than were Crete and Melos. The Naxian vessels do not show up in noticeable proportions at Kea, the final site in the Western String. Hilditch summarizes her ceramic analysis in that volume with the conclusion that the Western String theory is not supported by the finds at Mikri Vigla on Naxos and Skarkos on Ios. The sheer number of Naxian imports at Akrotiri during the late MC supports "reconfiguration or rejection" of the Western String model (Hilditch 2019, 454-455). The finds and sites that Hilditch cites were on blue highways. These scattered ceramic finds, without indications of accumulated wealth, do not contradict the notion that the Western String of Akrotiri-Thera, Phylakopi-Melos, and Agia Irini-Kea were the interstate highway's rest stops. No site found on Naxos dating to the late MC or LC I period has exhibited monumental architecture including fortification walls and wall paintings other than a

few simply painted plaster fragments from Mikri Vigla. And Naxos is northeast of Thera, out of the way of a direct route from Crete to the mainland, more poised to serve intermediate shipping along the eastern string of Cycladic islands, from which a few sherds have been found, but no hint of a busy port town.

Much of the resurgent settlement on the Cycladic islands dates to LC IIIB and especially to LC IIIC, well beyond the time period under study here. While there is scattered evidence of external contacts on many Cycladic islands, *e.g.* the graves and remains of house (?) walls at Agriokastro, at the northwest tip of Antiparos, dating to the late MC through LC I (Papadopoulou 2018), there are no indications of prosperity comparable to what has been found at Melos, Thera and Kea – monumental buildings, wall paintings, fortification walls, and high-value imports. Peggy Sotirakopoulou (2010) has raised the question whether the darkness of the MBA Cyclades outside the Western String was a reflection of actuality or lack of excavation; her answer was ambiguous, but the evidence seems to lean toward both a dearth of excavation and a dearth of wealthy sites to be found. In fact, had more north-south shipping routes flourished during the later MC and LC I, the harbor rents at the three islands of the Western String might not have been so rewarding.

Another Route North from Crete: Kythera

While Minoan influence moved north along the Western String islands during the late MH, it had reached north much earlier on a more westerly route through Kythera to the southern and western mainland of the Peloponnese. Cretans, probably from western Crete, appear to have sent something like a scouting party to Kythera in the late EBA or early MBA. This small group was followed by something like a full-scale colonization that abruptly changed the island's culture from an EH to an EM or early MM culture (Coldstream, Huxley 1972, chapter 9; Bevan *et al.* 2002; Broodbank, Kiriatzi 2007, 264-265; Broodbank *et al.* 2007, 221; Kiriatzi 2010, 694-695). Settling at Kastri on the protected, south shore of a bay formed by a promontory about half-way up the east coast of the island (Broodbank, Kiriatzi 2007, 242, fig. 1), these settlers clearly maintained contact with western and possibly central Crete. The town they established at Kastri served as a port between Chania/Kydonia, and possibly Knossos, and the small port at Agios Stephanos at the head of the Laconian Gulf, as well as sites along the coast of Messenia from the MBA, extending through the Cretan Third Palace Period (Broodbank *et al.* 2005). Minoan influence through the southern Peloponnese most probably arrived through the Kytheran Minoans, rather than from the Minoans on Crete itself. A combination of Bronze Age sites along the west coast of the notoriously dangerous Cape Malea – Pavlopetri, now underwater, and Elaphonisos, now an island but connected to the mainland as late as the Roman period as the tip of the Onugnathus peninsula – appear to have been an intermediate port between sites such as Agios Stephanos on the upper Laconian Gulf and sites on the east coast of the Peloponnese.[2] Moving north to Messenia, Robin Hägg noted nearly forty years ago the upper-class appearance of Minoan presence in that region,citing the characteristics of grave deposits in the Grave Circle at Pylos; aristocrats rather than artisans seem to have been the cultural messengers in Messenia (Hägg 1982, 35). A decade later George Korres (1993, 238-239) reported on Minoan imports, but detected no efforts at colonization, along the Messenian coast during MH and early LH (for the Griffin Warrior grave at Pylos and its meaning, see the end of this section).

The 'Other Island' and North Past the Western String

While the islands of the Western String appear to have accumulated their wealth by providing port services, Kolonna on Aegina was an export-oriented town which appears to have earned its wealth through production of goods as well as provision of services.[3] Kolonna is located on a low peninsula on the northwestern coast of Aegina opposite

2 Janko 2008, fig. 1 for a map of the Gulf of Laconia and sites along its coast; 553-563, 587-588; Harding *et al.*, 1969, 142, fig. 1; Waterhouse, Hope Simpson 1961, 141-148. The underwater research at Pavlopetri through 2013 is reported at https://www.nottingham.ac.uk/pavlopetri/index.aspx.

3 Klebinder-Gauss, Gauss 2015, 80-81; Tartaron 2013, 220-223 provides an extensive overview of Kolonna during the MBA, continuing in subsequent pages with the LBA.

the Argive coast, with two shallow ports, to the north and south. The neighboring arable plain was productive, and the sea provided supplementary food resources (Sgouritsa 2010; Sgouritsa, Salavoura 2014, 85). Kolonna's massive fortification walls date to early in the MBA, and its mansion, the Large Building Complex (LBC), first dates to not long thereafter, roughly corresponding to the First Palaces on Crete (Gauss *et al.* 2011). The potters of Kolonna specialized at an industrial scale in the production of cooking wares and table wares, both of which proved extraordinarily popular, particularly throughout the Peloponnese and Central Greece, if somewhat less so in the Cyclades and on Crete. The predominance of Aegenitan matt painted pottery throughout Attica, Corinthia, the Argolid, Boeotia, and Euboea in a 'horseshoe-like circle around Aegina and the Saronic Gulf" during Middle Helladic times, and throughout a bit more expanded area through early Mycenaean times, may reflect the inability of local workshops to compete with large-scale production on Aegina (Gauss, Kiriatzi 2011, 242-247; Gauss, Knodell 2020, 248 fig. 2, 252, 256 fig. 7). Aeginetan exports in the MBA have been found at Athens, in Corinthia and the Argolid, in the Cycladic islands and Boeotia, at Lefkandi on Euboea, at Mitrou in East Lokris, and at Limantepe on the Anatolian west coast; and in LM IA at Knossos, Çeşme/Bağlarasi, in southern Italy, and in the fill of shaft graves at Mycenae (Gauss, Kiriatzi 2011, 243-247). Imported pottery at Aegina has been analyzed as coming from Boeotia – probably Orchomenos – the Lerna-Argos-Tiryns-Mycenae area of the Argolid, and from several Cycladic islands – probably Kea, and the presently indistinguishable Thera/Melos (Kiriatzi *et al.* 2011, 139-156). While figured wall paintings, a Theran-Cretan innovation, do not appear to have arrived at Aegina in the LBA, locally produced Minoan-style pottery associated with those paintings appeared for about a generation and then disappeared, having been produced strictly for local consumption. But actual Minoan imports appear continuously throughout the MBA at Kolonna, although they reach a peak in the later Protopalatial period (MM IB-II).The MH shaft grave just outside the main gate of the fortification wall, with its Middle Cyladic and Middle Minoan pottery and local imitations of Kamares ware (Kilian-Dirlmeier 1997, 123-154), the fortification walls, the LBC itself – with no even nearly comparable structures on the mainland – and the Aegina Treasure,[4] all point to a strikingly wealthy settlement, regardless of the distribution of that wealth across its population. The inland site of Lazarides has its earliest material dated to the 16th century BCE although most finds there date to LH III. A potential port site exists at Portes, about an hour away on the east coast. A great number of andesite grinding stones and millstones have been found there, together with indications of production of grapes, wine and cereal. Also found were potter's marks, lead and stone weights belonging to several metrological systems, metal items of bronze, lead and silver, and imported pottery from the northeastern Peloponnese. Impressive remains of quarrying are found about 2 km north of the site.[5]

Agia Irini on Kea was clearly in commercial contact with Kolonna, as demonstrated by the latter's products found at the former site. Kolonna was clearly a shipping point between the Cyclades and Attica and the northern Peloponnese. While port fees may have contributed to Kolonna's prosperity, its industrial pottery production seems to have dominated its income stream. Whether it also exported other products – agricultural and crafts – will likely remain unknown. The rest of the island, while not as fertile and agriculturally productive as Naxos, may well have alleviated Kolonna's dependence on imported agricultural products. Although Aeginetan ceramics have been found as far away as Italy and are well represented throughout the Greek mainland, outside of Agia Irini and Akrotiri, they are not common among the Cycladic islands and Crete (Lindblom 2001, 44). Aeginetan ware far outweighs Cycladic ware on the mainland, but Aegina may have played an important role in Hellado-Cycladic pottery – and other – exchange in the MBA (Nikolakopoulou 2007, 357). Chemical analysis has identified imports at Kolonna from a wide variety of locations: a non-local fabric group consistent with Kea, Kythnos and Seriphos; a fabric

4 Williams 2009 appears to have satisfactorily attributed the treasure's find spot to Aegina, probably not far from the shaft grave discovered in 1982 and published by Kilian-Dirlmeier 1997, *contra* Higgins' (1979) earlier opinion that it represented looting from the funerary complex at Chrysolakkos, Malia on Crete.

5 Sgouritsa 2010, 176-178; Sgouritsa, Salavoura 2014, 87; Sgouritsa 2015, 323-327. Sgouritsa 2010, 179, fig. 1 and 2015, 325, fig. 1, provide a map of Aegina with the locations of Kolonna, Lazarides, and Portes.

consistent with several sites on Kythera, or possibly the western Argolid – Lerna-Argos-Mycenae-Tiryns area; and Boeotia in general, Orchomenos in particular (Gauss, Kiriatzi 2011, 130-144). Kolonna may well have been an intermediary between the Western String's northern end at Agia Irini and the west coast of Attica, as evidenced in Maran's reports of Melian Black and Red ware and Cycladic White pottery, probably from Melos, from late MH Kiapha Thiti (Maran 1992a, 172-176), as well as the east coast of the Peloponnese.

The literature to date on the traffic along the Western String has implicitly envisioned the last leg to have been from Agia Irini to the southeast tip of Attica, in the region around the Lavrion mines. The recent excavations at Mitrou, however, on the Boeotian coast across from Euboea, about half-way up that channel, have opened the scope of Agia Irini's commercial contacts into MH Boeotia and beyond, with some Kamares sherds having been reported at Mitrou and further north at Volos (Whitley *et al.* 2006-2007, 43). Quite a bit of this traffic in southern Aegean material has been found further north, at Pefkakia-Magoula on the Bay of Volos,[6] and also a fair amount of it or of imitations of it even further north in the Chalkidiki at sites like Torone (Cambitoglou, Papadopoulos 1993; Morris 2009) and Molyvópyrgos (Heurtley 1939, 91, 123, 211-212, figs. 77-82, 226, fig. 97). Christopher Hale has posited that Agia Irini served as a distribution hub between central Greece and the other Cycladic islands, a notion long ago raised by John Overbeck on the basis of the Grey Minyan finds at Agia Irini and Paroika (Hale 2014; forthcoming; Overbeck 1982). Overbeck (1982) also pointed to the striking similarity of Grey Minyan ware at Eutresis and Grey Minyan ware at Agia Irini, already pointing to Kea as a link from the Cyclades to central Greece. Much earlier and further inland, Hetty Goldman found Cycladic imports at MH Eutresis (Goldman 1931, 182-186). She also reported Grey Minyan pottery at Eutresis later found most similar to that at Agia Irini, suggesting to later scholars connections between Agia Irini and sites in Boeotia (Goldman 1931, 135-144). And Efi Karantzali recently has reported a post-Kamares kantharos rim and handle in a MH III-LH I layer beneath a LH II-IIIA1 architectural phase in the Doka Plot at Frantzi in the Spercheios Valley. Neutron activation analysis of the sherd points to a Minoan source or, statistically less probably, a Boeotian one (Karantzali 2014-2015, 49-50 n. 66, 71 no. 95, fig. 24).

Pottery or People?

So far, I have focused on movement of goods to account for ceramics found in various places other than their likely potting origins and the attendant maritime routes connecting such nodes. Along the Western String islands or between various islands or between islands and the mainland, evidence has been found suggesting the movements of potters using local clays to make vases in clearly extra-local traditions. The clearest example is that of Kythera, as noted above, where Cretan potters may have settled as mature workshops and supplanted the EH ceramic tradition on the island. Jones and Rutter found that Minoanizing fineware from Agios Stephanos was made with local clay by potters who were trained in the Minoan tradition, who were probably from either Kythera or Crete (Jones, Rutter 1977, 218). Korres found no case for Cretan presence alongside the Minoan pottery found at sites along the Messenian coast, although the recent discovery of the Griffin Warrior grave and Tholoi VI and VII at Pylos hints at Minoan influences at the very highest level of Messenian society (Korres 1993, 237; Davis, Stocker 2016; Smith 2016, 31-32; Wade 2019). On the other hand, a brief exposure to Minoan potting at Aegina around the Large Building Complex led to no cross-fertilization between Aeginetan and Minoan traditions, and no Minoanizing pottery produced there was exported. During the same period, potters at Lerna absorbed various ceramic traditions to create their own style (Lindblom *et al.* 2015, 229). This foreign-potter phenomenon is not restricted to the MH or LH I periods. Lis *et al.* (2015) have recently investigated evidence for the mobility of potters within the Aegean all the way into LH IIIC period. It will surely require scientific analysis of fabrics to distinguish the roles of commercial exchange of products and the movement of potters, whether commercially or familially motivated, in the diffusion of ceramic styles throughout the Late Bronze Age.

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6 Maran 1992b, I, 197 for Attic or Aeginetan, 367-368 for Minoan and Minoan or Minoanizing, citing Rutter and Zerner 1984, 82, nos. 6 and 9; II, 30-38 for Agia Irini Ware from the very earliest MH levels and Minoan/Minoanizing.

POPULATION AND DEMOGRAPHY

Several scholars have made estimates of the populations of Melos and Kea between the Grotta-Pelos Period and the Middle Bronze Age and LC I (Cherry 1979, 37-43; Wagstaff, Cherry 1982, 138-140; Broodbank 2000, 90, table 1). All of the estimates are small, and the smallest of these estimates are generally the most satisfactory, although there is risk of circularity, or at least non-independence, in some of the estimates. Population issues on Melos and Kea are similar, but those on Thera seem more intricate and will be considered subsequently.

On both Melos and Kea, by the later MC or LC I, virtually the entire island population resided in the single town, Phylakopi on Melos and Agia Irini on Kea, according to the results of island surveys (for Melos, Renfrew 1982, 37-41, table 4.1; for Kea, Cherry *et al.*, 1991 and Georgiou, Faraklas 1985). This extreme nucleation raises a pair of related questions: 1) could the largely agricultural population (labor force) access sufficiently productive, arable land to feed itself without imports? and 2) how large could such a population have been, given the sustenance constraint? In fact, these two issues are opposite sides of a single coin. A less directly related question is whether a large population could have resided in these towns and survived by trading some local products for food imports. Gamble, Wagstaff and colleagues explored the application of catchment areas to estimate maximum populations that could be sustained on Melos (or Phylakopi after concentration of the island's population in that town) with 20th century grain output figures, adjusted for the contribution of mechanized agricultural technology, deriving populations low enough to be difficult to accept (Gamble 1979, 132; Wagstaff, Augustson, Gamble 1982, 174-179). Wagstaff and Gamble alternatively loosened the restrictions of quite small catchment areas, by recognizing the possibilities of animal transportation – cattle, superseded by the donkey – a transportation technology also explored by Brodie (2008, 303-304) as a means which would have expanded the reach of a town's population into the arable interior of Bronze Age Melos. With this alternative approach, Wagstaff and Gamble estimated the male agricultural labor required to support a total island population of around 2,000 from the entire island's arable which, allowing for a demographic structure including women and children in a nearly stationary population, would have occupied nearly the entire adult male population (Wagstaff, Augustson, Gamble 1982, 179-180). Sanders (1984) noted that the catchment-area methodology of Wagstaff and Gamble failed to generate populations for Melos reported for various dates in the mid-second millennium CE, even using land productivity parameters more likely to characterize Melos. Using Ottoman tax records and price data, and correcting an order-of-magnitude digit error in the estimate of hectarage requirements to feed a single adult, Sanders calculated that Melos was capable of feeding roughly eight times the population calculated by Wagstaff and Gamble. However, he proposed these calculations only as a corrective to the maximum population calculations provided by Wagstaff and Gamble, not as a revised estimate of actual population in the early part of the Late Bronze Age. Regardless of the precise estimates, at any rate, both approaches to the populations of the islands or their towns lead to the issue of exporting some other products for food when labor is diverted from agriculture.

Cherry applied a 0.1% per year population growth rate, consistent with the range recommended by Carneiro and Hilse for Neolithic population growth rates in the Middle East, to a population of 40 in the Grotta-Pelos phase to estimate a Melian population of "about 740" in the MBA, *ca.* 2200 BCE (Cherry 1979, 37-43; Carneiro, Hilse 1966, 179). Wagstaff and Cherry used a MBA population of 750 in 2200 BCE to produce a population of Phylakopi between 2,000 and 3,000 by 1400 BCE, implying annual population growth rates of 0.12% and 0.16% (Wagstaff, Cherry 1982, 137-143). Applying the 0.1% growth rate to the population base of 750 in 2200 BCE would give a population of 1,367 in 1600 BCE for Phylakopi and essentially all of Melos, but this figure ignores the northern portion of the site which has been lost to the sea. Nonetheless, Broodbank recommends occupation densities of 200 to 300 people per hectare, while the population of 1,367 would give a density of 760 (Broodbank 2000, 330-331). Broodbank's density range would yield a population of Phylakopi II between 360 and 540, again for the portion of the site not lost. Wiener (1990a, 133) offered the opinion that not more than 500 people per hectare should be used to estimate populations of densely populated Cretan towns in the Late Bronze Age.

Direct analysis of Agia Irini's population at various dates has attracted less attention. The site's area is somewhat less than 1 hectare, which places narrow limits on reasonable estimates. Davis's suggestion to place the LC

population somewhere between 780 and 1,250, on the basis of Wagstaff and Cherry's growth-rate-based population estimate for Phylakopi, has met with the same objection on density grounds that Broodbank has raised against 4-digit, growth-based estimates for Phylakopi's LC I population (Davis 1984, 18 n. 16; Broodbank 2000). Schofield (1998, 119) appears to have implicitly used the density range of 200 to 300 people per hectare to suggest an all-time ceiling of around 500 for Agia Irini's population. Gorogianni (1998, 119) has raised Whitelaw's earlier suggested density for Neopalatial Cretan towns, of 200 to 225 people per hectare, slightly to yield a LBA population between 280 and 335 residents. Little evidence of contemporary rural full-time residence, nor of other contemporary settlements, has been found in surveys on Kea, so the population of Agia Irini was by and large the population of Kea.

Akrotiri, on Thera, is a considerably different case. Broodbank's array of EC population estimates for each of the Cycladic islands, based on area and overall density, gives Thera a smaller population for each density than it gives Kea, despite the considerable disparity in sizes of Agia Irini and Akrotiri in MC and LC I (Broodbank 2000, 90, table 1). Only occasional glimpses of Thera's pre-volcanic terrain have come to view, but what has been seen, as well as evidence of other pre-volcanic settlements on the island, suggests that it was more populous in the MC and LC I than was either Kea or Melos (Sperling 1973; Davis, Cherry 1990; but cf. Doumas's comments in 1990b, 200). However, it is doubtful that agriculture on the island would have been able to feed the population of a 20+ -hectare town or city such as Akrotiri, which could have contained between 4,000 and 6,000 people ventured by Doumas (1983, 45; 2001, 91). Palyvou would trim Doumas's projected sizes of the town by one-half to two-thirds, yielding a population of Akrotiri of 1,500 to 2,000 individuals (Palyvou 2005, 27-29; Palyvou 2016 does not revisit the population issue). At either population range, but particularly at the higher one, Thera clearly was not a 'closed' island, and there is no reason to expect that the population of its port town would bear any particular proportion to its total population, a point raised by Rackham on the basis of his conjectural reconstruction of the island's pre-eruption ecology – that Akrotiri was too populous to have been fed by the rest of the island's population (Rackham 1990).

Turning to Crete, the most recent estimates of population at Knossos are Whitelaw's, who suggests some 8,000 by the end of the Prepalatial Period (MM IA), and in the neighborhood of 14,000 at its peak in the New Palace Period (Whitelaw 2004, 156, fig. 10.8). Then we have Malia, Phaistos, Kommos, Poros, Amnisos, Gournia, Pseira, Mochlos, Petras, Palaikastro, Zakros, Chania, and innumerable other towns and villages, plus the rural population, to add to an overall Cretan population. Extrapolating from the population of Neopalatial Knossos, and applying the ratio of urban to total population throughout Europe prior to the Industrial Revolution, of between 5% and 10% (De Vries 1984, 39, table 3.7), it is not difficult to estimate a population for all of Crete near or upwards of 300,000; half that population would have made Crete a large island relative to those in the Western String.[7] Branigan (2001, 46-48) uses Cretan town area and residential density conjectures to arrive at figures half this magnitude, with 42 to 49% of the population urban. He does notice, however, that such urban-rural population ratios pose a problem for urban food supplies, particularly in the larger towns.

A number of extended and partial estimates for the population of mainland Greece exist for the Mycenaean period. Ober estimates the population, including those of Crete and Thessaly, at 600,000, which at an annual population growth rate of 0.1% per year would have been some 445,000 three hundred years prior (Ober 2015, 73). McDonald and Hope Simpson (1972, 141) and Whitelaw (2001, 63-64) estimated the population of the Mycenaean Pylian kingdom at around 50,000, which would have been around 37,000 three hundred years earlier. Chew (2000, 220) and Chapman (2005, 95) estimate the kingdom of Mycenae to have contained around 30,000 individuals at its peak, or around 22,000 during the late MBA and LH I. All these figures imply a large population

7 If a party of 100 people reached Crete around 7500 BCE (Horowitz 2013, 272) and increased their numbers at the rate of 0.1% per year between that date and 1700 BCE, the island's population would have been a bit over 188,000 in the later year. Subsequent groups of immigrants, increasing at the same rate, would have raised the island's population by LM IA above that number in proportion to party size and date of entry.

relative to the Western String islands. The relatively rural location of this larger population, compared to the towns and cities on Crete in particular, would have little, if any, impact on the conclusion that the mainland's population was large relative to that of the islands. In reality, the mainland commerce with Crete would have involved primarily the urban (or town) populations from specific places – Mycenae, Tiryns, Athens, Thorikos, Pylos, Thebes, Asine, and other identified sites.

The point of reproducing these population estimates is to show conclusively that, despite their occasional indications of affluence, primarily in interior or exterior architectural features, the populations of Phylakopi, Agia Irini, and even Akrotiri, were small, whether the lower or higher population estimates are considered. The 500-pound gorillas in this trade network were Crete and the mainland. Actually, the mainland probably would have been more like a 250- or 300-pound gorilla, as the products of its more predominant, non-urban areas would have been heavily represented by bulk agricultural goods rather than lighter-weight, higher-value manufactured goods that producers in urban centers were more likely to make – had it not been for the silver exports of the mines at Lavrion. This said, the mainland probably did supply some bulk agricultural goods to the islands, as the following analysis will show was probable. The point of showing that these islands were small is to motivate the question: Where did the affluence come from? Could the wealth required to build the mansion with the flying fish frescoes at Phylakopi have been generated by the agricultural endeavors of 500 or 600 people, the population estimate generated by the product of site acreage and occupational density estimates of 200 to 300 people per hectare? Or House A at Agia Irini by the surplus extracted from an even smaller number of agriculturalists plus possibly a few metal smiths? The opulence of what has been uncovered so far at Akrotiri seems similarly out of the range of Thera's likely larger population.

Schofield's characterization of the three islands' towns as likely port-stops on a trade route between Crete and the mainland, particularly Attica with the metal ore resources of the Lavrion area, has weathered the emergence of additional evidence as well as new directions of thinking about Minoan political domination (Schofield 1982a). Many other studies have contributed to or commented upon the Western String hypothesis (Davis 1979; Cherry, Davis 1982; Georgiou 1998, 211-12, 213-14; Crego 2007; Overbeck, Crego 2008; Berg 1999; 2006; 2007). Positioned to collect port fees (which certainly need not take the form of coinage – although unminted precious, or even some base, metals might suffice), residents of the islands could have earned more than they could have by exploiting only on-island resources.[8] Additionally, the much larger populations supporting the trade between the two ends of the route would have sent far more shipping than the islands themselves ever could have generated, giving the islanders a very large stream of traffic to have serviced, offering the potential for considerable enrichment of at least some of the island residents. The following section shows how such a trading system would have affected the islands' economic structures and incomes.

Attention to these three islands' population sizes also yields implications regarding their Minoanization during LC I/LM I. Wiener's (1984) classic article on the Minoan conical cups characterized two types of external cultural impact, a "karum contact" and a "Versailles effect," the former the result of foreigners' physical presence at a site, the latter a prestige effect not requiring much in the way of an expatriate presence. Comparing the relative presence of the Minoan conical cups at the three Western String islands and other sites in the Cyclades and the Peloponnese showing Minoan influences, he leaned in favor of karum contacts on Kea, Akrotiri, and Melos (Wiener 1984, 25). By 2013, Wiener leaned in favor of a Versailles effect along the Western String islands as well as other sites around the Aegean that have yielded extensive Minoan cultural influence (Wiener 2013, 166). Which

8 As a relevant subsequent example where information on precedents is not available, Bresson (2016, 286-296) notes that during the Classical through the Imperial periods, Greek coastal cities collected port transit fees "clearly distinguished from customs duties" (288). Kroll (2020) refers to harbor fees in Greek cities in Asia Minor before the mid-first millennium BCE. Porten and Yardeni (1993), as discussed by van Alfen (2020) reported fixed fees, in addition to *ad valorem* taxes on cargoes, charged to ships entering and leaving an unnamed Egyptian port, probably Thonis-Heracleion, in 475 BCE, large and small ships charged different amounts. Amarna Letters 39 and 40 describe request relief from any ordinary charges on royal shipments from Alašiya to Egypt (Moran 1992, 112-113). Moran describes these fees as duties, but that is not clear from the texts.

is more likely to be correct? The small populations of Kea and Melos in particular suggest Versailles effects, and as the conjectured population of Akrotiri has fallen from the 4,000-6,000 range to the 1,500-2,000 range, the scope for many Cretan expatriates living there shrinks as well, multitudes of conical cups notwithstanding. Gillis reached the same conclusion regarding the existence a large Cretan population presence at Akrotiri on the basis of characteristics of the conical cups at that site and various sites on Crete (Gillis 1990, 115). For some reason, those three islands appear to have taken up Cretan rituals, or at least some of the materials of those rituals, more extensively than the populations of, *e.g.* Agios Stephanos and Mycenae. Of course, the same urban considerations would apply to the overall Cretan population's trade volumes.

As a final note on the relationship between island population sizes and potential colonization, quite a number of cities on Crete were populous enough to have been able to overwhelm the populations of these three islands easily. Why would they have not done so? Because other cities on Crete may well have objected to the islands' dominance by another Cretan city. Even under a possibly unified Cretan state, cities could have maintained sufficient commercial rivalry to raise such objections.

ACTIVITIES ALONG THE WESTERN STRING

In 2006 Ina Berg brought into question the concept of the Western String as a major shipping route between Crete and the mainland. It is useful to address some of her concerns. Begin with the proportions of imported pottery on the three islands and on Crete and at sites on the mainland. They are nearly invariably small percentages, as Berg cites from numerous sources. The traces of Cretan influence in painted designs on pottery, pottery shapes, architectural features, fresco painting, religious symbolism, writing, and so on – "Minoan taste, techniques and life style," as Dietz (1998, 15) expressed it – include all the features contained in the term 'Minoanization' that have been identified, recounted, explained, questioned, and debated for decades. It is reminiscent of the globalization of many of the features of contemporary and recent American pop culture, if not necessarily on the same cultural plane. Pottery is one of the least destructible products surviving from ancient times, and it is common to associate pottery of one place found at another place as evidence of some kind of contact, with commercial trade recently edging up to the margins of respectability in archaeological explanation. It may be an occupational hazard to think of the exchanges of products in antiquity as being pot for pot, to the mis-estimate of the volume and value of other products involved in ancient trade. More than two decades ago, Giampaolo Graziadio (1998, 30-31) delivered an eloquent disquisition of the place of pottery, particularly fine pottery, in Bronze Age Aegean trade: "[…] pottery was part of a more varied flow of traded goods, since even the finest wares were traveling as a by-product of the trade […] In evaluating the intensity of contacts, pottery may therefore be deceptive." Among the other products, of which traces no longer remain either because of their malleability or perishability, he named the following: finished or partially finished metal products, various raw materials, foodstuffs stored in baskets, liquids such as wine and oil, textiles, leather and fur, wood and wooden furniture, raw wool, herbs, aromatic oils, slaves, horses and other live animals. In fact, Crete and Aegina may have been in commercial competition with their ceramic cookwares, akin to that between Le Crueset and Staub today in their high-end cast-iron cookwares. But returning to the pottery, as Davis (1986, 103) says, some of the pottery clearly was imported for its own sake – small, open-mouth pieces, handsomely decorated. From both characteristics and find contexts, this is undeniable.

Another issue Berg questions is the regularity of shipping in the Bronze Age Aegean, which merges with the matter of the type of ship engaged in that trade. She favors the notion of the irregular, seagoing peddler – the Bronze Age correspondent to the late 19th century CE tramp steamer, whose romance is fostered in the writings of Conrad and Maugham set in the southwest Pacific. Those are not the craft celebrated in seals and paintings and are unlikely to have captured the carriage trade in most of the items cited by Graziadio. An old tub such as the Kyrenia ship of the 4th century BCE was surely an outlier in terms of age and seaworthiness for its time and may have been such a tramper, and Petruso (1992, 67) thinks the LBA Cape Gelidonya ship was a "Bronze Age tramp steamer" too. It may have been. However, a new ship had to be paid for, and those machines were not cheap, if evidence of

ship construction costs for the Classical period are any guide. To keep the owner of a new ship from suffering a financial loss on the craft, the ship would have had to be kept employed productively, not wandering around from port to port looking for something to barter. If merchant ships were losing propositions, they would not have been built. Who built them and who owned them are good questions.

Related to these twin issues of itinerary and ship quality is the technology of Bronze Age shipping. Berg (2006) relies on the analyses of Hara Georgiou which develop considerable technological information about Bronze Age merchant ships from the depictions of rigging on seals and in the Thera frescoes. The ships could tack against the wind, opening most of the year to shipping. While a ship *could* run before the wind, Georgiou points out that no sailor in his right mind would want to run before the wind in the Aegean. She also notes that Bronze Age ships could sail at night, navigating by a combination of stars and recognizable landmarks. Berg interprets the ability of ships to sail at night as implying that they need not have made intermediate stops at the islands of the Western String. But would they have *wanted* to sail at night, particularly in some waters? No part of the Western String model has contended that hopping from Crete to Melos to Thera to Kea to the mainland was necessary, night sailing or otherwise. A ship might have stopped at only one of the islands on a voyage between Crete and the mainland, or possibly two, but not necessarily three. In fact, these three islands may have been in competition with one another to provide port services. Richard Janko, in his historical conclusions to the Agios Stephanos volume, discussed the western trade route from Crete to the Peloponnese, via Kythera and around the treacherous Cape Malea and towards the Argolid. The winds and squalls around the Cape, particularly the prevailing northeastern meltémi, frequently caused sailors to wait for days or weeks to round the Cape, and he reports that in medieval times the delayed sailors preferred to wait out the weather at Melos (Janko 2008, 586-587). So at least one of these Western String islands may have entertained port calls by ships on more than one route during the Bronze Age.

Speed of sailing and distances are important considerations in port stops. Georgiou notes that Nestor's passage in *Odyssey* 3. 155-190 made 5 knots the first day for about 20 hours, but took four days to cover the next 115 miles (Georgiou 1993, 361). Winds and currents could make substantial differences in speed. So, what could an 'average' speed of a Bronze Age merchant vessel have been? Lionel Casson assembled extensive data on shipping distances and times to arrive at average speeds for the Hellenistic and Roman periods, for both favorable and adverse winds. Surely ship technology had improved speed in the intervening millennium and a half or more between the activity along the Western String and Roman Mediterranean shipping, but his data equally surely provide upper limits on speeds. With favorable winds, Casson cites average speeds of 2.8 to 6.2 knots. The 2.8-knot speed was a trip that encountered bad winds on the way back. Most figures are between 4.8 and 6.0 knots (Casson 1986, 283-288, tables 1-4). With unfavorable winds, average speeds fell to between 1.5 to 3.3 knots (Casson 1986, 289, table 5). He notes that a trip from Puteoli to Alexandria could be done in as few as 9 days, while the trip back could take over 50, and even 70 days (Casson 1986, 289 n. 82). Georgiou (1993, 357, table 2) provides some distances: from Crete to Phylakopi – from Chania 84-88 nautical miles and from Herakleion 95-104 nautical miles –; from Phylakopi to Akrotiri 51-68 nautical miles. These numbers give from 1.5 to nearly 3 days for a voyage from Herakleion to Phylakopi, for speeds of 1.5 and 2.6 knots. A port stop might have been welcome – water, food, exhaustion, or just plain boredom. And besides, Phylakopi might have been a break-of-bulk point for shipments headed to destinations other than northwest along the Western String islands. A speed of 1.5 knots gives an alternative measurement of 36.8 miles per day. Abell and Gorogianni rely on conflicting speeds of 20 kilometers, or 10.8 nautical miles, per day based on Broodbank's guess regarding EBA ship speeds, and Barako's figures of 2.5 to 3 knots taken from Odysseus's squadron's sailing time from Crete to the Nile Delta under favorable winds (Broodbank 2000; Barako 2003, 167; Gorogianni, Abell forthcoming).

Another important issue Berg raises involves what has come in recent years to be called 'agency.' She notes that the literature on the Western String has implicitly assumed the islanders to have been passive while active mariners were Cretans – or mainlanders? My own studied surmise is that the frequent, implicit assumption that the ship builders, owners, and at least some of the sailors were Cretans or mainlanders is probably correct.

Trees adequate to build vessels for open-sea transport were not available in the Cyclades. People who knew how to design and build ships were most likely the people who knew how to sail them – *i.e.* they were the people with the experientially gained knowledge of nautical engineering that could keep a ship afloat and obtain better performance. Ships would have been built on Crete or at places on the mainland with suitable timber, which was probably further north than was generally exploited in Minoan times. Some islanders may have signed on early in their lives to learn to sail a large merchant vessel on the open sea as opposed to navigating a small fishing smack far enough from an island to drag in a fish or two near home. As Georgiou (1993, 362) has expressed, sailing was a full-time profession, and the island populations were small. Turning to the agency of the islanders, their decisions to supply port services and charge enough for them to let the island populations accumulate wealth would have been agency of its own sort.

Finally, related to the agency issue and the regularity and frequency of trade, the character of these interactions should be addressed. The extensive presence of Minoan-system balance weights found not only extensively throughout the Western String islands and Crete, but in multiple-weight sets at such mainland sites as Vapheio and Mycenae suggest regular, peaceful, non-monetized, market commerce (Petruso 1992, 56-58). Petruso's assessment of the environment in which the balance weights he studied were used was that the goods weighed (and by extension, those counted) changed hands in a relatively peaceful environment among the regions using these weights, further implying mutually amenable political relations. Davis (1986, 103) inferred that the volumes of Cretan and Melian pottery at Agia Irini in Period V "suggests that trade between Keos and these places was frequent and steady." I cite Petruso's and Davis' conclusions not as any sort of proof, but as evidence that I am not the only student of the time and region who has reached this conclusion.

Barber (1984, 182), on the other hand, cites the LC I city wall at Phylakopi as evidence that relations among the Cycladic islands may not have been "entirely cordial," although he concedes that the wall probably would not have kept the Cretans out had they wanted to force their way in. The walls do pose questions whose answers could have had impacts on commerce. Agia Irini had walls quite early – as did Kolonna on Aegina – although the Keians began with a relatively flimsy wall before they had time to rebuild along a more distant chord across the peninsula early in Period V. If Renfrew's 2007 conclusion is correct, Phylakopi did not build a fortification wall until after the Thera explosion, but Brodie *et al.* (2008, 415) think such a conclusion is premature since Area H, on the southern side of the town, has not been intensively excavated but was not occupied until the MC period, so a previous fortification wall could have been incorporated into buildings or dismantled for the stone used in later construction. They find it difficult to believe that Phylakopi would have been an "open city" until LM I when Kolonna and Agia Irini had been fortified since early in the MC period. A city wall has not been found at Akrotiri, but only a small portion of what was undoubtedly a large town or city has been excavated. The 'Mycenaeans' on the mainland did not build walls until well into LH III, with the reasons widely debated. Stefanie Weisman (2008, 18-22) makes an interesting case for Agia Irini's fortification walls forming a defense against the southern Attic community at Thorikos, near Lavrion, which was the source of the metals which appear to have formed the core commodity in Agia Irini's shipping business. Thorikos was unwalled, both communities have yielded warriors' graves, and Agia Irini's fortification walls give the appearance of a community that felt threatened. Alternatively, could these walls have been largely symbolic, demarcations of town from "not town"? Hiller (1984, 28) suggested that the walls at Kolonna and Agia Irini might have been physical statements of independence from any other community. Bronze Age communities sank substantial resources into other infrastructure components which were not directly productive but which they evidently valued quite highly. This issue of motivations for fortification walls remains an open one, but the overall weight of the evidence seems to speak of regular, peaceful commerce, even if the threat of violence required vigilance and substantial investment in some locations. The case for a *Pax Minoica* of several centuries seems reasonable as a mechanism for keeping the sea lanes safe for this commercial traffic. Hiller long ago (1984, 28) noted that without physical demonstration of the power to enforce, threats of enforcement would not have been credible. The commerce seems sufficiently constant, and evidence of attacks sufficiently rare, to make a case for the Cretans keeping the pirates of earlier periods at home.

DEVELOPING THE MODEL: FARMING, SHIPPING, AND THE TRADE BALANCE

By the MBA, polities in the Aegean were in trade contact with Egypt, the Levant, Mesopotamia, Anatolia, Italy, and even the Baltic region. Cornwall was also a possibility, as was Central Asia. Warburton (2016, 111-130) has assembled overwhelming evidence of flourishing private markets in Mesopotamia and metrological links between Mesopotamia and Egypt from the third millennium. Alberti's research on weight systems reinforces the appearance of substantial commerce from an early date, as convertibility was devised for independently developed metrical systems of different regions (Alberti 2003; Alberti, Parise 2005; Alberti 2011). She notes that "[...] the major Near Eastern units were indeed in use also in the Aegean by the Neopalatial period [on] Crete and the contemporary Cyclades and mainland, as multiples of the basic 'Minoan' unit […]" (Alberti, Parise 2005, 382). Between the end of the MBA and the beginning of the LBA the Aegean weight systems were incorporating Near Eastern measurement units into their systems (Alberti 2011, 9). Focusing on the balance weights on LBA Crete Michailidou (1999, 108) considers them tools of industry and trade and their contexts and distribution across the island to indicate "the existence of an internal exchange system at all social levels for recording and trading." In the same volume, Cline (1999, 133) suggested that, "an Aegean economic 'world-system' dominated by Crete may have interacted with an interlocked series of Bronze Age 'world-systems,' each dominated by Egypt and other polities in the eastern Mediterranean, and which reached to the central regions of Mesopotamia and perhaps beyond." The overall impression is of a sophisticated, international trading system, the study of which with contemporary concepts is a choice of the proper intellectual tools rather than the use of anachronisms.

The commercial traffic along the Western String surely carried some of these materials, most of it going north, with material from mainland Greece and further north in Europe going south. Additionally, inter-Cycladic traffic also plied these waters, if on a smaller scale than the main, southeast-northwest route of the Western String. For example, Bikaki (1984, 26) reports that of 32 pots with potters' marks dated to Period VI Agia Irini, identified by the time of her writing, 22 were imports, 10 of which were from other Cycladic islands. Christakis (2010, 52) notes that a Linear A inscription on the rim of one of four "very probable" Naxian pithoi in the Temple Repositories in the central palace at MM III Knossos refers to an inventory of 117 units, which are estimated to have contained 3,369 liters of wine, far beyond the capacity of the pithos on which it was written. Vlachopoulos (2016, 119) reports that Naxos had relations with Melos, Thera, mainland Greece and at least MM III Crete. With a heyday through LC II/LM IB, Mikri Vigla, on a promontory between two coves, probably was Naxos' export point for marble and emery as well as the Naxian pottery that has emerged elsewhere in the Aegean. Sotirakopoulou (2010, 833-836) finds that the appearance of a 'dark age' in the Cyclades is more a reflection of excavation and publication than any reality. The islands had "contacts and exchange" with communities in Attica, Corinthia, and the Argolid from the very beginning of the MBA, although contacts with the eastern Aegean were sporadic at that time. As an example of the intricacy of the trade relations of the Cyclades at the time, Knappett and Nikolakopoulou (2005, 179) report a wheel-made bridge-spouted jar, very much Minoan in shape and decoration, found in a Period C context at Akrotiri (contemporaneous with Agia Irini Period V and Phylakopi City II.iii). Its fabric appeared to be Koan. So, we have a Minoan-inspired vase produced on Kos and in use at Akrotiri.

Island contacts with Crete during MM IA-IIA were rare, but became numerous during MM IIB-IIIA, when Cretan influences were quite strong. By LC I, a few eastern Aegean vases had appeared at Agia Irini, but apparently there was no regular or sustained contact during the MC despite Knappett and Nikolakopoulou's report of the Koan import noted just above (Davis *et al.* 1983; Gorogianni, Abell forthcoming). From further afield, Cline reported 93 Canaanite transport amphorae in the Aegean, and Rutter more recently reports nearly 70 more throughout the LBA, but only one from a Western String Island – a nearly complete amphora from Akrotiri, dating to LM IA; otherwise all of the LM I examples and nearly all of the LM II-IIIA2 Early examples have been found at coastal sites on Crete; expansion to mainland sites began in LM IIIA2 Developed.[9] With these shipping containers – used

9 Cline 1994, 95-96; Rutter 2014, 54, table 5.1; 55, table 5.2; 58-59, table 5.3. Without trying to re-assign the provenance of each of Cline's imports to the Aegean published in 1994, it is useful to update the overall conclusions from more recent publications. The finds from Kommos on the southern coast of Crete account for the vast majority of ceramic imports into the Aegean through the middle of the 12th

and re-used – spread from Cyprus, the Levant, Egypt, and northern Syria, the LC Aegean had become part of a thoroughly international trading network, with Kommos on the south coast of Crete probably the Aegean gateway port for eastern Mediterranean goods, at least through the middle of the 13th century, after which time Tiryns appears to have taken over that role (Knapp, Demesticha 2017, 65; Ben-Shlomo, Nodarou, Rutter 2011, 347-348).

Nonetheless, Thera, Kea, and Melos have yielded treasures of civilization during the late MC and LC I that the rest of the Cyclades have not. The lion's share of traffic moving along the Western String surely were Cretan and mainland Greek products, and apparently that traffic was considerably greater and more regular than traffic among other Cycladic islands and between those islands and Crete and the mainland during this time. Apparent Levantine and Cypriot products were not in the product stream in the Aegean at this time. Anticipating a bit, the empirical testing of the model will rely on shocks to the Cretan economy. There is no immediate reason to think that events on Crete would have affected traffic between the eastern Mediterranean polities and those in mainland Greece along the Western String. The Western String islands do stand out, geographically and archaeologically, as a special transportation route despite findings of recent excavations on the other Cycladic islands.

The modeling problem is to address the ability of port service provision to account for the wealth observed on these three islands. The origin of the traffic is of secondary importance to the issue of the volume of traffic. Consequently, the modeling concentrates on the two end points of the Western String traffic – Crete and the Greek mainland – and the Western String islands themselves. Rather than explicitly model all three islands of the Western String, along with Crete and the mainland, little is lost empirically and much is gained analytically by further simplifying the geographical setting into a single, small island and a much larger trading partner representing the combination of Crete and the mainland.[10, 11] An account balance between two trading partners is far simpler than the balances among three or more. Simplifying the work alternatives on the island to agriculture and a very broadly conceived shipping services allows a focus on the activity of primary interest – the shipping services, which are service exports – with the ubiquitous activity of farming remaining in the close background. And the smallness

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century. Sites in the Nile Delta and on the Levantine coast between Jaffa and Ras Shamra account petrographically for most of the Egyptian and Caananite jars at Kommos from LM IB onward. Sites in the Nile Delta, around Memphis, appear to have been the production sites of Egyptian jars, while most of the transport amphoras appear to have been produced on Crete. Mainland Mycenaean imports began to arrive in LH I and extend through earliest LH IIIC. Cypriot imports appeared at Kommos during LM III: Day *et al.* 2011, 550-553; Tomlinson *et al.* 2010, 219-220.

10 I have experimented with the construction of trade balance identities for Crete, the mainland, and an 'island.' There is naturally an expansion of the number of terms on each side of each identity, which need not pose an insuperable problem, but the difference between f.o.b ('farmgate') prices in exporting regions and c.i.f. (delivered) prices in importing regions requires, eventually, through the accounting system, an assignment of carriages to Cretan ships and mainland ships (I have expressed skepticism elsewhere regarding the provision of shipping by Cycladic islanders, but that is another issue). The difference between a c.i.f and an f.o.b. price is transportation costs. This specification requires that I identify the proportion of shipping of each product category carried by Cretan and mainland ships. No information is available to make such an assignment. And considering that back-hauls must be considered, the accounting problem would not be simplified by an assumption of proportionality. Other ways around such an assignment problem involve modeling the marginal cost of shipping for various categories of products, which takes us even further outside the boundaries of available information or even guesswork. The single shipper and the single harbor provider, while certainly not entirely satisfactory, at least provides a route around the information requirements of more detailed accounting.

11 The approach adopted here toward simplification in modeling may warrant some explanation, particularly as the model abstracts from the multiple islands of the Cyclades, the many different communities on the mainland and many aspects of the metals trade. First, the focal point is the port services provided by the three islands. The composition of the trade volume moving through those and other ports is of secondary importance; only its magnitude, and ultimately its value, is of consequence to the port service revenues. Further, other inter-island shipping traffic in the Cyclades would have been noise compared to the volumes moving along the big three of the Western String – akin to an urban alley relative to an interstate highway. Second, I have abstracted from many individual mechanisms that would have been involved in the processes of production and trade, such as smelting metal ores, record keeping and administrative tracking for which there is written evidence, and so on. This absence of detail is in contrast to an engineering model, which specifies each mechanism involved in creating the model's results. A drawback of the engineering-model approach is that whatever its creator does not put in the model will not operate – it does not allow for any improvisation by the agents modeled. But combined with the equilibrium conditions defining the solution to the few-details model, the sheer absence of detail allows the individuals whose behavior is being modeled to find solutions to the circumstances they face(d) that the modeler may well never have thought of. Ironically, this very lack of detail gives agency to the individuals in the model and allows for agency in their prehistoric counterparts.

of the island, established empirically for the real islands in the preceding section, implies that the much larger mainland (and Crete, in the real world of the time) determines values of traded goods, which further simplifies the analysis. Readers may recognize the following model as derived from contemporary neoclassical economic theory and be concerned that that theory is applicable only to monetary, thoroughly marketed economies. That is untrue; contemporary economic theory needs involve neither money nor markets.[12] I do not attempt to incorporate any anthropological nuances regarding trade, such as gift exchange and social exchange, into my analysis, but I do derive a number of economic nuances which I consider to produce more valuable social insights.[13] Alberti (2012, 23) contends that even in the MBA in the Aegean "a large part of the exchange [was] carried out outside the official system of 'gift exchange' and 'administered trade,'" which I consider sufficient grounds for concentrating exclusively on the economic nuances. And finally, my analysis omits consideration of many relationships that are of interest in their own rights but are subsidiary to the principal problem at hand. In defense of this triage I cite Tobler's Law, an inside bit of humor from a geographer several decades ago, that everything is related to everything else, only near things more so than far things (Tobler 1970). I am producing a model, not a photograph.

Considering the current popularity of network concepts in Aegean archaeology, it may be worth explaining why I use a simpler modeling approach. Three issues bear consideration regarding the use of network models such as reported in Knappett to study trade or exchange (Knappett 2011). First, trade or exchange is a transaction between two agents. No direct effects are imposed on any other agent in the trading system; price effects deriving from a sufficient number of agents making bilateral transactions may affect all members of the trading system, but that is not a network effect. Transparent examples of networks come from contemporary electricity systems and urban street-and-highway systems. In the case of an electricity system, a sudden increase or decrease in load (demand) from any node in the system automatically requires rebalancing the entire system of electricity flows and generation. In an urban street system, closure of a particular route, or the addition of an additional vehicle entails rerouting of traffic across multiple streets. In neither case is direct interaction of any pair or group of agents involved. Exchange systems do not share these characteristics of automatic non-personal reactions. The approach to trade developed in international economics fits the transactional characteristics of exchange, even exchanges involving many agents, more closely than does an automatically rebalancing network model. Substitutions among products or among ports and shipping routes, such as is suggested subsequently in the text, may have a superficial resemblance to a network, but that concept need not be implored to account for such effects.

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12 In case the topic of rationality may be a concern, I direct readers to Jones (2014, 57), where what rationality involves in contemporary economics is explained. As for application to non-market, even non-monetized, transactions, Jones (2014, 82-85) offers an exposition of Gary Becker's time allocation model and some of its applications. The involvement of development with quasi-monetized, rural economies with many missing markets bore the development of what is known as the farm household model, with examples such as Barnum and Squire (1979), Nakajima (1986), Singh, Squire and Strauss (1986), Key, Sadoulet, and de Janvry (2000). It may provide some reassurance to know that the farm household model of neoclassical economics formalizes and extends the models of Chayanov (1966) and Sahlins (1972), the latter of whom provides some neoclassical economic insights into the allocation of time by households with tenuous or no connections to markets. Finally, contemporary economic modeling is completely consistent with Christakis's (2008, 120-123) assessment of the LM I Cretan Neopalatial economy.

13 I am unpersuaded of the importance of such concepts as gift exchange and social exchange, and even of their validity, based as they are on analogies, as models of how prehistoric societies conducted their daily tasks of keeping themselves fed, housed, and amused with interesting things. Spriggs (2008) notes the culturally disturbed situations of Polynesian societies studied by late-19th and early 20th century anthropologists, and Eric Wolf's influential treatise (1982) made similar points some thirty years earlier. Taking up from Wolf, Pauketat (2007, especially, chapter 7) demonstrates deficiencies of the evolutionary chiefdom-to-state model. Analogical reasoning regarding ancient social and political organization and cultural practices, extending well beyond material culture, based on recent (19th and 20th century) ethnographies, has been applied widely in archaeology, but with what appears to be fewer, and more loosely applied, controls on what economists would call *ceteris paribus* conditions – differences in circumstances between two non-experimental situations under comparison for which a student should control when comparing specific behaviors. The practice has not gone unremarked or uncriticized. In fact, within the Aegean archaeological community, Broodbank (2000, 15) has criticized the transfer of contemporary or recent past ethnographic behavior to times and places in antiquity as "freezing [ancients] in an unchanging state that denies their past the potential to be substantially different from the ethnographic present." He reinforces the point with, "Polynesian chiefdoms were never in fact the analogues for societies from Wessex to Cahokia that they were once deemed to be" (Broodbank 2000, 27).

Delving more explicitly into the network model of Knappett, Evans and Rivers, the second issue involves the utility formulation of that model, and the third involves the implications of the results of the model's application to post-Theran-eruption trade disturbances to my own analysis (Knappett, Evans, Rivers 2008; Knappett, Rivers, Evans 2011). That model is not explained transparently in the appendix of either publication, but it is clear that the crucial components, the S_i, v_i, and e_{ij}, are not subject to empirical measurement other than rough guesses ("expert judgment"), and the methods for assigning those values to 34 sites are not revealed. The next consideration is the model specification itself, called both a "gravity model" and a "cost/benefit function" (Knappett, Evans, Rivers 2008, 1022) or a "utility function" (Knappett, Rivers, Evans 2011, 1022). The model consists of four additive terms – exploitation of resources, benefits of maintaining links, overall population, and costs of maintaining links (Knappett, Evans, Rivers. 2008, 1022). There appears to be a pair of benefit terms and a pair of cost terms, each pair containing one term measured additively across sites and another term added across pairs of sites. Each of the terms contains the expression $s_i v$ (Knappett, Evans, Rivers 2008, 1022) or $S_i v_i$ (Knappett, Rivers, Evans 2011, 1022) – carrying capacity s_i, percent of carrying capacity utilized v_i – and why these common components are not factored out is not explained. Nor is why the exploitation of resources is measured by $s_i v_i (1 - v_i)$ explained, and the answer is not intuitively obvious. All of the terms are dimensionless numbers (Knappett, Rivers, Evans 2011, 1022), and the Hamiltonian function noted in the appendix (Knappett, Evans, Rivers 2008, 1022) is a measure of energy in a system, so it is unclear how the minimization of this function through stochastic choice of the four multipliers using the Metropolis or Metropolis-Hastings algorithm has any meaning for benefits of inter-island trade. Far more intuitive for the behavior of agents participating in inter-island transactions would be a maximization of the net benefits of interaction. While the results appeal to the common sense of Aegean prehistorians, they may result from unreported experimentation with parameter values, hinted at in both appendices. Reflecting on the model structure, the fixed size and distance parameters may be overriding the influence of the more judgmental interaction parameters, rendering the results more a reflection of geography than of behavior.

Returning to my own modeling, economic activities on the island are comprised of agriculture and the provision of shipping services, the latter broadly defined to include such disparate activities as ship repair (primarily carpentry); sail and rigging repair; blacksmith services to re-fit worn, broken or lost metal components; supply of provisions – water and food (but not production of the food, which is the scope of the agricultural activities); production of containers for shipping [*e.g.* successor containers to the barrel jars of Period IV discussed by Crego (2007, 335-336), which she identifies as clearly shipping containers], including water and food jars; and even sailing – as I said, broadly conceived. Morgan (2020, 413) arrives at the same conclusion that my model of the town's activities derives: "the vital fact that Agia Irini owed the growth of its cultural development to the maritime trading network."

A single, equally inclusive agricultural good is produced on the island with labor and land.[14] The earnings per unit of labor supplied (wage) of a worker in agriculture and the rent per unit of land accruing to the owners of land are determined by the production technology of the agricultural good and the labor time applied to a unit of land.[15] The price of the agricultural good is determined by the larger trade partner and includes any shipping cost involved in transporting agricultural products to the island. Locally produced food may or may not be sufficient to feed the island's residents; if not, additional food will be imported. It also is not obvious that all the arable land on the island will be used, especially if the demand for labor in shipping services is sufficiently great; on the other hand, if the arable area is sufficiently small relative to the labor force (population), the islanders would be pushed into some kind of export activity or, failing those efforts, migrate off the island.

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14 The agricultural production function is $A^{\ell} = f(N_A, \bar{L})$, where the superscript ℓ on the agricultural output designates locally produced food products, N_A is labor devoted to agriculture, and the bar over land L indicates that the amount of arable land on the island is fixed.

15 The agricultural wage rate is $p_A f_N$ = w, and the rent per unit of land $p_A (f - n_A f_N)$ = r, where f is the average product of labor, f_N is its marginal product, n_A is the labor/land ratio, and p_A is the price of the agricultural good.

The sole alternative activity available to island residents is transport services, broadly conceived, produced with labor and the island's immutable (within the time span relevant to the analysis), site-specific attributes that give the town a good harbor.[16] The volume of shipping services provided is given to the island by the trading partner, and the site-specific attribute – the harbor – is beyond the control of the island residents. As with the application of labor in agriculture, the earnings per unit of labor provided in transport services are determined by the technologies involved and the amount of time applied to those activities.[17] Free movement of labor between agriculture and shipping services equalizes the returns to labor in those activities. The site-specific attribute earns a pure rent (a value above production cost) that is determined by the production technology, the labor time applied, and the price charged for the shipping services. As the demand for shipping services increases, more labor is applied, yielding an increase in site rents.[18]

The production function for transport services can be used to determine the amount of labor implicitly demanded to provide those services.[19] With the total island labor force fixed, once the demand for transport, or shipping services is known, the allocation of labor between agriculture and shipping services is also known.[20]

Turning to the islanders' consumption, their demand for food is determined by their income and tastes, the latter characterized by a price and an income elasticity of demand.[21] The island income is the sum of agricultural income, labor earnings from provision of harbor services, and rents to the port facility.[22] The island's supply of food is comprised of local production and imports.[23] The ratio of labor productivity to land productivity (called the wage-rental ratio in contemporary economics) is given to the island by the trade in food as well as the trade in transport services.[24]

It might seem that the second millennium Aegean was non-monetized and therefore that trade must remain balanced in value as has been suggested to this point. However, consider a moment exchange in the contemporary Near Eastern empires and then think about what merchant ships could carry around with them to pay for harbor expenses, victuals, and so on. It will soon become apparent that these merchant seamen must have carried some easily portable means of exchange that could be used as a store of value rather than a hold full of grain or various junk that might or might not be hawked off at various stops. Silver provided these services in the Near East and surely provided them in the Aegean.[25] Jumping ahead a few centuries, consider what a cumbersome process bartering the contents of the Uluburun ship would have involved if the ship had reached port safely and discharged the cargo to its different bidders and claimants. The Aegean – particularly the Lavrion mines – were a major source of silver at the time. The mines were being worked during the MH, as revealed by lead isotope testing of litharge from a MH residential building on Velatouri Hill at Thorikos which yielded part of a MH Gray Minyan vase and some MC

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16 The volume of transport services is given by $\bar{T} - g(N_T, \bar{S})$, in which the bar over the T indicates that the amount of shipping services provided is given to the island by the trading partner, and the bar over the S, indicating the site-specific attributes, indicates that those are outside the control of the island residents.

17 The wage rate in transport services is $p_T g_N = w$.

18 As the demand for shipping services increases, more labor is applied, yielding a change in harbor rents of $p_T (g + g_N - n_T (g_N + g_{NN}))$, $g_{NN} < 0$, and site rent p_S increases as $\bar{T}$ increases.

19 The production function for transport services can be inverted to yield the amount of labor demanded to provide those services: $N_T = g^{-1} (\bar{T}, \bar{S})$.

20 The total island labor force is fixed, $\bar{N} = N_A + N_T$, so once the demand for shipping services is known, the allocation of labor between agriculture and shipping services is also known.

21 Elasticities in general are the percent change in one variable caused – or sometimes simply associated with – a one-percent change in another variable. Price and income elasticities of demand are common indicators of individual preferences. The island's demand food is $A^d = k_A p_A^{\varepsilon} Y^{\eta A}$, in which k_A is a constant term, $\varepsilon < 0$ is the price elasticity of demand for food, $\eta_A > 0$ is the income elasticity of food demand.

22 Island income is $Y = p_A A^{\ell} + wN_T + p_S \bar{S}$, in which $wN_T + p_S \bar{S} = p_T \bar{T}$.

23 The island's supply of food is $A^{\ell} + A^m$, where A^m is imported food in the case where $A^d > A^{\ell}$.

24 The wage-rental ratio is $w/r = \omega$.

25 Michailidou (2008, 205-216) addresses the subject of silver money in the ancient Near East and its likely use in the contemporary Aegean.

sherds (Stos-Gale, Gale 1982, 476-478). Davis (1977) concluded that most of the small number of silver vessels from the Shaft Graves at LH I Mycenae were of Minoan manufacture, probably on Crete. Three out of four of the silver vessels Stos-Gale and Gale subjected to lead isotope tests were made with Lavrion silver, but they suggest an alternative trade route: rather than shipping silver from the mainland to Crete and the finished products from Crete back to Mycenae, they may have been made by Cretan silversmiths at Mycenae. Either way, silver would have been one of the items exported by the mainland, with a good deal of it in forms suitable for use in exchange – a type of money. Stos-Gale and Gale also suggest that the considerably more numerous gold vessels in the Shaft Graves may have been made with gold from Egypt – purchased with silver (Stos, Stos-Gale 1982, 479).

Accordingly the trade accounts must include a capital account, which implies that an export surplus in goods and services must be accompanied by an inflow of capital – silver in this case.[26] The set of inter-island accounts is comprised of a current account – consumption goods that an importer pays for in the present period – and a capital account – transfers of wealth that an importing agent buying more than it sells sends to its exporter to make up the difference in the value of the current account transactions. The value of food and non-food imports plus any capital (silver) inflows must equal the value of service exports; this is an accounting identity, not a behavioral equation.[27] The absolute values (prices) can be expressed as prices relative to that of non-food imports, which can be set to unity for the sake of simplification,[28] and the demand for the array of non-food imports can be represented as a function of island income and tastes, again represented by an income elasticity of demand.[29]

The individual relationships governing the activities of Cycladic islanders have been presented in the foregoing paragraphs, but it may be helpful to talk through the determination of the magnitudes of the individual variables, even at the risk of some repetition. To kick off the activities of this system, we have Crete's and the mainland's demands for shipping services from the Western String islands of the Cyclades. Given the site/harbor resources, Crete's and the mainland's demand for shipping services determines the island's labor time allocated to the provision of shipping services and hence the time the islanders spend in farming. The extent of land area on the island that is cultivated is determined by the externally given wage-rental ratio. Determining labor in agriculture determines local agricultural (food) production. The demand for shipping services also determines the rent to the site/harbor. Labor allocated to agriculture (or to shipping services) determines the absolute productivity of labor (the wage rate), so determining island income. The local price of agricultural goods (including transport costs to the island) is determined by the cost of imported food. The demand for agricultural goods (food), given local production, determines food imports. The price of harbor services is given to the island by the international maritime market's demand for those services. Thus the trade balance, which would sum to zero in the absence of a capital account, is determined, and the value of imports of non-food goods is known from knowledge of the value of transport service exports and the value of agricultural imports less the change in the capital account – the price of imports is determined in the international (inter-Aegean) market.[30]

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26 The trade balance with a capital account is $p_A A^m + P_M M + p_S S = p_T \bar{T}$, where M is all non-food imports, p_T is an index of their unit value, p_S is the price of silver, and S is the amount of silver inflow. If S < 0, there is a silver outflow. Both M and p_M can be considered vectors of quantities and specific unit values of individual types of goods and services.

27 Berg (1999, 482), in inferring that Melos had by and large withdrawn from trade with either Crete or the mainland judging from the small quantity of LM I/LH I pottery found there, would implicitly exclude service imports of fresco artists or teachers of fresco artists, as Morgan (2007, 376, 379, 381, 389) recommends a LM IB date for most of the Phylakopi frescoes. In fact, Berg's inference of a reduction in Phylakopi's trade volume in LC I may be largely correct, the point here simply being that trade in services exists as well as trade in both unobservable and surviving goods.

28 The relative prices are $p_A^* = p_A/p_M$, $p_T^* = p_T/p_M$, and $p_S^* = p_S/p_M$, and the trade balance equation can be re-written as $p_A^* A^m + M + p_S^* S = p_T^* \bar{T}$.

29 The import demand function is $M^d = k_M Y^{\eta M}$, where the price of imports is unity and $\eta_M > 0$ is the income elasticity of demand for non-food imports.

30 Summarizing by variable, given site characteristics $\bar{S}$, demand for shipping services $\bar{T}$ determines labor allocations N_T and N_A. Land use is determined by ω. N_A determines local agricultural production, A^ℓ. $\bar{T}$ determines harbor rent p_S. Either N_T or N_A is sufficient to determine w, so island income, Y, is known. Cretan and mainland production costs and demands determine p_A. The demand for agricultural goods,

An increase in the demand for shipping services would have drawn island labor from agriculture into those related services, reduced local food production, and increased food imports. While both agriculture and shipping experienced seasonalities, activities in both endeavors overlapped temporally.[31] In the trade balance, the demand for shipping services increases on one side while the value of food imports increases on the other.[32] Whether non-food imports, on the same side of the trade balance as food imports, would have increased or decreased depended on the income elasticities of demand for the two categories of good.[33] There is a reasonable presumption that the increase in expenditure on food would not have exceeded an increase in income, so non-food imports most likely would have increased as well. So an increase in export income from shipping services would most likely have resulted in an increase in non-food imports as well as the food imports required to compensate for reductions in food production required to increase shipping services. It is difficult to miss the incidental diversification of food sources for the island in this process: more shipping and related services from the island would have pulled labor out of agriculture but would have reallocated farmers' time to efforts that produced exports with which food imports could be purchased.

It may seem to be a considerable omission that metals and metallurgy appear nowhere in the model other than in the implicit forging of some repair parts for ships. It is widely considered that the shipping along the Western String was, to a great extent, inspired by Cretan demand for non-monetary metals from Lavrion in southeastern Attica.[34] Siphnos, a Cycladic island not one of the Western String three, was the ore source of a small proportion of silver and lead objects found around the southern Aegean, and Kythnos produced some copper, but their outputs were swamped by those of Lavrion (Gale, Stos-Gale 2008, 388-89, figs. 37.2b, 37.3b, 37.4b, 37.5a-b). There may have been some smelting of ores, at least at Agia Irini, although for what purpose is largely unknown. I do not believe the evidence indicates that Agia Irini, or northwest Kea more generally, was the location of any extensive smelting operations as part of an export industry (importing ore, exporting intermediate or finished metal products), and its own population was too small to create an extensive demand for metallurgical products. If this is incorrect, and some islanders on Kea – but probably neither Akrotiri and almost certainly not Melos – were involved in such metallurgical activity for an export market, then the model developed here is incomplete, but not terribly misleading: metallurgical exports as well as service exports would have contributed to affluence at Agia Irini, but the model probably represents the major types of activities at Akrotiri and Phylakopi reasonably accurately, if abstractly. Also, grouping all three major metals – lead, copper, and silver – together in the metals trade may serve adequately for some time, although as noted in the introduction, the entry of Cyprus into the Cretan copper market by LC I-II would have affected primarily copper from Lavrion but should have affected either the lead or the silver as well, as the ores generally were found mixed together in the same rock. Both Akrotiri and Phylakopi have yielded some crucibles as well, but with no appearance of more than attending to local demand.

These predictions regarding resource reallocations are independent of any political organizations or relationships – between Crete and the islands, between the mainland and the islands, between the mainland and Crete. The model generating them skirts the cultural issues of Minoanization, insightfully addressed by Broodbank (2004) and Berg (2007, chapters 4-5), but does rely on economic agency of the islanders themselves in their choices of labor allocation, somewhat along the lines developed by Abell (2016) in her nuanced analysis of choices of production technique by potters and of pottery imports by consumers at Agia Irini during Period V. Such features frequently

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A^d, given local production, A^ℓ, determines food imports, A^m. The price of harbor services, p_T, is given to the island, and the trade balance is determined, and non-agricultural imports, M, are known from the values of transport service exports, $p_T\bar{T}$, and agricultural imports, $p_A A^\ell$, and silver imports or exports, S, are known from the trade balance – the difference between the values of imports and service exports.

31 Isager, Skydsgaard 1992, 162, table 11.1. Seasonality of various activities arises in several other discussions of costs and labor supply below.

32 In the trade balance equation, $\bar{T}$ increases on the left-hand side and $p_A^* A^m$ increases on the right-hand side.

33 With Δ meaning 'change in,' the issue is: "Was $p_A^* \Delta A^m \gtrless p_T^* \Delta \bar{T}$?" in which $p_T^* \Delta \bar{T}$ represents an increase in island income.

34 Although there is no indication that polities in the Aegean at this time used any metals as money, as silver (hacksilber) had been used for some time in Mesopotamia, they would have served as stores of value and occasional exchange devices. Otherwise the demand for these metals was primarily as an input to manufactured products.

viewed as manifestations of cultural influence, such as the frescoes and Minoan pier-and-door architecture, are treated implicitly as the products of labor (service) imports satisfying the external trade balance.

While the model is austere, its simplifications allow us to link together causally the islands' role in the maritime shipping that we are confident took place, the islands' imports of food that we cannot observe, other goods that we can observe, and the consequences of the islands' population sizes, which may be a good bargain. What, specifically, does the model tell that is not obvious from either casual or close inspection of the archaeological material? First, serving as a port required the residents of an island to import at least some of their food. The time devoted to providing port services and related activities had to come from somewhere – and agriculture is the only alternative use of labor the model specifies, but in the real world of some thirty-eight hundred years ago it could have come out of manufacturing or industrial activities, ritual activities, even sleeping time (Biddle, Hamermesh 1990), as well as out of agriculture.

Second, the great resource for these three islands were their ports, not the labor productivity of their populations nor to a significant extent any industrial activities, nor need it have been exports or re-exports of raw materials. When the harbor at Akrotiri disappeared, the port authorities – such as they may have been – at Agia Irini and Phylakopi initially may have rubbed their hands at the prospect of reduced competition for anchorage and port services along the Western String route only to be sadly surprised, at least eventually, when alternatives (substitutes) for Akrotiri emerged, possibly rerouting shipping and reducing the demand for port services at Agia Irini and Phylakopi.

Third, and following from the second, whoever controlled the harbors – either individuals or corporate bodies – acquired the riches. With labor productivity unaffected, ordinary residents' incomes and wealth would have been largely unaffected. Whoever, or whatever family or dynasty, built and lived in House A at Agia Irini may well have been able to claim much or most of that town's harbor revenues. Fourth, the salad years of pre-eruption harbor activities provided the residents of all three islands with some greater stability of food supply by forcing them into importing agricultural goods – their food supplies would have been diversified thereby. Post-eruption, the residents of Kea and Melos would have received the additional disbenefit of losing that diversification in their food supplies when their harbor activities contracted. These results deepen our understanding of the lives of these islanders during this period.

Fifth, the model describes the best possible use of the harbor facilities, which implies that the resulting resource allocations would have been largely or totally invariant to ownership – private Cretan overlords, Cretan governors, or whatever other ruling structure that alternative theories of Cretan involvement in the Western String islands might envision. For such persons or institutions to have done otherwise would have left clear value-enhancing opportunities unexploited.

TESTING THE TRADE BALANCE MODEL

As a test, more impressionistic than exhaustive, of the model's predictive capacity I consider the responses to the LM IA Thera explosion sometime well into LM IB (Betancourt 2009, 103; Soles 2009, 107) on the remaining islands of the Western String after Akrotiri and Thera effectively disappeared.[35] Nevertheless, there are countervailing effects. First, the disappearance of Akrotiri would have reduced competition for port services facing Phylakopi and Agia Irini – an immediate, or short-term effect. Second, and longer-term, the Mycenaean mainlanders were expanding and found new trading partners further east – Cyprus, Egypt, and the Levantine cities, which may have sustained Phylakopi for a more extended period. Turning to the principal result that I explore, had Crete remained

35 The question may be posed why I have not developed some sort of quantitative index with which to test rigorously the hypotheses of the model. First, as Broodbank (2004) pointedly noted, there are few if any indicators that yield unambiguous interpretations regarding the spread of Cretan influence through the Cyclades. Second, any quantitative measure developed for hypothesis testing should be derived from the model generating the hypothesis. Some measures could be constructed, but insufficient data would surely render them unusable. One advantage of this model is that some of its hypotheses can be tested with available data, such as they are.

economically vibrant, the model predicts that Agia Irini and Phylakopi would have been little affected, but Driessen and Macdonald (1997), updated by Driessen (2013), have made an enduring, if not universally agreed-to, case that economic activity on Crete was damaged by the eruption, recovered sporadically and sputteringly, and succumbed to inter-island conflict in LM IB. Driessen and MacGillivray have presented an impressive array of cases of LM IA destructions along northern and eastern coastal areas of Crete that resemble contemporary patterns of tsunami destruction, and Driessen recently has summarized the island-wide evidence for Thera-related changes on Crete, noting particularly that violence and community conflict are rare during emergency phases of natural disasters but are not uncommon during recovery phases as the allocation of resources for recovery may be distinctly uneven (Driessen, MacGillivray 2011; Driessen 2019, 199). The rebuilding during LM IB would have involved a drawdown of mobile wealth throughout these communities and possibly beyond. The economic retrocession of Crete, whether it was caused by a reduction in demand or an interruption in supply imposed by natural catastrophe, warfare, or both, would be equivalent to a reduction in demand for imports in the model. Rutter has emphasized the non-uniformity of the destruction horizons over Crete during LM IB Late and LM IB Final, implying that no single event would have affected sites all across Crete at the same time (Rutter 2011, 326-327, 340-341, table 4; 2017, 137). Even if a single event precipitated a cascading of events across the island, the end result would have been a reduction in Cretan demand for imports. That in turn would cause a reduction in shipping service exports and a reduction in overall income in the remaining islands, Kea and Melos, or more specifically, in their towns, Agia Irini and Phylakopi. The reallocation of island labor time from shipping services to agriculture would be unobservable directly but might be checked indirectly by changes in relict farming evidence.

Changes in consumption of metals could be more problematic as an indicator of income changes. A reduction in the island towns' consumption of metals might have been induced by the reduction in their incomes, but a depression in the price of metals, particularly copper, caused by entry of Cypriot metals into the Aegean market would have had the opposite effect. Considering this possibility of opposing effects, as well as the potential for melting down and reuse of metals, I do not pursue them here.

The reduction in the Cretan component of the trade (which would be equivalent to a reduction of equal value in mainland trade in the opposite direction) would have been compounded by the elimination of any merchandise exports that formerly came from Thera. The reduction in trade would have had multiplier effects on aggregate income at both ends of the trading system – Crete and the Mainland – although both of these regions may have developed other trading partners during LM IB, *e.g.* with Egypt and other Levantine states (Warren 2001, 117). Nonetheless, the reduction in trade along the remaining Western String islands should have had the consequences predicted by the model. But returning to the destruction of resources in the southern Aegean as a consequence of the Thera eruption, it must be remembered that most, if not all, of Thera's population – surely larger than that of either Kea or Melos – may have made their way to safety somewhere else, contributing to other locations' labor forces. Forsyth (1997, 104, 115) presents contrary opinions on that subject. The principal economic losses from Thera were produced, immobile capital (residential housing, production facilities, and harbor facilities; some land of modest agricultural capacity), the value of the services of its harbor, and the value of any agricultural and other exports it may have provided.

Part of the hypothesis (hypotheses) of the model developed in this paper involves the status of the three islands prior to the Thera explosion as well as developments subsequent to the explosion. I characterize the development of activities on the islands – as well as developments in the primary indicators – prior to the explosion to determine the islands' *a priori* conditions. They should be consistent in timing with developments associated with the intensification of inter-island contacts. For example, if the three towns showed rapid growth in wealth prior to the uptick in trade with Crete, which surely was headed to the mainland, the model's principal timing prediction would be falsified.

Subsequent to the Thera volcanic explosion and its extended aftermath, I focus primarily on changes in two indicators, pottery and frescoes, and to a lesser extent on a third, architecture – its construction and reconstruction – to detect changes in trade and income. While metals could serve as such an indicator, its reusability hinders observation in ways that do not affect the other three.

Changes in the *relative proportions* of Minoan and Mycenaean pottery are used as an indicator of a change in the volume of shipments from Crete. Additionally, the *volumes of imported pottery*, if detectable, could provide evidence that a reduction in trade did occur, although the proportions seem to be a well-accepted indicator in the literature (Mountjoy 2009, 73). Imported pottery volume is an indicator of trade volume and participants and hence is a leading indicator of changes in income and wealth. The issue of proportions versus absolute amounts does raise an economic issue however: if the Cretan component of trade going north fell, the mainland shipments, by value, going south would have to fall in parallel unless the mainlanders acquired some new trading partner or partners to which the remaining Western String islands would have been an acceptable route. Kea and Melos by themselves simply were not large enough to support large volumes of trade between themselves and the mainland.

I treat the frescoes as indicators of local income and wealth, so the dating of their painting is a lagging indicator of changes in income and wealth, lagging because income generates wealth, and a change in income for an extended time would be required to change in wealth. Wealth in the form of structures could be destroyed in an instant although maintenance expenditures deriving from mobile wealth could be used to rebuild damaged structures. Monumental architecture – public buildings, mansions, fortification walls[36] – is also an indicator of wealth, with its lagging relation to income. Cook has calculated the labor-time cost of the fortification walls at 24,000 person-days at Phylakopi and 8,000 person-days for substantially shorter wall length at Agia Irini (Cook 2014, 127, 130). Estimating adult male populations at both sites at 25%, these figures amount to twice the labor available in a year at Phylakopi and 73% at Agia Irini (see below for calculations) for a much shorter length of wall in Period V. These are not insubstantial demands upon the resources of these communities. Accordingly, the fortification walls qualify as structures that only wealthy communities could afford.

Akrotiri

Although the post-volcanic consequences for Akrotiri are painfully obvious, part of the hypothesis involves the island's activities prior to that explosion. With a population at Akrotiri as large as Doumas's estimate of 4,000 to 6,000 individuals – 800 to 1,500 households of four to five people[37] – the scope for household specialization would have been considerably greater than that on either Kea or Melos, which could have raised Akrotiri's competitiveness for export activities, particularly the possibility of an export textile industry (Tzachili 1990b; 1999). However, with Palyvou's (2005) recent reduction of that range by roughly three-quarters, that scope would contract considerably, but I nonetheless consider the activities which have been entertained on the basis of archaeological evidence. The exceptionally large number of loom weights in one room of the West House, combined with the absence of loom weights elsewhere, has prompted some speculation about a textile workshop that might have supplied the local community as well as exporting, although Tzachili's preferred interpretation of the find pattern is something more of a community co-operative weaving center, like a time-share in a contemporary business center. Both Tzachili (1999a) and Wiener (1990b, 210) have raised the important issue of sail-making from linen made from flax. If some of the textile activity left in the record at Akrotiri in fact involved sail-making, that activity would have been based on imported flax, and probably imported linen, considering the requirements of water, a perennial scarcity on Thera (Doumas 1990a, 26-27), in treating flax. Kourmoulis (1990) identified an aquifer which would have been tapped by wells in the pre-eruption period, but he offered no estimate of water quantities in late MC-LC I times. Woolen cloth, of course, would have depended on a substantial sheep population, for which there is some evidence from pre-eruption Thera (Gamble 1978, 750). Its competitiveness with Cretan products probably would have depended on the variety that the Theran products would have contributed to an Aegean market, in both wool and weave quality and in patterns. Panagiotakopulu *et al.* (1997) have raised the possibility of wild silk weaving as a Theran export industry, based on the find of a

36 Gauss 2018, 42 notes that fortifications are both a result of communal effort and a demonstration of communal power.

37 See Christakis 2008, 36-37 for household size estimates for Neopalatial Crete.

calcified cocoon at Akrotiri. Morgan's (1988, 30-33) compelling examination of the festoon and pendant motif in the miniature wall paintings led her to suggest that saffron was likely to have been a high-value, commercial export during the later MBA and early LBA, as it apparently was in Classical and later times. Considering the import requirements for at least some of these activities, whether they would have yielded a net positive inflow of resources (a positive capital inflow) is a question that cannot be answered. As sources of net wealth, I find it difficult to see these activities as engines of growth.

With the reservations registered above regarding Thera's ability to support various domestic and export industries, recent research is yielding compelling evidence of a considerably different environment on Thera prior to the volcanic eruption than has been the case since, with implications for the island's economy. Asouti's (2003) analysis of wood charcoal remains found a variety of species of tree dating from the EBA through the LBA, some imported but most growing locally. She inferred a cooler and moister climate on the island than has previously been believed. Palynological analysis by Vougioukalakis (2006) identified pollen grains from an array of trees, shrubs and vines, again suggesting a relatively moist climatic regime. Vlachopoulos and Zorzos (2014) have used phytoliths and diatoms in conjunction with the post-2000 literature on Thera's pre-eruption vegetation to portray a vibrant landscape with forest, land covered with grasses and sedges, and some wetland. While only olives, among the many food plants of interest, produce phytoliths, the grasses and sedges – which include papyrus – do, which yields the impression of a landscape covered with that vegetation. Food crops such as barley, lentils and peas, remains of which have been retrieved from Akrotiri, cannot be ruled out has having been produced on the island, but the phytoliths are of no help in identifying possible local production. Whether this emerging view of Thera's pre-eruption landscape and its capacities alters my views of its capacity for production of silk and flax for sail cloth, I cannot say, and none of these authors has ventured inferences in those directions. It does not seem out of possibilities that Thera's support for Akrotiri and its wealth was not inconsequential, but the evidence for weighing and measuring still suggests that external commerce was a major contributor.

Despite the island's size and the population of Akrotiri, or rather at least partly because of Akrotiri's population, no student of the island has expressed the opinion that the island could feed itself, and several have claimed that it could not. The island did not have abundant water resources, which would have limited some potential industrial activities such as retting of flax in preparation for sail making. The apparent distribution of specialist craft workers throughout the excavated houses is sufficient to have furnished the town's demands, but does not give the appearance of export industries. However, the wide distribution of balance pans and balance weights using the Minoan measurement system throughout the houses – with at least one weight in each excavated house, but not before the LC period – does give the appearance of widespread merchandising (Michailidou 1990, 407, 417-418; 2008, 41-99, esp. 65). At the time of Michailidou's 1990 writing, 102 balance weights had been found, with 19 in Complex A, 26 in the West House, and 49 in Complex Delta. Weighing items and material evidently was a regular activity for virtually all households at Akrotiri, not restricted to some central authority. Michailidou, noting that Betancourt had suggested port services as an export that gave the Cretan island of Pseira its appearance of some modest prosperity (Betancourt 1995, 165), named port services as a major export of Akrotiri (Michailidou 2008, 217). Nikolakopoulou's evaluation of the storage facilities and containers at Akrotiri concluded that the community's involvement in long-distance trade activities and the island's strategic geographical location accounted for the prosperity observed there (Nikolakopoulou 2011, 258). Tzachili (1990a, 210) noted that 300 loom weights had been recovered from Room 3 of the West House, from which she inferred a specialist weaving activity, as loom weights were not found in every other building.

Although Cretan influence and material culture at Akrotiri go back well into the earlier Middle Minoan period if not earlier, they began a sharp uptick around the beginning of the New Palace Period on Crete. Increasing income from port fees and associated support of shipping beginning in MM IIIB would have created a wealthier Akroterian society by early in LC I, although this wealth would have been attenuated by the destruction evidenced

around the end of MM IIIA.[38] The social cooperation revealed in the reconstruction efforts and the reconfiguration of the town with public spaces are indicators of a well governed, socially unified urban polity at this late MC date. Despite the MM IIIA/IIIB destruction, the wealth of the community is reflected in its two- and three-story houses, the upper stories of which were damaged in the early-LC I earthquake, known as the seismic destruction level.

Nearly every excavated building at Akrotiri has yielded frescoes, several extensively. These are on upper floors which typically involve reconstruction after the earthquake destruction near the beginning of LC I. None of the frescoes predates LC I/LM IA, by which time higher port revenues would have built up considerable wealth. Only solid, red plaster has been found among the remains of the houses destroyed in the early LC I seismic event.

No evidence in the remains at Akrotiri suggest that the town had reached the pinnacle of its wealth prior to, or even contemporaneously with, the uptick in commerce between Crete and the mainland. The LM IA period seems to have been a one-time-only period of prosperity. The industrial activities in the town would, for the most part, have met with competition in off-island sales, which would have constrained the profitability – or, more to the point of the model, the wealth generation capacity – of those activities. This leaves harbor service payments as the major source of the town's wealth by the end of LM IA.

Agia Irini

Jumping ahead in time a bit, Morgan (2020, 17) paints a vivid picture of Agia Irini during its heyday as an entrepot: "this sheltered bay would have received ships coming from Crete, Thera, and Melos from the south, from the Greek mainland immediately to the west, and from the east, along the Cycladic trade route via Thera and perhaps Crete from the Dodecanese and the coast of Anatolia. Thera, Melos, and Kea were the stepping-stones of trade and communications, the pathway between Minoan Crete and the Mycenaean mainland." Beginning earlier, however, Kea was abandoned during the Early Cycladic period by Neolithic occupants who had established settlements at Kephala and Paoura, in the northwest corner of the island, as well as possibly some scattered farmsteads not far away. It was re-settled by groups possibly from several parts of the mainland and possibly Aegina during the MM I period (Abell 2014), or possibly by Keian residents from Karthaia (Hale forthcoming). Crego (2010), alternatively, has made the case for settlement by mostly, if not exclusively, men from Aegina in Agia Irini Period IVa to establish an off-shore ceramic production and distribution establishment for Kolonna, with women appearing only in Period IVb. By the 17th century BCE the island's population was not close to 1,000 individuals, so it clearly was not a destination for substantial colonization. Nevertheless, Davis estimated that the Period V fortification wall expanded the area enclosed by the Period IV walls by as much as fifty percent, which certainly does suggest at least a one-time influx.[39] Beyond that inflow during the later part of Period IV, organic population growth, with negligible subsequent permanent migration, appears to have been Agia Irini's demographic engine. Another site on the eastern side of the island contemporary with early Period IV has been found recently under the 4th century BCE temple at Karthaia (Panagou 2010-2012, 354; Gorogianni 2016, 149, n. 5). Its ceramic assemblage contains nearly the full range of imports as found at contemporary Agia Irini. Likely the harbor facilities at Agia Irini, or its location, or both, were superior, leading to the competitive abandonment of that site. Mountjoy has offered a telling account of the geographical advantages of Kea in general and Agia Irini in particular: "Its location facilitated contacts with Boeotia and Euboea and, particularly, with Athens and the Saronic Gulf, as well as with southern Attica [...]. It also meant it was the first port of call not only for boats going southwards from Attica to Melos, but also for those sailing eastwards to the central Cyclades. Moreover, boats coming to the Saronic Gulf from the north Aegean would have come round the north-west of the island and stopped in the Bay of Ay. Nikolaos" (Mountjoy 1999, 863).

38 Nikolakopoulou, 2013, 214; Palyvou 2016, 177, would place the seismic destruction at the beginning of LM IA, about 50 years before the volcanic eruption.

39 Hale forthcoming deduces a shorter Period V, implying a shorter length of time for construction of the Period V fortification walls, in turn implying access to more labor effort, resources and organizational capacity than previously believed.

Cook (2014, 127, 130) estimated that the Period V fortification wall at Agia Irini would have required 8,000 person-days to construct, which he calculated would have required 68 people working full-time for one season. He considered that Agia Irini's population easily could have furnished that number, but some simple calculations suggest otherwise. Begin with a population of 500 people in the town, 40% adults divided evenly between men and women and 60% children, two-thirds of whom survive to adulthood. Suppose that 75% of the adult men were capable of such work. Those calculations yield 75 men capable of fortification construction, of which 68 comprise 91%. A work force occupied in agriculture, port activities, and the various industrial activities indicated by the archaeological remains would be hard pressed to devote 91% of its male workforce (the adult women surely worked as well, if not in heavy construction activities) to wall construction for a full season. My own suggestion is bringing in temporary construction workers from off the island. Labor requirements for repairs after the Period VI earthquake would have been smaller – *ca*. 4,500 person-days – but the capacity to hire the requisite labor may have decreased, leading to lesser restoration. In both cases, seasonality of various activities may have affected the supply of construction labor and the ability to complete repairs.

Considerable evidence for metallurgical activity has emerged at Agia Irini. The important question for present purposes is whether it was a local or an export activity. A combination of archaeological observations and economic reasoning suggests that it was primarily a local activity and not a major contributor to the apparent wealth of at least some residents. The material evidence first. Agia Irini was the closest port to the mines at Lavrion, and consequently, with lower shipping costs than at more distant islands. By the LC period evidence of small-scale metallurgical work was found in many houses, although Overbeck (1989) and Davis (1986, 89, 99) have reported evidence for metal working in Periods IV and V as well. At least part of the metallurgical activity may have produced replacement components for ships. Lead balance weights would have been another obvious candidate for local production, since lead was a major product of the Lavrion ores. As to smelting of ore at Agia Irini, or outside the town to avoid noxious fumes, the proportion of the ore extracted from the Lavrion mines that was exported as ore and that which was smelted locally to save on shipping costs is not known, but an oxhide ingot has been found at Agia Irini. While it may seem reasonable that ore would have been processed near its extraction site to avoid carrying tons of unproductive rock, Betancourt has found that ore smelted at Chrysokamino in EM eastern Crete was imported from Kythnos and Lavrion (Betancourt 2006, 181).

The LC evidence for metallurgy at Agia Irini is primarily – but certainly not exclusively – from House A but also from the Western Sector from as early as Period IV [Overbeck 1989, 75 (litharge), 118, 127, 165 (slag), 116, 148 (crucibles), 103 (tuyere)] and through the post-earthquake part of Period VII. Fourteen reports of crucibles or crucible fragments, one with a piece of bronze attached, come from House A, Rooms 19-21 and 25-27, with some litharge from lead smelting found in Room 19 and another small piece found in disturbed but probably Period VII levels of Corridor 29 and Stairway 32 (see *supra*). The stone multiple mould found in Room 19 was designed to cast some simple tools and knives, while the mould from Room 17 appears to have been designed for an ax. The oxhide copper ingot fragment from Room 19 was an import from Cyprus (Stos-Gale, Gale 1990, 89; Stos-Gale, pers. comm.). Five reports of crucibles or crucible fragments come from the Western Sector, along with two reports of bronze fragments and several reports of litharge. The lead and litharge found on the floor of Room W.23 of the Western Sector appear to have been associated with vase repairs as much as anything (Schofield 2011, 168). Schofield (1990, 209) noted the scatter of metallurgical activity across most houses at Agia Irini and considered that the town, rather than individual households, specialized in metal products for export. Refining silver from Lavrion's silver-rich lead ore could have been a profitable endeavor, and there are some remains of cupellation. The net inflow of silver, refined or as ore, could have represented the return to the town's harbor services.

Now for the economic reasoning. Without exploitable ore resources on the island that have been discovered to date, residents of Agia Irini would have had to either import ore, smelt it, and cast items or import previously smelted metal to produce metal items for export. Two factors would reduce the competitiveness of such an export manufactory on Kea: the break-of-bulk incurred in the off-loading of ore or metal at Agia Irini and loading of subsequently manufactured items; and the remoteness from the sites of final demand, largely on Crete. Ore sites and

demand sites would be lower-cost smelting sites than intermediate locations, as noted by Stos-Gale (2011, 226). Smelting, as well as casting finished products possibly in addition to ingots, at ore sites would give lower transportation costs. Silver was being extracted at Lavrion from evidence of litharge in a late MH layer (Hope Simpson, Dickinson 1979, 209), and Gale, Kayafa, and Stos-Gale (2007, 160) suspect that copper was produced, including smelting and casting, from an early date. Casting, if not necessarily smelting, near markets offers the advantage of better information on what customers want (Jones 2014, 452-454). The example of Chrysokamino in eastern Crete shows that agents on Crete preferred to import ore and smelt it locally and produce locally demanded items near the markets for them, despite the greater expense of shipping ore than finished products (Betancourt 2006; Stos-Gale, Gale 2006, 313-316). Stos-Gale (2000, 61) notes that shipping ores to a smelting site has been common "throughout the history of metallurgy." We can only surmise that the ore did not change ships somewhere along the journey. An additional economic fact relevant to the possibility of a Keian metallurgical export endeavor of sufficient magnitude to account for the town's wealth is the size of its labor force, which, regardless of possible metallurgical employment, faced demands from both port and supporting activities and at least some agriculture. The labor force was simply too small to support such a powerful export engine. The issue is not whether some of these export activities existed, but whether they could have accounted for the apparent wealth of the community. I conclude that they could not have and that the simplifications I have made in my model are not misleadingly distortionary.

Local potting dominated the ceramic consumption, with a few exported pots found in other Cycladic islands (Cherry, Davis 1981, 337, ill. 2). Keian pottery does not appear to have been as popular as Melian pieces, judging from off-island distributions of the two islands' ceramics, whether popularity is associated with tastes or shipping patterns. No non-household-scale industries appear to have developed, and certainly no dedicated export industries. The island's population probably was too small to permit a great deal of specialization. Some of the agricultural activity could have produced rope for sales to docking ships, possibly from goat hair and even leather. However, some 73 to 85 rural sites dating from the Neolithic through the end of the Bronze Age have been identified by surveys in Northwest Kea, a small number to occupy some two thousand years, suggesting a relatively small role for agriculture on the island.[40]

The balance weights found at Agia Irini and studied by Petruso (1992) are clear evidence of weighing and measuring, undoubtedly with economic gain in the minds of the users. They belong to the same metrical systems as the weights found at Akrotiri. Schofield (1990, 210) noted that balance weights were found in nearly every building in Agia Irini, as was the case at Akrotiri. Davis (1990, 210) reported one lead balance weight of "insecure context" from Period V. Adding to the evidence of the balance weights as indicators of commerce and standardization, Bikaki (1984, 22) interpreted the increasing use of potter's marks beginning in Period V and continuing through Periods VI and VII as labeling, for content or for production recording – or both – using derivatives of Linear A script. Even if the people inscribing the marks were illiterate, she infers "assimilation of Cretan cultural elements resulting from continuous relationships." Some of the marks from Period VI use a type of composite sign that appears on the lead weights, offering a tangible linkage between the potter's marks and the weighing and measuring. As Michalaidou inferred for Akrotiri, Alberti (1995, 25) concluded from the dispersion of the weights across habitations and work places that no centralization of their use could have been possible.

Evidence of manufacturing or craftwork of one sort or another – frequently more than one type – has been found in every building of the LC I-II settlement (Schofield 1990, 202), although Georgiou (1990, 210) concluded that none of the households were specialists – all were 'part-timers.' Davis (1990, 210) nonetheless thought that the roughly 100 loom weights from the areas of Houses L and M were enough to suggest specialist weavers. Schofield (1990, 201) agreed about the non-specialist character of most of the working areas from which various materials were found, but suggested that the settlement as a whole may have specialized in producing certain manufactured

40 Georgiou and Faraklas (1985) identified 45 sites, and Cherry's survey identified 28 certain and 12 possible sites (Cherry *et al.* 1991, 218-221, tables 9.2-9.6). Ignoring any overlapping sites, if each site were occupied for 25 years, and only one site at a time were occupied, these sites would occupy 1,825 to 2,125 years. This would not have been a dense rural settlement.

items, "possibly for export." As for specialized manufacturing equipment, Georgiou (1986, 4-22, 23-28) reported 90 fireboxes, 19 in House A alone, and 27 firestands from Periods V through VII. The use of neither is clear, but they are equally clearly not final consumption goods, but intermediate goods of some sort. She suggested dry distillation of perfume substances for the fireboxes, but she conceded that the substances found in them in analyses by the U.S. Department of Agriculture's Center for Wood Anatomy Research would not have smelled very pleasant, which puts something of a damper on the notion of lucrative perfume exports (Georgiou 1986, 10-11). For the firestands, Georgiou alternatively suggested some role in metallurgy although the burn marks did not come from direct exposure to flames or coals.

How does this characterization of productive activity at Agia Irini square with the model's specification of two alternative activities, shipping services and agriculture? The evidence for local agriculture is minimal, so people had to do something to eat. So they made things. Some of the things were clearly sold to other residents, and some surely were sold externally. Some of those external sales well could have been products to support harbor activities. And the non-specialist appearance of most of the households suggests that their members did something else than make the things whose evidence of processing remains in many cases. Of course no real economy has only two possible activities for people. That is why what I have constructed is called a model and not a photograph or a census. The scientific question is whether the departure of the island's actual activities from the model's focus on harbor services over this extended period is sufficient to vitiate theoretical insights from the model. I say not. The products that the households at Agia Irini made and surely sold outside the island would not have made them rich. Too many other communities had nearly the same access to the same materials and technologies that the Keians had. The competition throughout the Aegean would have kept profits to 'economically normal,' *i.e.* zero, profits.[41]

Architecture at Agia Irini was more modest than that at Akrotiri by the beginning of LC I, although evidence of contact with Crete is apparent as early as the Old Palace period and began to grow steadily by MM IIIB. No monumental architecture appeared prior to the construction of House A early in LC I/LM IA. Although a few rooms had been built during MM IIIB, construction on House A began early in LC I/LM IA, with a complete plan of its eventual layout determined from the start, according to Cummer (Cummer, Schofield 1984, 32), which would indicate confidence in continuing prosperity. Of course, construction was interrupted in Period VI (LC I/LM IA) by earthquake and fire, and repairs probably would have required a draw-down of wealth.

After the Thera explosion and the recession on LM IB Crete, a reduction in shipping or trade emanating from Crete seems to be borne out in the pattern of Minoan and mainland (Mycenaean) pottery at Agia Irini. Dealing with proportions first, Minoan pottery was dominant at Agia Irini in its Period VI (LM IA/LH I), maintained a presence through Period VII (LM IB/LH II/LC II) although distinguishing it from Mycenaean pottery has been difficult, but was sharply reduced if not eliminated altogether in Period VIII (LM III/LH III) as Mycenaean pottery became dominant.[42] Morris and Jones (1998, 190, table 1) note that Mycenaean pottery was present in about the same proportion as Cretan pottery from LB I-II through LB IIIA2. It did not replace Minoan pottery when Minoan disappeared in LB IIIA1. Until Gorogianni and Abell's publication (forthcoming) of their extensive analysis of the provenance of ceramics at Agia Irini, the Bronze Age pottery from Agia Irini had been published less extensively than that at Phylakopi, although some major trends in Cretan/mainland proportions could be inferred from a number of the publications. Gorogianni and Abell's report generally corroborates the contentions of the previous publications but greatly extends and refines the identification of provenances, particularly in the critical Periods VI and VII. The proportion and absolute volume of Minoan – and Minoan-influenced, locally produced – pottery began to increase in Agia Irini Period V (MM III, late MH, late MC) and became dominant during Period VI (LM IA/LH I/LC I). Period VII (LM IB/LH II/LC II) saw an increase in mainland (Mycenaean) pottery, many of

41 What commonly pass for profits in lay conversation are actually returns to various types of capital, many of them human skills. When these returns are compared to the investments required to develop them, there are no 'profits' left, only normal returns to these types of capital.

42 Cummer, Schofield 1984, 143, 146; Hershenson 1998, 162 notes that after Period VIIb destruction Minoan imports and fine decorated Cycladic wares drop off steeply.

the pieces actual imports (Bikaki 1984, 26, 31, 40; Cummer, Schofield 1984; Georgiou 1986, 52-53 on industrial pottery; Mountjoy 2008, 469-73; Schofield 2011, 1, 12-13, 87-88, 112, 193, 195). Petruso (1992, 35) reports the introduction of lead balance weights at Agia Irini by LM IA/LH I and their continuing use during LM IB/LH II, but a sudden decrease in mixed Period VII-VIII contexts, and their total absence from clear Period VIII contexts – all suggesting the rise and falling off of trade that involved weighing commodities such as metals, cloth, and grains.

Agia Irini was rocked seriously by several earthquakes during these periods – at the end of Period V and later in Period VI, from both of which the town recovered quickly, and an especially damaging one at or toward the end of Period VII, from which the town never really recovered (Caskey 1962, 273-74; 1972, 392, 394-95, 398). According to Marthari (1984, 132), the Period VI earthquake at Agia Irini occurred between the early LC I earthquake at Akrotiri and the mature phase of LC I not long before Thera volcanic explosion. The town's non-structural wealth should have been near its apogee around this time. Although the earthquakes interfere with a clear view of the effect of the reduction in Cretan trade on Agia Irini, the strength of the recoveries from the first two quakes does correspond to times of vigorous maritime trade, although the second quake may have occurred (shortly?) after the volcanic eruption at Thera. Caskey (1962, 273) suggested that after the Period VII earthquake, "The people may have been exhausted economically," which could correspond to their having run down their non-structural wealth from a combination of reduced exports of transportation services and repeated investments in structural repairs.

The monumental House A was battered repeatedly by earthquakes and was finally by and large abandoned during Period VII (LM IB). The town's ability to rebuild after these destructions appears to have attenuated, which I interpret as indicating a long-term decline in their movable (non-structure) wealth, which the model predicts.

The preliminary dating of the frescoes at Agia Irini was to LM IB/LH II, likely after the disappearance of much of Thera in the volcanic explosion (Coleman 1973). Abramovitz (1980, 69, 81-82) ventures chronological conjectures of LM IA for some of the hunt figures in the Northeast Bastion and the splash patterns in House A, Room 39. Morgan (1998, 201) believes that the paintings in the Northeast Bastion were executed during Period VI (LM IA/LH I) or shortly thereafter, which would accord with the apogee of Agia Irini's prosperity.

Agia Irini, or at least some of its more privileged residents, flew high during the middle and tail ends of the prosperity earned by the town's harbor services during the late MC and the LM IA period. The destruction of Akrotiri may have had no short-term effect on traffic at Agia Irini, but as Cretan traffic died down during LM IB, LH I traffic might have been able to compensate for previous volumes on the basis of its capital exports – the export of silver to various places, including Agia Irini. While mainland traffic declined along with Cretan traffic, mainland silver exports may have kept Agia Irini's financial coffers full for a while. Eventually, the reduction in physical traffic would have told on the harbor revenues. While building might have kept up during the early part of LM IB – Period VII at Agia Irini – the wealth could have been dwindling through routine repairs and finally through repairs to the catastrophic earthquake. The geography of Agia Irini and Melos did not change after the Thera explosion, and with the improvements in maritime technology that had emerged over the previous several hundred years, merchant shipping should have been able to find a way up the remaining Western String without stops at Akrotiri. But the evidence of wealth deteriorating at Agia Irini from Period VI through Period VII is inescapable.

So, how should the test vis-à-vis Agia Irini be judged? Evidence of an increase in the volume of trade begins in Period V, which also saw the construction of the expanded fortification wall and watch towers, a major investment. This growth in the town's prosperity preceded the major expressions of wealth – House A and the frescoes, which may have been delayed by the allocation of resources to the fortifications in Period V. The town's residents made a little bit of many things – pottery of course, some weaving with different apparent scales of production, some metal tools, some cupellation of silver, some non-metallic product(s) requiring controlled heating, some work with bone – all activities and products with widespread competition. Weighing goods was an activity practiced by nearly every household in the town, indicating widespread participation in commerce. After the volcanic destruction of Akrotiri, the initial change facing Agia Irini could well have been a modest increase in harbor traffic as it absorbed some of what Akrotiri would have served, as Phylakopi would have as well. Signs of

prosperity continued into Period VI (the earlier part of LM IB) but did not increase. Recovery from the Period VI earthquake would have been a drain on the town's wealth, whoever owned it. During LM IB, Crete's economies struggled, probably for a variety of reasons, some due to physical reactions to the Thera explosion, and its external trade volume (value) declined. That would have reduced income from harbor services and retarded or even reversed the growth of wealth as non-growing resources were put into repairs. Having drawn down wealth to repair structures after the Period VI earthquake, the town's residents were not as well placed resource-wise to face the next earthquake, the severe one of Period VII. Consequently, repairs of much of the structural damage caused by the Period VII quake appear to have been deferred for lack of resources. Minoan pottery was the dominant ceramic import during Period VI, Mycenaean pottery increased in volume and in proportion to Minoan pottery during Period VII, and Minoan pottery virtually disappeared in Period VIII along with much of the activity at Agia Irini. This was also a period of developing ascendancy for the Mycenaean polities, some of which could still export silver in the capital account, and some of which surely expanded their commerce with places beyond Crete, compensating somewhat for reduced trade with Crete and propping up the port business at Agia Irini. This is an intricate summary, but the temporal patterns of evidence of prosperity and Cretan participation conform to the predictions, but with lags.

Phylakopi

The composition of Phylakopi's population in the late MBA and in its LC I phase has been a recurrent question: long-term island natives, Cretan conquerors, Cretan administrators? I have addressed the island's – and the town's – small population previously, but Hood seems to sew up the issue succinctly by noting that neither the composition nor the quantity of Middle Minoan imports would have been sufficient to supply Cretan settlers. There is hardly any of the plain ware so common at Cretan sites of the period, and cooking ware, notably tripod bowls and jars, are noticeably absent (Hood 2007, 253-254).

At Phylakopi, the late Second City and the early Third City were co-extensive with the Neopalatial period on Crete. Minoan influence was strong in architecture and frescoes as well as in pottery in the early part of the Third City [in Renfrew's revision of Mckenzie's 1904 classification: LM IA-LM IB] (Renfrew 1978, 404-416), but in LM IB/LH IIA the proportions of Minoan and Mycenaean pottery largely reversed and remained so through LH IIIB (Mountjoy 2007, 326; 2008, 469-473; 2009, 73). Mountjoy (2007, 333) was able to assign only one sherd at Phylakopi to LM II. Period 2 of the Third City is the last time any Minoan imports turn up (Barber 1984, 182). Turning to quantities, while LM IA pottery at Phylakopi is plentiful and LH I scarce, LH IIA pottery from the mainland is well represented there. Very little pottery at Phylakopi can be assigned to LH IIB/LM II, possibly in part because of lack of good settlement stratigraphy, although all the LH IIB pottery found there was imported (Mountjoy 2007, 333). In subsequent years, there is a large amount of LH IIIA1 pottery, all from the mainland, while LM IIIA1 is very scarce (Mountjoy 2007, 335), but very little LH IIIA2 pottery, most of which was imported (Mountjoy 2007, 338). Continuing into LH IIIB, there is very little pottery of this style, most of which is imported, and all of the LH IIIC pottery is locally made (Mountjoy 2007, 341, 344).

These developments appear to imply a permanent reduction in the absolute volume of Cretan shipping through Phylakopi after the Thera volcanic eruption and hint at the possibility of an absolute reduction in mainland shipping over ensuing years, decades, and centuries, although how rapid the decrease might have been early on remains elusive. What the mainland would have traded with Phylakopi that would not have been disproportionate to what that small town and its supporting island could have produced remains a question – agriculturally based products, possibly, going in both directions. Continuing, if diminished, shipments through to Crete could have cushioned a decrease in service export income at Phylakopi, as well as could the opening of Mycenaean trade with regions further east, from Cyprus to the Levant and Egypt, which could have gone through Phylakopi as a service port.

Morgan (2007, 372, 396-97) judges that the frescoes were on the walls of the Pillar Crypt, itself a LM IA construction (Davis, Cherry 2007, 301), in LM IB, but the time of their painting should be down-dated to LM IA,

although she does not rule out the beginning of LM IB. Meanwhile she notes that the distinction between LM IA and LM IB is one of ceramic fashions and not necessarily a reliable guide to dates. There is no evidence of frescoes being painted after LM IB, which would be consistent with declining island incomes after that date due to the reduction in maritime shipping between Crete and the mainland along the Western String.

Insubstantial quantities of metal were found at Phylakopi, but Stos-Gale reported one piece of litharge and one piece of lead from LC I-II, all other metal objects dating to LH III (Stos-Gale 2007, 461-461, table 10.9 and fig. 10.21). Petruso (1992, 56) noted that the 1904 Phylakopi report talked about four lead discs (Bosanquet, Welch 1904, 192), which he examined and determined to be balance weights on the Minoan measurement system. As to the possibility that Melian obsidian is what gave Phylakopi's Third City its riches, Torrence (1978) presented substantive contrary arguments: that it was difficult to export blades, which is where value added would have entered, and that as a consequence, most of the Melian obsidian found abroad is in the form of macro-cores, which would be chipped at destinations. She also found no evidence of restricted access to those resources on Melos (Torrence 1986, 169-171). Apparently the value of the obsidian at the resource sites was low enough to make claiming ownership unprofitable, leaving transportation costs as the major component of the value of obsidian delivered to customers around the Aegean.

Barber (1984, 181 n. 26) presented a prior argument contrary to Torrence's, that exerting Melian control over the island's obsidian resource would have been difficult. He thought that look-outs easily could have spotted ships and sent people to meet or intercept them. He also thought that Melos "had the ability to exert pressure on her island neighbors" regarding the sale of obsidian, but by the time the Western String trade route was in full swing, bronze would have replaced obsidian in many uses, reducing, if not eliminating, any such monopoly power the Melians may have had at one time.

The salient architectural features of City III.i – the early LC I period on Melos – are the Mansion, the Pillar Room, and the fortification wall. The Mansion was built at the very beginning of the site's LC I sequence (Davis, Cherry 2007, 302), but it was so thoroughly cleared away in preparation for the construction of the LH III Megaron that very little evidence of activities in it survived. The one fragmentary Linear A tablet found at the site was found in 1974 in the area of the Mansion, which has prompted speculation whether the Mansion, which is accepted as an administrative center of its time, may have contained a Linear A archive. The Phylakopi tablet is a typical list of commodities, and closely follows the form of a tablet from Tylissos on Crete. Renfrew concludes, but only "as a balance of probabilities," that the tablet was written locally (Renfrew, Brice 2007, 456, 458-459). Two vases with Linear A figures scratched on after firing are unprovenanced (Karnava 2008, 383).

Using their seriation of some 30 thousand sherds from 9 trenches, Davis and Cherry determined that the tephra fall from the Thera volcanic eruption followed the construction of the Mansion and preceded the construction of the fortification wall at the western end of the peninsula, although they are unable to determine the number of years elapsed between the three events (Davis, Cherry 2007, 302, fig. 7.19). Cook estimated the labor requirement for the LH I fortification wall at Phylakopi at 24,000 person-days. The same construction methods were used at both Agia Irini and Phylakopi, but the Agia Irini walls did not have to encircle the entire town. If they had, Cook (2014, 127) estimates that the labor requirements would have been much the same as at Phylakopi.

The remains at Phylakopi are skimpier than those at Akrotiri and Agia Irini, but the temporal pattern they reveal does conform to the model. The volumes and proportions of Minoan to Mycenaean pottery reverse themselves between City III.i and City III.ii – from predominantly Minoan to nearly exclusively Mycenaean. A single LM II sherd is reported. Lead balance weights have been found, indicative of commercial weighing, but in nowhere near the number and wide distribution of the balance weights and balances at Akrotiri and balance weights at Agia Irini. Evidence of local metallurgical activity is quite limited, although one piece of litharge dated to LC I-II has been reported. The island's obsidian would not have been an important source of wealth, particularly at this date in the Bronze Age with competition from bronze for many implements. The first monumental architecture found at the site is the LM I Mansion, built before the Thera eruption. The frescoes may have been painted in LM IA, but

definitely none were painted after fairly early in LM IB. Apparently little construction or other signs of prosperity appear between LM I and LH III. The pattern of increasing prosperity until a little after the Thera explosion, replacement of Minoan ceramic influence with Mycenaean, and eventual decrease in prosperity and external commerce show the same pattern that emerged at Agia Irini, with differences in timing. The LH III construction of the Mycenaean-style megaron atop the remains of the previous Mansion and of the sanctuary certainly are indicators of continued prosperity into that later period, probably more so than continued at Agia Irini. In fact, the rapid Mycenaeanization of the town may very well have been the prime factor in propping up its economy through LH III. The Reshef-like bronze figurines found outside the sanctuary (Renfrew, Cherry 1985, 303-306; Maran 2011) suggest that shipping from the Near East and Cyprus may have substituted at least in part for reduced Cretan commerce.

SUMMING UP

So, how could these three small islands of the Western String have amassed such affluence as the finds excavated from them indicate? Their populations were too small for some elite to have skimmed extensive riches off their poorer neighbors. Skimmings from such a small number of relatively poor people would not have bought much. The islands were also too small to have affected the values of any of their locally produced goods or services. While the previous literature has not focused on what I see as the mystery of these islands' towns' affluence, it has linked that affluence to trade between Crete and the mainland. I concur, but I investigate somewhat more deeply into the mechanisms of that affluence.

Increasing demand for intermediate harbor facilities over time would have raised the rents accruing to those facilities and to the individuals with control or some other kind of rights over them. Simultaneously, the demands for shipping services and related activities (which I envision widely enough to include ceramic production and some metallurgy as well as producing non-surviving containers carrying water and victuals, etc.) would have pulled people's efforts out of agriculture, leaving those islands to import food. The export of the shipping services (a service export, not a merchandise export – in contemporary terms) would have paid for the food imports as well as more luxurious merchandise imports and service imports that could have spread Minoan and mainland cultural traditions, which clearly happened. The reliance on food imports may have had an unintended benefit of diversifying the islands' food supplies in environments subject to periodic droughts.

The last major section of the paper has offered at least a rough test of the model's predictions, focusing on the relationship between changes in the Cretan and mainland demands for island shipping services, and changes in island income and wealth. Observations from the period do not yield relatively small, short-term changes in Cretan and mainland demands for shipping services and corresponding reactions in behavior in the islands, such as deferral of construction of a monumental building. However, the Thera volcanic explosion does offer a large change, permanent for all practical purposes from the perspectives of the contemporary actors, and evidence does exist to examine adjustments on Kea and Melos to the Cretan reaction, in particular to the combined event of the loss of Thera and economic disruptions at home.

There appears to be strong evidence that the volcanic eruption that terminated Akrotiri as one of the ports of the Western String damaged various economic activities on Crete, ultimately, or possibly quickly, reducing its trade volume and its corresponding demand for Western String shipping services. If not for the silver exports in the capital account, the value of mainland shipments to Crete would have had to equal the value of Cretan shipments to the mainland by the requirement of balanced trade, and the demand for shipping services facing the two remaining Western String towns, Agia Irini and Phylakopi, would have decreased sharply. However, the existence of the capital account, on which the mainland would have run a deficit (exports of silver), and the emergence of new, Mycenaean commercial partners from further east could have compensated at least partially for reduced commerce with Crete, leading to the lags in response at Agia Irini and Phylakopi. Evidence from those towns suggests that they eventually became less affluent, particularly the smaller Agia Irini. Frescoes were not painted after sometime late in LM IA or

very early LM IB; rebuilding after earthquakes became less vigorous; the volume, as well as the proportion, of genuinely Cretan pottery fell at both towns. So the reduction in the combined Cretan and mainland shipping services was followed, at various time lags, with the predicted reduction in island income and wealth. And the mainland Mycenaeans eventually developed other trading relations, substituting for the reduction in Cretan shipments, but that becomes part of yet another, later story. While the results of this test of the model are not without their ambiguities, particularly those of dating and possible adjustment periods, they do seem to be in accord with the model's predictions of archaeologically observable reactions.

Could the finer architecture and frescoes have belonged to expatriate Cretans, merchants or otherwise, rather than to natives of the islands? Of course, but that would not be inconsistent with the economic forces the model contains, while it leaves open many questions of local sovereignty versus some sort of Cretan authority and the lack of evidence for most of the mechanisms for acquiring and enforcing it (Warren 1981).

The lag structure of responses at Phylakopi is longer than that at Agia Irini, probably because of events outside the purview of the model. If, taking into account the likely events outside its scope, the model is considered as having predicted successfully both proposed cases, we have a sample of two, which could under no circumstances be considered statistically significant. If we think that the model's prediction is successful for Agia Irini but not for Phylakopi, that is a fifty percent success rate, which also is not statistically significant, but which as a baseball player's batting average would be sufficient to put that player in the Hall of Fame. Clearly percentages of success are not particularly useful in judging the success of the model/hypothesis developed and tested here. More nuanced evaluation is required.

We can think of such additional nuance and how to incorporate it into an analysis by imagining that we had numerical data sufficient to subject the model I have proposed here to the statistical technique called multiple regression analysis.[43] Without thinking to the future and the emergence of Near Eastern connections at Phylakopi represented by the Reshef figurines from a late context, a regression analysis would indicate that the predictions for Phylakopi were excessively pessimistic. Without accounting for the new market, the regression model would reveal evidence of an omitted variable bias. That bias would be the emerging commercial opportunities with the Near East to compensate for the reduction in Cretan demands.

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43 Multiple regression analysis is seldom, if ever to my knowledge, used in archaeology, but it is a workhorse statistical method in social, natural, and physical sciences as well as in numerous engineering disciplines in research situations in which the investigator wants to know the effect of some exogenous variable on an endogenous variable of interest, but the investigator knows that several other factors may influence the relationship. Multiple regression analysis is able to hold constant those 'other factors' to obtain a clearer effect of how the variable(s) of influence perform in testing a hypothesis. The 'missing variable' in the case of Phylakopi would be its ability to have developed new markets in the Levant.

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RESPONSES

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ASSESSING INSULAR ECONOMIC STRATEGIES: SOME RESPONSES TO D.W. JONES' MODEL OF MIDDLE AND LATE BRONZE AGE CYCLADIC PROSPERITY

Jones proposes a model for understanding Cycladic prosperity during the Middle and Late Bronze Age (MBA, LBA) that is not concerned with how 'Minoan' or not island communities were, with thought-provoking discussion of insular networks and economy. As he notes, a model cannot be expected to account for every archaeological detail, and simplification is required to highlight the primary components of interest. A model also needs to be built on a strong foundation, however, and problems with some of the assumptions underlying this one provide cause for caution in its application. I will focus on issues of carrying capacity and food imports, craft specialization, Cycladic participation in exchange and maritime activities, and the model's testability.

Evaluating carrying capacity, food production, and imports

Jones raises questions around demography and the carrying capacity of small islands, and he demonstrates the need to integrate analyses of local subsistence production, agricultural activity, and storage more thoroughly into narratives of material culture change in the MBA-LBA Cyclades. Such studies are rare[1] outside of Akrotiri, despite

1 Important exceptions exist, *e.g.*, Nikolakopoulou 2002; Marthari 2019; Sarpaki 2019; Gorogianni 2020.

the fact that archaeological surveys on Melos and Kea decades ago encouraged examination of connections between (proto)urban sites and their hinterlands (Renfrew, Wagstaff 1982; Cherry *et al*. 1991). Although Jones' discussion seems to be most focused on labor available within the male population, women and children often participate in agricultural production and specialized craft-making in economically critical ways (Tinker 1987; Kelly, Ardren 2016), including in situations where men are occupied with activities like trade, sailing, or war that require long absences from home (*e.g.,* Horden, Purcell 2000, 175, 228). In his discussion of the construction of fortification walls, Jones notes that adult women would have worked in other areas, but the extent to which women and children are incorporated into his estimates of available labor in agriculture or craft production is not clear.

The relative environmental marginality of the islands and small size of their communities when compared with neighboring mainlands are not sufficient evidence on their own that large-scale importation of foodstuffs was required in Late Cycladic (LC) I. Nor is it clear that such imports would be more likely to come from mainland Greece and Crete than from nearby insular and coastal communities.[2] Our understanding of environment, diet, and nutrition in the MBA-LBA Cyclades is limited by incomplete preservation and, apart from Akrotiri, rare paleobotanical, zooarchaeological, or isotope analyses (among others) that could clarify how many calories were available and consumed in the form of different kinds of animal products, seafood, and plants in Cycladic communities. Such analyses provide an empirical basis for evaluating whether local environments were capable of supporting subsistence needs. Evidence from Akrotiri suggests a mixed diet, including animal protein and seafood on top of different kinds of plants (pulses, fruits, and cereals) (Trantalidou 2000; Berg 2007, 39-50; Birtacha 2008; Sarpaki 2019; Mylona 2020). Thus, for Akrotiri at least, estimates of carrying capacity cannot be based solely on the amount of land cultivable for cereals.[3] In addition, it should be noted that systems of land tenure and access in the MBA-LBA Cyclades are unknown, although Jones' trade balance formula seems to be based on suppositions about how land tenure and agricultural labor ought to operate in a capitalist system, with assumptions of private ownership and individualized profit motives. It is not clear that the same formula would be appropriate to an alternative system of property rights or land use.[4]

Our best evidence for the importation of foodstuffs to Cycladic communities is ceramic, in the form of non-local closed vessels appropriate for transport and storage of agricultural goods. The model suggests that we should expect increased food imports through time, since more imports would be required as labor moved from agricultural production to working in port services, viewed as the main avenue for increasing wealth. At Agia Irini and Akrotiri, however, the proportion of imports in ceramic assemblages decreased or remained constant from the earlier MBA to LC I.[5] Nor does the ceramic evidence reflect large-scale importation of foodstuffs in the LBA. In

2 Neighboring communities of course may include non-Cycladic ones. This form of local interaction, however, does not seem to fit the model's simplification in a straightforward way, since coastal eastern Attica, for example, cannot be understood to carry within it the full productive and demographic capacity of all of southern mainland Greece, much of which was not directly connected to eastern Attica through either geography or exchange. We might also ask whether Euboea, an island, is considered part of "mainland Greece" in this model, since Kea and Euboea seem to have had an important exchange relationship throughout the MBA-LBA (Tankosić, Mathioudaki 2011, 124-128; Abell 2022).

3 Small Cycladic communities were able to sustain themselves through diversified agricultural production in combination with exchange in many other eras (*e.g.* Reger 1994; Broodbank 2000; Dodd 2020; see also Horden, Purcell 2000, 224-230). For arguments against straightforward connections between estimates of demography and arable land in the Cyclades in later periods, Brun 1996, 110-113; Étienne 2013, 25-26.

4 Non-capitalist approaches to property rights and land tenure are well known; extensive scholarly attention has been focused on common property systems in particular (*e.g.* Ostrom, Hess 2007; Tanner 2007; Lomazzi, Menard 2018).

5 Around 25% of the total assemblage at Agia Irini and 12-23% at Akrotiri was imported in the earlier MBA (Overbeck 1982; Hilditch 2019, 400, table 3.14; Nikolakopoulou 2019, 190). The estimate for Agia Irini takes discarded pottery into consideration (Abell 2022). The higher estimate of 23% at Akrotiri may not be relevant for the entire site (Mathioudaki 2019, 317). I am not aware of a quantification of earlier MBA imports at Phylakopi. At Agia Irini, importation of agricultural products is better attested in the earlier MBA, when many imported vessels in Cretan or Minoanizing wares were closed, and locally produced barrel jars could have been used to transport bulk products to and from Kea (Overbeck 1989; Crego 2007). Barrel jars have design features like string holes and ledge-rims to secure lids, which are clearly intended to enable transport. Although large jars exist in later periods, these transport-specific design features have no obvious successor in the local LBA assemblage.

LC I, imported ceramics made up 15% or less of the assemblages at Agia Irini, Akrotiri, and Phylakopi (Cherry, Davis 1982, 337, fig. 2; Berg 2007, 112; Marthari 2019, 139-140; Gorogianni, Abell forthcoming, table 2). Although storage and transport vessels are attested, imports also included many tablewares (Marthari 1990, 61-65; Berg 2007, 111-15; Hood 2007; Dickinson 2007; Kriga 2018, 629; Abell 2022). At Akrotiri and Agia Irini, storage/transport vessels were also imported from places other than mainland Greece and Crete, including Naxos and other Cycladic islands, the eastern Aegean, Aegina, and probably Euboea (Davis *et al.* 1983; Knappett *et al.* 2011; Mathioudaki 2019; Nikolakopoulou 2020; Abell 2022).

Although it is possible for bulk goods to be conveyed in archaeologically undetectable ways, the proliferation of amphoras and stirrup jars in this and later periods show that ceramics were a common transport container for agricultural products. The modest ceramic evidence for imported foodstuffs at Agia Irini, Phylakopi, and Akrotiri, therefore, probably is not merely a lacuna caused by archaeological invisibility. The ceramic evidence suggests that imported agricultural goods did not make up a large proportion of locally consumed and stored foodstuffs at these sites. At the same time, the importation of Cycladic closed vessels and presumably associated foodstuffs shows that island communities were producing enough surplus to allow export.

Inscriptional evidence also suggests that local agricultural production operated beyond basic household subsistence. A few Keian, Theran, and Naxian vessels were inscribed with Linear A logograms for wine, which demonstrates that this commodity sometimes required monitoring and, as such, probably was intended for exchange (Karnava 2008; Christakis 2010). Other inscribed marks on pottery have connections to Linear A, such as the transaction sign AB 04 at Agia Irini (Bikaki 1984, 22-40; Nikolakopoulou 2019, 220-222). Like wine logograms, these signs were large and inscribed in intentionally visible positions. Since the signs are isolated, their meaning is unclear. Yet their size and placement, which parallels the wine logograms, could suggest that they were intended to allow monitoring of the products inside the inscribed vessels. Monitoring would be required either because the contents of the vessel were inherently valuable or because the distribution path needed to be clear, for example, as a political tribute or taxation, as a commodity destined for market exchange, or as part of a contribution to an event like a feast. Tablets inscribed with logograms for sheep, textiles, and oil from Complex Delta at Akrotiri also demonstrate local monitoring and accounting of agricultural products beyond what would be expected for basic subsistence production (Boulotis 2008; Karnava 2008).

Specialized craft production

Jones argues that craft production in the Cyclades was not specialized, or at least not specialized enough to be relevant for explaining the relative prosperity of Western String communities.[6] 'Specialization' in its most basic sense means production aimed at exchange beyond the household, but it can be difficult to distinguish between different forms and degrees of specialization. Archaeological data are often inadequate for addressing key issues like the precise scale (*i.e.*, how much was made) or intensity (*i.e.*, how much time did people spend crafting) of production. Nevertheless, economically significant specialized industries probably existed in Cycladic communities, based on ceramic exports, as well as variable distribution and quantities of craft tools within and between sites.

Exports provide clear evidence for specialization beyond household needs. Vessels from Melos and/or Thera[7] were proportionally nearly as common as Cretan ceramics in the later MC and LC I at Agia Irini (Abell 2016; 2022). Melian/Theran imports appear also on Naxos, at Mitrou, in Attica, the Argolid, and the eastern Aegean (Barber, Hadjianastasiou 1989; Graziadio 1998; Şahoğlu 2007, 316-318; 2015, 606; Hale 2016, 291; Raymond *et al.* 2016, 61, table 4.4; Barber 2017; Gorogianni *et al.* 2020). Naxian and other Cycladic imports appear at Akrotiri, Phylakopi, and Agia Irini, while miscellaneous Cycladic imports are reported from Çesme-Bağlararası (Berg 2007, 111-115; Davis, Cherry 2007, 267; Şahoğlu 2007, 316-318; Kriga 2018; Hilditch 2019; Mathioudaki

6 The Western String concept was developed first by Davis (1979) not Schofield (1982), as Jones suggests.

7 Geological similarities between the two islands make it difficult to distinguish between products from Melos and Thera (Hilditch 2019, 435-438).

2019; Nikolakopoulou 2020; Abell 2022). The most abundant class of ceramic imports at Kolonna on Aegina is compatible with a Keian provenance, while Keian imports are also reported from Attica, Mitrou, southern Euboea, and possibly Lefkandi, in addition to Phylakopi and Akrotiri (Gauss, Kiriatzi 2011; Tankosić, Mathioudaki 2011, 124-128; Hale 2016, 291; Dickinson 2020, 170; Gorogianni *et al.* 2020). Trade in Cycladic pottery at intra- and inter-regional scales demonstrates that ceramic production was specialized, a conclusion also suggested by high levels of standardization in certain aspects of local pottery at LC I Agia Irini and Akrotiri (Davis, Lewis 1985; Katsa-Tomara 1990). As Jones notes, Aeginetan pottery exports show the existence of a specialized ceramic industry that was important to the local economy there. By the same logic, pottery exports would have been economically significant for Cycladic communities, too.

Certain craft tools at Akrotiri and Agia Irini were found in some houses, but not others.[8] Some craft goods, therefore, must have been exchanged beyond households, especially within local networks, at both sites.[9] For example, at Akrotiri, evidence for metalworking is spatially limited, although a mould and possible fragments of ore in the West House suggest that residents of that building produced some metal objects (Michailidou 2007). Although this production may have been relatively small-scale, objects made by people in the West House probably circulated within the local community, since relevant knowledge, raw materials, and tools were not broadly shared, yet finished metal objects have been found throughout the site (Michailidou 2008a).[10]

Comparative data can be examined in order to evaluate whether evidence for craftmaking at one site or in one household represents a typical signature for production elsewhere, thus providing some basis for assessments of differences in the scale of production between communities. At Akrotiri, a large number of loomweights have been discovered, especially in the West House (over 450) and Complex Alpha (around 200) (Tzachili 1990, 381; Cutler 2016, 175-176). Preservation at Akrotiri is exceptional, of course, but well-preserved destruction deposits elsewhere have not produced loomweights in similar quantities. For example, LC II destruction deposits at Agia Irini are artifact-rich, yet only around 100 loomweights were found in LC II contexts in House A, and fewer are reported from the Western Sector (Cummer, Schofield 1984; Schofield 2011). On Crete, specialized, large-scale production has been hypothesized, for example, at Middle Minoan (MM) II Quartier Mu at Malia, but only 527 total loomweights have been recovered there, and no building contained more than 170 weights (Cutler *et al*. 2013, 98-99, 102-115, 117-118). Textile manufacture at Akrotiri, especially in the West House, seems to have operated at an unusually elevated scale of production by Aegean standards (Cutler 2016, 176).

Linear A tablets from Complex Delta record textiles in large numbers, among the highest anywhere in the Aegean (Boulotis 2008, 80). Residents of Complex Delta may have registered textiles that were not produced in their own household, since no loomweights were found in the part of the complex where the tablets were located. Boulotis (2008, 85-86) suggested that residents of this part of Complex Delta might have supplied wool that was woven elsewhere, either in one of the other parts of Complex Delta, which may represent separate households, or in the West House or Complex Alpha, where loomweights are prevalent. Taken together, archaeological and documentary evidence for the production, exchange, and monitoring of textiles suggests that weaving was a complex industry at Akrotiri, which had significant economic potential, at least based on the high values often afforded to textiles in east Mediterranean societies (Tzachili 1990; Boulotis 2008; Michailidou 2008b, 212-213).

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8 The spatial distribution of craft tools at Phylakopi is difficult to assess on the basis of current publications, so it is omitted from this discussion. It may be noted, however, that apart from obsidian, Melos has deposits of several minerals that were extensively exploited in antiquity, especially in the Roman period (Le Quéré 2015). One of them, alum, also may have been exploited in the Mycenaean palatial era, when two smiths are recorded in Linear B tablets providing alum (of unknown but possibly Melian origin) to the Mycenaean palace at Pylos (Palmer 1989, 96-97; Nakassis 2013, 170).

9 I assume that craft tools found in primary deposits inside houses were probably used by people resident in or regularly working in those houses, even if the precise production space is unclear.

10 Finished metal object probably were also imported from communities elsewhere.

At Agia Irini, metallurgy and/or metalworking was probably targeted toward regional exchange.[11] Preliminary analysis suggests that fragments from dozens of crucibles were recovered from LC II deposits across the site, while many crucible fragments have been found in deposits of other periods, as well.[12] Metallurgy and/or metalworking in these periods is also attested by artifacts like moulds, slag, litharge, and tuyeres (Wilson 1999; Davis 1986; Overbeck 1989; Abell, Georgakopoulou forthcoming). In House A alone, ten or more crucibles were found in LC II destruction deposits; slag, litharge, a multiple mould, and at least two ingot fragments were also recovered in that building (Cummer, Schofield 1984).

The Keian assemblage is not typical of the broader Cyclades, which is clear from comparison with Akrotiri. It is also unusual when compared to Crete, where most sites do not have extensive evidence for metallurgy (Evely 2000, 335-341).[13] Several metal workshops have been identified on Crete, such as the Late Minoan (LM) IB Artisans' Quarters at Mochlos and the LM II Unexplored Mansion at Knossos. Moveable finds connected with metalworking in the Artisans' Quarters include 8 moulds, 19 ingot fragments, waste fragments, copper strips, and one possible crucible (Soles *et al.* 2004). In the Unexplored Mansion, metal scrap, waste products, and up to 17 crucibles were found (Catling, Catling 1984, 219). Deposits of large numbers of crucibles on Crete are not very common, although eleven were found in MM III-LM I deposits in Building T at Kommos, eleven were found in LM III deposits from different areas at Kommos, 12 or more were found in an LM IA context at Palaikastro, and many fragments from an unknown total number of crucibles are reported from MM-LM Poros-Katsambas (Blitzer 1995, 501-506; Dimopoulou 1997, 2012; Evely *et al*. 2012, 1822). The evidence from House A, not to mention the rest of Agia Irini, is comparable in terms of the range and quantity of equipment and debris with Cretan assemblages that have been interpreted as evidence for specialized industries. The abundance of crucibles at Agia Irini suggests a focus on smelting or melting, a role that makes sense given the strategic location of Agia Irini just opposite the polymetallic deposits of Lavrion. No settlement with similarly plentiful evidence for metallurgical activity has yet been found in the area of Lavrion, which may suggest that Keians acquired ores directly rather than through exchange with intermediaries.[14]

Metallurgy/metalworking at Agia Irini and weaving at Akrotiri seem to have been organized at a household level and may not have been a full-time, year-round activities. These characteristics, however, do not demonstrate that production was either unspecialized or economically insignificant.[15] The existence of different kinds of part-time and household-based specialized production is widely acknowledged (*e.g.* Costin 1991). Such activities can be a critical means of economic diversification for households and broader communities (Hirth 2009; see also Kovacevich 2016).

As Jones notes, some evidence for market-based exchange mechanisms, like the use of standardized weights and balances, exists in the MBA-LBA Cyclades. Michailidou (2008b) has argued that standardized weights were used in connection with specialized craft-making, given their association with buildings where such production is

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11 More fireboxes, probably used in making perfume or unguents, exist at Agia Irini than at any other Aegean site, which suggests that this was another major local industry (Georgiou 1986; for debate about function, Abell 2020, 390-393). Jones suggests that the presence of pitch or tar in the capsule prohibits the interpretation of these objects as tools for processing aromatics. Georgiou, however, argued that the capsule was used to hold fuel for heating the device, not the aromatic plants themselves; thus, the microscopic analysis supports her hypothesis.

12 The assemblage is under study by me and Myrto Georgakopoulou, who generously allowed me to mention these preliminary results.

13 Chrysokamino is not considered here, because it dates to MM IA and earlier (Betancourt 2006) and so is not directly relevant to Cretan metal extraction strategies of LC I. The Cretan assemblage that most closely resembles the Keian one in terms of the range of material and abundance of crucibles may be MM-LM Poros-Katsambas, but that site is not yet fully published (Dimopoulou 1997, 2012).

14 In such a situation, initial beneficiation and smelting still could have happened on the Attic mainland rather than on Kea itself. Although Thorikos had connections with Kea in the earlier MBA, evidence from that phase is limited, and evidence for on-site metallurgy, which is much more limited than at Agia Irini, dates to MBA III-LBA I (Papadimitriou 2020). Examples of insular exploitation or control over neighboring mainland resources are known from other periods and places, like the *peraia* of Hellenistic Rhodes.

15 Although Jones says that Georgiou and Schofield saw craft production at Agia Irini as unspecialized, they argued instead that these household-based industries were specialized and economically important; they also drew comparisons with non-palatial, specialized production based in households on Crete and elsewhere in the Cyclades (Georgiou 1986, 53; Schofield 1990, 209-210).

attested at Akrotiri and Agia Irini; similar connections have been drawn at Mochlos (Brogan 2006). Standardized weights in the Aegean are most numerous at Akrotiri, Agia Irini, and Mochlos, all of which also have substantial evidence for imports (Carter 2004; Soles, Stos-Gale 2004; Brogan 2006; Michailidou 2008b).[16] Residents of these sites seem to have participated in maritime exchange actively in various ways, including as specialized producers and perhaps also as specialized traders,[17] rather than by waiting for ships from other areas to appear and focusing primarily on the provision of basic harbor services.

Cycladic agency and maritime capabilities

In order to support the hypothesis that providing port services represented the main wealth-generating strategy for residents of Phylakopi, Agia Irini, and Akrotiri, Jones argues that Cycladic islanders probably did not have their own trading vessels. This argument assumes that (1) Cycladic islanders would not have been able to make boats in significant quantities or of large size because of limited timber resources on the islands and (2) small boats are incapable of participating in exchange in economically significant ways. Neither of these ideas, however, is as straightforward as Jones suggests. The degree of forest cover on most Cycladic islands in the Bronze Age is unclear. Nevertheless, some, like Kea, can and do support small forests today, and analyses from Akrotiri show that wooded areas were present on Thera during the Bronze Age (Asouti 2003). Trading and raiding with longboats was a major feature of Cycladic society and economy in the Early Bronze Age (EBA); the existence of active intra-Cycladic exchange networks and maritime iconography suggest that islanders were highly invested in the production and use of boats in that era (Broodbank 2000). In later periods, textual evidence confirms that Cycladic islanders were capable of maintaining small fleets, as for example when several islands sent triremes to the battle of Salamis (Hdt. 8. 46-48).

If timber resources on the islands were not adequate for boat-building needs, wood could have been sought from neighboring islands or mainlands with more forest cover. Timber can be transported to communities where it is needed for shipbuilding, or ships may be constructed on the spot[18] near timber sources.[19] Shipbuilding, like other major construction efforts, could presumably also involve pooling labor from multiple communities. The potential exploitation of mainland resources by islanders was suggested above for Agia Irini, in reference to Lavrion ores. Evidence from Akrotiri also demonstrates the importation of timber and/or finished wood products, including cedar, a valued construction material in the eastern Mediterranean (Asouti 2003, 479-481). Palyvou (2005, 112)

16 Jones is incorrect that Egyptian, Levantine, and Cypriot imports are absent from the Cyclades in this period. Objects from the eastern Mediterranean appear at Agia Irini, Phylakopi, and Akrotiri (Cline 1994, 259, 263, 268; Dawson, Nikolakopoulou 2020, 161-167), including coppers compatible with Cypriot sources, which exist at Agia Irini and Akrotiri (Gale, Stos-Gale 2008, 406-408). Copper compatible with Cypriot sources is also attested at MM Quartier Mu, which shows that access to Cypriot copper was not a new feature of LC I-II, contrary to Jones' argument (Poursat, Loubet 2005).

17 Doumas, for example, has long advocated a view that sees some Cycladic islanders, especially at Akrotiri, as traders or merchants (*e.g.,* Doumas 1982, 2014; see also Boulotis 2008; Michailidou 2008b).

18 Ship construction near timber sources is attested in later eras as, for example, when Athenian boats were built in Macedonia (Blackman 1987, 45-48).

19 The ephemeral nature of shipyards makes them difficult to locate archaeologically, and few are known in the Mediterranean (Blackman 1995, 233). I am grateful to Justin Leidwanger for discussion on this point. Shipsheds for storage and maintenance exist on Bronze Age Crete (Shaw, Blackman 2020) and may be represented in the miniature paintings of both Akrotiri and Agia Irini (Blackman 2011, 8; Morgan 2020, 135-137). The locations where boats were first constructed, however, are unknown. Tantalizing but ultimately inconclusive evidence could suggest that residents of Agia Irini were involved in shipbuilding and maintenance, through the export or use of *miltos*, an iron oxide that occurs naturally on the island. In later eras, iron oxide served as a colorant and perhaps preservation agent (real or perceived) when painted on hulls (Blackman 2011). Keian *miltos* in particular was renowned in antiquity, although preserved documents do not explicate how it was used (Photos-Jones *et al.* 1997; Lytle 2013b; Carrara 2014). The discovery of hematite in association with the shipsheds at LBA III Kommos suggests that the use of iron oxides for ship maintenance may have begun already in the Bronze Age (Shaw, Blackman 2020). At Agia Irini, a thick deposit of red soil was excavated in room N.6 of the Northern Sector, which the excavator noted did not look like the usual red soil associated with disintegrated mudbrick or a hearth; he posited that the deposit might have been composed of some kind of decayed stone (Gorogianni 2008, 202-205). Unfortunately, it is impossible to determine whether this material actually was *miltos*, and the significance of the deposit remains unclear.

has suggested that the common use of timber in architecture at Akrotiri might have been encouraged by a local tradition of shipbuilding, which could have involved sharing knowledge of carpentry and access to wood sources.

The use of unsailed boats did not inhibit the frequent and in some cases relatively long-distance movement of goods in the EBA Aegean. About 25-30% of the ceramic assemblage at EBA Agia Irini was imported, proportionally more than was imported in LC I (Wilson 1999, 90, table 3.1). At Dhaskalio, much or all of the ceramic assemblage was imported, especially but not exclusively from within the Keros triangle (Hilditch 2013; Sotirakopoulou 2016). At both sites, imports included large pottery shapes like hearths, barrel jars, and pithoi, some of which came from relatively distant islands, like Siphnos, the probable source of Talc ware. In addition, all of the building stone at Dhaskalio seems to have been imported from Naxos (Dixon 2013). This kind of evidence demonstrates that non-sailing craft in the EBA Cyclades were capable of moving substantial quantities of material, including large, heavy objects, within local and in some cases longer-distance maritime networks. The invention of sailing boats would not have negated the possibility for smaller and/or unsailed craft to move within such networks in later eras. In general, movement within local maritime networks may be more frequent than longer-distance voyaging, because it can be accomplished with simpler technologies and smaller boats (Tartaron 2013, 185-188).

The EBA evidence suggests that we should not underestimate the potential for regular movement and economically significant activity along Cycladic 'blue highways' in the MBA and LBA. Artifact distribution patterns of the earlier MBA, before the era of Minoanization, suggest that islanders were capable of moving within Cycladic networks without relying on ships from mainland Greece or Crete (Overbeck, Crego 2008; Sotirakopoulou 2010; Nikolakopoulou 2019). It seems very probable that such capabilities, which could have relied on both sailed and unsailed vessels, continued to exist in the LBA.[20] After all, island communities have good reasons to maintain the ability to participate in maritime movement on their own terms, through building or acquiring boats and developing knowledge of seafaring. Maritime connections are vital for ensuring survival in times of agricultural shortfall, while some individuals in small communities like Agia Irini or Phylakopi probably would have needed to seek out marriage partners from other places.

The movement of specialized trading ships may not have been the only means of exchange in the Cyclades, but these other kinds of activities seem to exist outside the mechanisms of Jones' model.[21] Raiding, for example, has operated closely with trading in many eras of prosperity in the Aegean and wider Mediterranean (Braudel 1972, 865-891; Reger 1994, 29-31, 262-263; Gabrielsen 2001; de Souza 2014). The existence of fortification walls at Agia Irini, Phylakopi, possibly also on Tenos and Naxos, as well as on Aegina and at several Attic and eastern Aegean sites suggests that conflict or raiding was one way through which people and things moved in southern Aegean networks (Davis 1986, 104-105; Privitera 2013; Kouka 2015, 228-230; Şahoğlu 2015, 600).[22]

Events like festivals, ritual activities, or feasts no doubt took place in each community, and some may have been attended by visitors from other locations. Events at which people from different communities regularly gathered would have provided good opportunities for periodic markets (for examples elsewhere, Hirth 2020, 284-289). Although it is difficult to demonstrate conclusively that periodic markets themselves took place, some evidence does suggest the existence of communal events that could have been attended by non-local people. The number of drinking vessels at Agia Irini, for example, appears to be well beyond what would be necessary to provision a single household or even the entire local community, with hundreds of cups sometimes found within a single building

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20 Ship-building knowledge, as Jones notes, is highly specialized. Yet other specialized knowledge in the form of craft and writing technologies was adopted in the islands, through interaction and probably limited mobility between Cycladic and Cretan communities (Karnava 2008; Abell 2014; Nikolakopoulou, Knappett 2016; Cutler 2019). Knowledge to build sailing ships, like the one depicted in the miniature painting at Akrotiri, could have been transferable through similar routes.

21 Although Jones credits Berg (2006) with the idea, she expressed skepticism about cabotage being the major mechanism of seaborne trade in the archipelago.

22 Additional evidence is provided by moveable finds like daggers, worked boar's tusks, and sword pommels, like those found at Agia Irini, as well as iconographic representations of men with arms or armor and emblematic depictions of martial equipment like shields, such as those that appear at Akrotiri (Cummer, Schofield 1984; Morgan 1988; Schofield 2011; Marthari 2018).

(Cummer, Schofield 1984; Schofield 2011; Wiener 2013, 154). Such a pattern might result from households stockpiling commensal equipment, especially conical cups, for use at communal events.[23] Hilltop shrines like Troullos on Kea, ritual (?) caves like Katafy on Paros and possibly Zas on Naxos, or urban buildings like Xeste 3 at Akrotiri or the Temple at Agia Irini, also could have acted as foci for communal ritual activity. The existence of imported objects at extra-urban ritual sites shows, at least, that the people who deposited them had access to regional networks (Caskey 1971, 394-395; Barber 2017; Mavridis 2018, 4). Finally, the miniature paintings at Akrotiri and Agia Irini depict people in boats arriving to shore in the probable contexts of a festival and feast, respectively (Morgan 1988; 2020; Televantou 1994). These depictions suggest that some events attracted participants from beyond a given community.

Testing the model

The mainlands of Greece and Anatolia,[24] as well as Crete, presumably always have had more people in them than the Cycladic islands. Thus, we might expect this model to apply in other cases where Cycladic communities appear prosperous from a regional perspective. Cursory consideration of other eras in the Cyclades, however, suggests that the reality is more complicated. For example, Delos is an island of similarly limited demographic or agricultural capacity and few naturally occurring resources, apart from its religious significance during antiquity. Yet the island emerged as a key node for the transshipment of goods in the Hellenistic Aegean. Although its wealth relied in many ways on new kinds of activities centered in and around the port,[25] Delos was also a major center of exchange, including markets and specialized craft production; it was not merely a stopover for boats moving between mainlands (Reger 1994, 249-271; Chankowski *et al*. 1998, 547; Lytle 2013a; Bresson 2016, 328-331). As Horden and Purcell (2000, 224-230) noted, the potential for connectivity is a key resource that small island communities can exploit, even when confronted with larger, more politically and economically powerful mainland polities; this principle seems to apply equally, if broadly, to both Hellenistic Delos and Bronze Age Kea, Melos, and Thera.

Although the model was developed to explain the prosperity of Agia Irini, Akrotiri, and Phylakopi in LC I, our understanding of the distribution of 'affluence' in the Cyclades is probably quite incomplete, since no other LC I settlements have been thoroughly excavated and published. Hints of possible prosperity and certainly participation in exchange networks exist. Naxian ceramic exports are well-attested, for example, while tombs on Paros and Ios include imported pottery and bronze objects, and fortification walls on Tenos and Naxos also may date to this era (Davis 1986, 104; Marthari 2009; Papadopoulou 2018). In general, LC I witnessed increased interaction, small-scale mobility, and demographic and economic growth in much of the southern Aegean, including the Cyclades as well as Crete, the Dodecanese, western Anatolia, and mainland Greece.

As Jones notes, the destruction of Thera must have had significant social, economic, and psychological impacts on other Cycladic islanders. Yet the connection between the removal of Thera as a node in Aegean networks and the declining fortunes of Agia Irini and Phylakopi is not very clear. LC II strata at Phylakopi are poorly preserved and so may or may not support a narrative of decline; LC III saw significant construction, including the Megaron (Earle 2016 with additional references). Major developments at Agia Irini date to the period after the Theran eruption. These include the expansion of House A; wall paintings in Houses A, B, and J; and continued participation in exchange (including with Crete) (Cummer, Schofield 1984; Morgan 2020, 38-41; Gorogianni, Abell forthcoming). This period probably lasted somewhere between 50-200 years at Agia Irini, depending on which absolute chronology is used. It is difficult, therefore, to connect the failure to rebuild after the late LC II

23 The existence of such events, attended by people from different regions, may also be a factor underlying the long-lived regional diversity of tablewares at Agia Irini, which appears to be rather atypical in comparison with assemblages elsewhere in the Cyclades as well as neighboring sites in Attica and southern Euboea (Abell 2022).

24 The fact that Anatolia is omitted from the model altogether is problematic, since Anatolia would have been no less a '500-pound gorilla' in southern Aegean networks than mainland Greece or Crete, according to Jones' method.

25 Port fees were also probably collected (Bresson 2016, 307).

earthquake directly with the disappearance of Akrotiri or turbulence on Crete. At the very least, the trajectories of Agia Irini and Phylakopi do not obviously parallel one another in either LC II or LC III, which makes imposing a uniform causal framework to explain the developments of these centuries difficult to sustain.

Jones' model is admirable in its attempt to address issues of Cycladic economy and prosperity without relying on established fault-lines in Minoanization debates. He provides useful food-for-thought, especially with respect to the subsistence requirements of Cycladic communities and the economic potential of providing harbor services at Agia Irini, Akrotiri, and Phylakopi. Unfortunately, a lack of empirical support for many of the assumptions built into his model undermines its explanatory power.

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THE WESTERN STRING IN THE LATE MBA AND LC I-II: A REACTION TO DONALD JONES'S ARTICLE FROM A WIDER PERSPECTIVE

Ever since the seminal articles of Jack L. Davis (1979) and Elizabeth Schofield (1982) on the connection between Crete and the Cycladic islands, there seems to have been a general consensus that there was a targeted link between these two regions, beginning in the mature stage of the MBA and lasting until LM IB/II when new protagonists, from the Greek mainland, slowly took over from the Cretans. During this roughly 350-year-long era (*ca.* 1800-1450 BC), this relationship has produced a unique body of archaeological evidence that has been investigated through the eyes of a widely accepted model, the so-called Western String Network. It presumes a special route along Akrotiri on Thera, Phylakopi on Melos and Agia Irini on Kea for Cretan traders travelling northwards towards the Lavrion metal mines. The paper by Donald Jones does not replace this model; instead, it aims to test the role of shipping and port services as a trigger for the income and wealth of the three small islands of the Western String.

Jones presents us here with an intriguing hypothesis: since Phylakopi, Akrotiri, and Agia Irini could not have produced much to sell with their small labour pools and populations, shipping and related supporting and lucrative services are considered as a potential explanation. In order to test this hypothesis Jones proceeds with a

very dense analysis and piles up a lot of evidence with a large bibliography, although it is not always clear how it ties into the main argument. The perspective adopted by Jones does not appear to be new, as aspects of trade between Crete, the Cyclades and the Greek mainland have been greatly discussed in the past. However, what is indeed new is the discussion on the ancient population estimation in order to address the ability of port service facilities to account for the three islands' income and wealth. Jones's analysis focuses principally on LM IA, which is correctly considered the acme of several processes started in the early Neopalatial period (*i.e.* MM IIIA) and a prosperous era until the volcanic eruption of Thera in the mature LM IA period. Accordingly, the paper is quite confident of the known picture that after the Thera event, in the late LM IA and LM IB port-town wealth tapers off because of the disappearance of Akrotiri from the Western String Network.

In doing this, Jones's paper offers a nested analysis by opening numerous main and side issues, which is not possible to review in detail. Instead, we would like to broach a few matters that arise from the adopted perspective.

The role of Minoanisation and the understanding of intercultural contact

The article intentionally keeps out the issue of Minoanisation as an explanation model for the gradual appropriation of Minoan cultural traits in the Cyclades (especially the production and circulation of the Minoan pottery style, the use of sophisticated wall paintings and monumental buildings), which actually represent the material core of the analysis, although these traits remain constantly somehow on the side. Recent approaches to the study of Minoanisation (Broodbank 2004; Gorogianni, Pavúk, Girella 2016) have addressed the importance of agency notions in order to understand social practices associated with cultural encounters. Admittedly, agency is present in the paper but – as specified by Jones – "it is directed to economic choices rather than to cultural ones although there may be overlap between these two scholarly categories". This phrase conceals a crucial aspect for the interpretation of 'contact' which is nothing more than two different entities encountering each other in a contact space. We therefore believe that, along with economic choices, as stressed by Jones (he treats Minoan frescoes, architecture and other Minoan cultural aspects as "the products of labour (service) imports satisfying the external trade balance"), the great transformation that involves the Cyclades as well as other regions of the Aegean, indicating a development towards complex societies at the end of the MBA and beginning of the LBA driven by unequivocal Minoan cultural traits, is the consequence of a dynamic social phenomenon. As a 'contact space', these three islands are a negotiable space where people met and decided. As argued by various scholars, spaces of intercultural contacts produce social spaces made by choices, rejections and appropriation which have been read under the lens of transculturation, entanglement and hybridity (Girella, Pavúk 2016; Stockhammer, Athanassov 2018; Maran 2019, with previous bibliography).

Following in this vein, Minoanisation has finally been analysed as a multi-scalar and dynamic process, especially with relation to modes of transmission and adoption of Cretan practices across a wide area and with different outcomes at regional scales. Although the presence of Minoan ceramic culture is substantially growing in the Cyclades during the MBA, the turning point of this process is the beginning of the Neopalatial period corresponding to MM III on Crete, with Knossos being mainly responsible. In the Cyclades this moment coincides with the increasing use of the wheel in pottery manufacture and the adoption of Cretan pottery shapes in the local drinking and eating habits. On Crete this is the period of a general breakdown of the system with several relatively equal palatial authorities alongside the rise of Knossos as the leading palatial centre in the Neopalatial era. Such a rapid intensification of interactions on multiple scales might therefore explain the rapidity with which Knossos emerges as a major shift in the nature of social complexity in Central Crete and its overseas territories.

Social Network Analysis and social complexity

From this perspective, another related issue has piqued our interest for being rapidly discussed by Jones in the central part of the paper when he presents his model. The Social Network Analysis (SNA), despite its recent popularity in the Aegean archaeology (*e.g.*, Knappett 2013, with some cautionary notes for instance in Tartaron 2018), leaves room for a more austere model (Jones's definition). There are, however, two issues related to SNA that could help in understanding exchange systems and social complexity.

Firstly, recent studies have proved how social complexity is dependent on multi-scalar networks and involves the interaction of social phenomena that are not often seen as related (for example, settlement patterns, religious practices, and writing systems) (Knappett, Rivers, Evans 2011; Rivers, Knappett, Evans 2013. See also contributions in Knodell, Leppard 2018). Furthermore, in modelling maritime networks there are other aspects, such as weather conditions and boat technology, which are not captured through SNA (Tartaron 2018). In this sense, networks resulting in patterns of social change are not necessarily gradual or uniform, and they rather tend to be rapid, revolutionary and stochastic (Rivers 2018; Evans 2018). The results are patterns in the dynamics of social complexity that can be explained, but not necessarily predicted. The Cycladic islands with their microregional interaction sphere exemplify a special 'small world', borrowing a term that was used in the literature to describe local interaction networks at different scales (Sherrat, Sherratt 1998; Malkin 2011. Or the notion of 'definite places' or microregions in Horden, Purcell 2000, 53-88).

This aspect does, for example, explain also the emergence of complexity in this archipelago already in the EBA, when the very small-scale nature of Cycladic society within a marginal insular environment created a special base of power. The undisputed freedom of movement of Cycladic longboats in the Aegean rather masked considerable internal inequalities among the Cycladic groups and was in the hands of a few people and places/nodes (Manning 1994). This brief detour into the past enables us to see in a different light the re-configuration of the Cycladic maritime network after the EBA, the apparent habitation 'gap' throughout almost the entire MBA and the emergence of a palatial society on Crete, with new actors and nodes. But this re-configuration must be explained also by moving from a 'local' level to an 'intra-regional' level of interactions. Only through this perspective one can better understand the role of the 'other islands', such as Kythera and Aegina, which join as important nodes in the network in the late MBA and early LBA (see *infra*).

From the above point we can segue into our second point, which is partially foreshadowed in the article: the role of the other Cycladic islands. These are traditionally considered to be 'silent' actors in the Western String Network, slowly emerging from the shadows in recent years, thanks to new excavations and scientific petrographic programs. It is true that at the moment Naxos, Ios, Paros and Andros do not show the accumulated wealth of Melos, Thera and Kea; however, the extraordinary variety of ceramic production detected at certain sites might mask a more dynamic and multi-scalar scenario, not limited to the western part of the archipelago (Knappett *et al*. 2011; Hilditch 2019). In other words, we wonder about the role of this seemingly 'silent' zone of the archipelago, about the possible existence of underestimated nodes of a more complex network, or, on the contrary, whether we see actors *deciding on purpose not to* participate in such a structured network. We wonder also, to what extent such a rejection can weaken and thus influence the network. All these cases would require a reformulation of the 'Western String' concept.

The role of the Western String between Crete and the Greek mainland in LM IB/LH IIA

This leads us to a further point that brings local-scale maritime networks and agency into an extremely dynamic scenario, when questioning the role of the Western String Network after the eruption of Thera at the end of LM IA (either late 17th or middle/late 16th century BC according to the 'high' and 'low' chronologies respectively). It is suggested by Jones that Crete underwent a considerable reduction in trade in LM IB and that the destruction of Thera caused a decreasing demand for shipping services, making Agia Irini and Phylakopi less affluent. The removal of the crucial node of Thera produced outcomes that must be perceived in a broader and more complex perspective. The post-eruption phase in the Aegean was not simply a remodelling of maritime routes, but a reconfiguration of power and the emergence of new leaderships. These are now more mainland orientated, primarily envisaged in this incipient period by the circulation of Helladic vessels, and with different degrees of social complexity hinting at transcultural negotiation between external stimuli and local agency (on Crete, Argolid, Messenia and Laconia). What is also interesting is, that on Kea we see now local variants of mainland pottery, various derivative small goblets of an LH I/IIA date. This is less common on Melos and certainly absent on pre-eruption Thera.

The picture of Crete as the one seriously damaged by the eruption, affected by an inexorable economic recession is partially true, but it needs corrections and to be considered in a wider scenario. Volcanic ash from Thera remains the major tool to measure the impact of the Santorini eruption on Crete, with the island being affected mostly on its eastern side (the evidence primarily comes from Palaikastro, Mochlos, Papadiokampos, Priniatikos Pyrgos, Sissi, Choiromandres and Pelekita), whereas the central and western parts seem not to have been involved or just marginally (synthesis in Driessen 2019 with bibliography).

The following LM IB period is now perceived as a much longer period than previously thought and dotted with destructions that appear to cover more than one generation (Brogan, Hallager 2011). Additionally, Crete appears to have been stressed as proved by the increase in exchange costs and major investments (architectural modifications, newly palatial building constructed, increase of storage spaces) that portray a long period of various dynamics and internal inequalities. The reasons of the LM IB collapse of the Cretan palatial system have been deeply discussed and major consensus now seems to focus on human agency (synthesis in Driessen 2019). This scenario appears to be confirmed by the analysis of T. Whitelaw (2019) on Knossos, which during LM IB became an expensive and unsustainable machine, unable to feed and maintain its urban territory, and becoming a source of tensions and discontent in the countryside.

Such a scenario coupled with the dropping number of Minoan ceramic imports in the Cyclades during LM IB does describe a vulnerable island apparently exacerbated by the difficulty in supplying the previous maritime network after the disappearance of Thera (Driessen, Macdonald 1997). To this process we add the first appearance of Helladic imports on the island with a major concentration at Knossos. It is also worth noting the marked increase in imports from the regions of the Eastern Mediterranean, which would point to an increasing Cretan interest in new trade partners in LM IB, reinforced in LM II in an already different political scenario (D'Agata, Girella 2022). What follows on Crete is indeed a revolutionary social transformation, primarily visible at Knossos in LM II, with a contribution of incomers from the mainland who helped creating a new political and social order (D'Agata, Girella 2022 with bibliography).

The pioneering study of Penelope Mountjoy on the LM IB/LH IIA pottery from Melos and Kea (Mountjoy, Ponting 2000) has proved the existence of Marine Style pottery produced on the Greek mainland and a change in the network from the mainland towards the south with a prominent role played by mainland protagonists. The study is now confirmed by additional research that has proved the presence of Helladic imports also in the Dodecanese in this early Mycenaean era (Marketou *et al.* 2006; Vitale 2016) and viceversa (Davis 2015). However, this picture requires some explanation.

That the shipping within the archipelago through Melos and Kea tapered off by LM II might be only one side of the coin. However, the seeming absence of major building programs and frescoes cannot be taken as an automatic sign of decline, as believed by Jones. Besides, it has been argued that House A, the administrative centre at Agia Irini, did not become significantly larger than the other buildings until LC II, Period VII. The number of mainland imports in this period grew to 51% (Gorogianni, Abell forthcoming), but it is worth noting that in terms of local production and consumption, Cretan shapes are largely present in the assemblage, showing that Cretan styles and practices were still the dominant cultural vocabulary (contributions by Gorogianni, Abell, Hilditch in Gorogianni, Pavúk, Girella 2016). Pottery, *nota bene*, can help one understand only partially a more dynamic phenomenon, which in the case of Agia Irini is rather difficult to detect in the local ceramic assemblage because of the multicultural character (Cycladic, Cretan, and Helladic) of its community likely from the beginning.

Therefore, the question is how much the previous scenario changed with the emergence of the mainland leaderships? An answer is offered by the paper of Knappett, Rivers, Evans 2011 who through computational network analysis prove a reconfiguration of the previous network more centred on Melos and Kea, though equally stable. Additionally, "the costs did not increase immediately, but took a while to be implemented. These costs concern the greater distance needed to travel from Crete to trade with the Cyclades, and perhaps a concomitant need for more ships, and more crews, as well as perhaps new storage and distribution facilities" (Rivers 2018, 56). Moving from a local-scale network to an intra-regional one, there are indeed two important novelties: the role of

Kythera and the Dodecanese in the eastern Aegean. These two nodes appeared already before, but in remodelling the network and concentrating the exchange/trade into fewer links they acquired a different role.

The analysis of the material culture and funerary landscape show a significant transformation of the island of Kythera with a growing integration into the Cretan culture. The site of Kastri around LM IB must have become a settlement of more than 6 hectares (Broodbank 2000; Bevan 2002). Kythera was the natural stepping-stone to the mainland on two main routes. Directly to the north in Laconia and to the west in Messenia.

Signs of significant transformations emerge in LH II in Laconia and Messenia with different degrees of intercultural entanglements between local and Cretan cultures. Contacts with the external world provided important stimuli for the development of socio-political complexity in Laconia, ranging from the potting community of Agios Stephanos along the coast to the internal region of the Eurotas Valley with the first definition in LH II of a new funerary landscape, with the construction of the tholos tomb at Vapheio, and the palatial building at Agios Vasileios (Chapin *et al*. 2014; Day *et al*. 2022). The exploitation of natural resources, like *lapis lacedaemonius* and *rosso antico*, as well as the metal ones explain the interest of Crete for this route through the 'colony' of Kythera.

In Messenia, several aspects of early Mycenaean burials and palatial architecture (masons' marks, ashlar masonry, court-centred buildings) point to connections between Pylos and Crete since the end of the MBA (Murphy *et al*. 2020; Nelson 2007). The recently discovered shaft grave of the Griffin Warrior points to a growing route of social complexity and transcultural process of appropriation and the elaboration of local and foreign elements in LH II at Pylos by emerging elites who aligned themselves to the ones of Neopalatial Crete (Davis, Stocker 2016). The process is almost identical to the one contemporarily developed at Mycenae with the richly furnished shaft graves.

The Eastern String

Turning to the east, the Eastern String connection was left out by Jones on purpose; however, Miletus, Trianda on Rhodes and Serraglio on Kos modelled a similar and at the same time a different 'small world' from the one prospected in the Western String, with its own relations between islands and coastal zones. The eruption of Thera might have had a special impact also on these sites of the Aegean. Both Trianda and Serraglio have produced further evidence of the south-easterly distribution of the Theran tephra, but this does not seem to have affected the continuity of life: both settlements underwent new urban plans (Marketou 1998; Vitale 2016). The appearance of Helladic ceramic imports along with locally produced Mycenaean vases is new: it is a tipping point that explains an intense and deeper Mycenaeanisation process. However, the picture is more complex. Minoan cultural traits did not diminish in this region after the Thera eruption and the construction of the palatial building at Zakros in a seemingly isolated region of Crete can be explained (with or without the control of Knossos) only with the strengthening of the Eastern String from Crete towards southwest Anatolia (through Kasos and Karpathos) and likely Cyprus with the exploration of new metal ores. Rhodes and Ialysos/Trianda are the basic stepping-stones of this double route and the first appearance of Cypriot imports at LB/LH II Ialysos/Trianda is in full agreement with this picture (Marketou *et al.* 2006). Within this new network Miletus was likely the final destination, even though its real function is not yet completely clear, since the site was very probably an island in this period, in the mouth of the Meander River, cut away from the rest of the mainland by the river itself but in addition also by the high mountains around it (Samsun Dağı/Mykale, Beşparmak/Latmus). After the eruption of Thera, Miletus in Period IVb shows evidence of an extensive Minoanised occupation dotted with the first appearance of LH IIA continental Marine Style pottery and imports from Kos (Raymond *et al.*, in Gorogianni, Pavúk, Girella 2016). The role of other sites and islands is yet to be understood: Iasos on the coast and Samos, for instance, might have relied on larger sites (Miletus, Trianda, Serraglio) for the connection to Crete. Aspects of the Eastern String and southwest Anatolian network remain elusive. Aside from the incorporation of new cultural traits into the local sphere, the agency of social groups of Anatolian communities was the main factor that shaped a different network with unexpected outcomes not documented in the Cyclades.

Indeed, of relevance to this discussion would be the analysis of the locally produced Light-on-dark (LOD)/Dark-on-Light (DOL) wares on Kos, combining local traditional shapes (mostly closed and transport) and Minoan

decorative traits and exchanged along a maritime route that embraced various sites of the Aegean (Knossos, the Cyclades, and Kolonna). What definitely deserves more attention is the distribution/occurrence of the Koan LOD and DOL wares in the central and western Aegean. Mostly closed shapes were exported, known by now from Messenia, across Crete, Agia Irini, Akrotiri to Cyprus, to Troy in the north. And what is possibly even more interesting is the fact that, whereas finds from Akrotiri are LM IA, many of the others are LM IB in date. This is worth of special attention, since tracing the distribution of these vessels across the Aegean could tell us also something about how the trade and exchange was organised *after* the Theran eruption.

Island archaeology: the role of other islands and archipelagos

In this final section we would like to slightly expand our notes geographically, reflecting the last comment on the Eastern String. One of the achievements of Jones's paper is to have stressed the centrality of islands. Islands with their 'small worlds', sea- and coastal-scapes developed their own networks (Girella, Pavúk 2016, 15; Broodbank 2018) and being 'contact zones' favoured entanglement and translation processes. Furthermore, island groups are ideal laboratories to construct comparative analyses. We have briefly discussed the southwestern Anatolian region and it is enough here to stress the need for a deeper analysis when facing an extraordinary micro-mobility within a much more elaborate geophysical scape (Mokrišová in Gorogianni, Pavúk, Girella 2016).

It is interesting how Aegina/Kolonna is conceptualised by Jones along the Western String: it was likely not the main destination from Crete, but a logical spin-off, especially when Argolis or western Attica were meant. This can explain the strong ties with Crete embodied by Minoan imports alongside local imitations. Hereby, we have to differentiate between imports and exports. Aegina is known mainly for three kinds of exported pottery: large decorated pithoi, matt-painted ware and cooking ware pots. They travel quite widely, but more to the north and west rather than to the east of the island (Gauss, Kiriatzi, Lis 2011). This has already been traced and is being uncovered as we write these lines, but it suffices to say that the three categories do not show the same patterns and that they change over time. A turning point is the beginning of the MBA when ceramic exports from Aegina are documented in a wider region demonstrating the effective control of the Saronic Gulf. By this period, the Minoanising phenomenon is of relevance also for Kolonna, although it remained rather limited in the MBA, with a persistence of the traditional hand-built pottery (Gauss 2021). However, with its extensive trade network, the early shaft grave, the monumental fortification and the so-called Large Building Complex (presumably the administrative building of the settlement remaining in use as late as LH IIA), Kolonna was the earliest first-generation state outside Crete in the late MBA. By the LH period, Mycenae had started to expand its control from the Argive Plain. Interestingly in this period, LH I and II Mycenaean imports at Aegina seem to be very rare, whereas contacts along the northern coast of central Greece, through the Euboean straights towards Malis and coastal Thessaly intensified (Pavúk 2012; Gauss 2021).[1] Mycenaean ceramic imports appeared in substantial quantities only from LH IIIA, when Mycenae swallowed the Saronic Gulf into its political and economic control. From this period onwards the island lost its centrality in the gulf and witnessed a reorientation of maritime connections with Mycenae upstaging Kolonna's traditional role (Tartaron 2013).

At the edge of the Minoanised area of the Aegean there is the northeast region (Girella, Pavúk 2016). This area is composed of larger islands (Samothrace, Imbros, Tenedos, Lemnos, Lesbos and Chios) confronting two major landmasses, the western Anatolian coast and the northern coast of Greece. It is also apparently isolated from the rest of the Aegean, but the role of Palamari on Skyros, Euboea and eventually eastern Cyclades as principal intermediators for cultural elaboration is becoming more crucial. Connections to and from the northeast Aegean are also sometimes questioned: given the wind and sea-currents, the trajectory along the west Anatolian

1 This is possibly where the various circuits start overlapping: the Aeginetan, Boeotian (True Grey Minyan and Mainland Polychrome) and Laconian (Lustrous Decorated Ware). It is possibly not without interest, that while the Mainland Polychrome imports are mostly closed shapes, the Grey Ware is almost always open shapes, *e.g.* goblets and kantharoi. There is one more distinction to be noted: whereas there are high numbers of Grey Ware at Agia Irini (almost all imported, it seems), it gets considerably less represented as we move south and east.

coast upwards would be the most likely when sailing northwards. However, a route through the central Cyclades would also not be impossible, but there has been no proper research into it. On the way back, southwards, the currents take one rather to Palamari on Skyros. With Aeginetan Matt Painted pottery of *ca*. MH II date at Liman Tepe in the Izmir bay, one could also expect contact along the northern Cyclades somehow. There is some Aeginetan pottery also at Troy, but it is rather LH I-II in date. On top of that, there seems to be some special link between central Greece or coastal Thessaly and the northeast Aegean, so there are further venues of contact possible.

Contact with Crete began during the Protopalatial period (namely MM II) and was widespread across the region at the end of the MBA (which roughly corresponds to MM III and LM IA). Particularly striking is the evidence from Mikro Vouni (Samothrace) with the unique appearance of administrative documents. However, Samothrace as well as other sites from Lemnos and Lesbos, and Troy itself do not appear to be the final destination of this network, but important nodes with different degrees of incorporation of foreign elements into the local cultures (Girella, Pavúk 2016). The search for raw material, with Thrace and the Troad being rich in gold, silver and copper, remains the valid explanation for the MBA Cretan interest in the north. However, the persistent absence (intentional?) of distinctive elements of Minoan culture (such as ashlar masonry, pier-and-door partitions, frescoes) and with extravagant outcomes on pottery consumptions, that vary from local imitations of Minoan shapes to hybrid ones, is outstanding and points to a different degree of incorporation of Minoan cultural traits into local habits. A significant change is registered at the end of the MBA and beginning of the LBA, corresponding to LH I, when the involvement with central Greece, Aegina and the Cyclades became more consistent. Furthermore, the Mycenaean interest in this area appears stronger only after LH II. The post-eruption outcomes in this far northeast region of the Aegean are therefore hard to understand. We have argued that an explanation after the disappearance of Thera might be found with a change of maritime route gradually orientated towards Cyprus for the exploitation of the copper ores (Girella, Pavúk 2016).

Concluding remarks

The configuration of the Western String in the post-eruption period is the result of the interaction of island-scapes with various coastal and inland zones. Its role and nature structured during the MBA and early LBA was gradually transformed after the Theran eruption and became profoundly affected by internal and external forces. Starting in LC II and during LC III, the role of Kea and Agia Irini was reduced. The progressive expansion of Mycenae on the Argive Plain and southwestern Corinthia re-defined the connection with the Lavrion: from the Argos peninsula it was indeed possible to reach the eastern coast of Attica bypassing the Saronic Gulf and Agia Irini. Furthermore, from the mainland, connections to Crete appear more reasonable either from the Argos peninsula via the islets stretching from Spetses to Melos or from the Laconian coast via Kythera and Antikythera towards western Crete.

The definition of a new network of authority is hard to grasp in this period on the Greek mainland, although the funerary evidence hints at increasing elements of elite representation. Likewise, the recruitment of task forces for enormous funerary building programs that marked the landscape reflects the consolidation of new forms of power and ideology. At this early stage, LB II/LM II, a Mycenaean kingdom was established on Crete with its administrative, political and military centre at Knossos. Likely controlled by the Greek mainland this new power defined a new agenda of international networks lasting several centuries by strengthening the east-west maritime routes to the detriment of the north-south routes and the Western String.

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THE WESTERN STRING IN CONTEXT: LOCAL LANDSCAPES AND AEGEAN NETWORKS

Donald Jones's foregoing paper presents a trade balance model, based on contemporary economic theory, to suggest that port fees are responsible for the extreme wealth exhibited in the three best known sites of the Cyclades of the Middle to early Late Bronze Age: Agia Irini (Kea), Phylakopi (Melos), and Akrotiri (Santorini/Thera). This model is intended to reexamine the Western String theory originally proposed by Jack Davis (1979), who argued that these three sites represented an important trade route between Crete and the metal-rich Lavriotiki, which in turn explains the relative wealth and high number of Minoan imports exhibited at these sites (on mainland contributions, see also Cherry, Davis 1982). As discussed by Jones, this theory has been revisited at numerous junctures since then, as survey and excavation datasets have expanded and new finds have come to light elsewhere in the Aegean. The most cogent recent review of scholarship on the subject is by Anna Belza (2018), who also reviews evidence for settlement throughout the Cyclades during the relevant period (see also Nikolakopoulou 2019, 21-30). The most striking feature of the overall settlement pattern is its marked contraction in the MBA after an EBA boom. By the MBA, major centers existed at the aforementioned "big three," though we know of very little else around and between them. In this response to Jones's article, I wish to highlight the blank spots in the Western String from a regional perspective, and how they affect our understanding of both local Cycladic landscapes and wider Aegean networks.

First, I consider what is known about the wider landscapes of Kea, Melos, and Thera, and whether the limited evidence available supports the demographic models posited by Jones. Second, I look to the places between to consider where else there is evidence for settlement and regional or long-distance interaction. From the outset, we must highlight the extremely uneven nature of the dataset, particularly the lack of systematic survey data, which makes the specific economic and demographic models proposed by Jones difficult to evaluate. While the original premise of a Western String route of Minoan-Cycladic-Attic connectivity – and Keian, Melian, and Theran efflorescence within it – is well founded, the notion of port fees driven by demographic growth is probably too specific to be tenable, at least without direct evidence and contemporary analogs. Moreover, Jones's model does little to acknowledge the particular geographical circumstances of each island, and folds all of them together into one part of a three-part model (Crete, island, mainland); this overlooks and conflates elements of spatiality and separation that inform the particular histories and archaeological records of each individual island. I believe that Aegean archaeologists would be better served by going back to some of the basics of heuristic geographic and economic modeling, such as central-place theory, gravity models, site catchments, and various types of network analysis (*e.g.*, Jarriel 2020). Nevertheless, the many questions raised by Jones's model suggest that we would benefit from examining more local and regional relationships within the Cyclades and how the big three fit into wider patterns of settlement and connectivity. The multi-scalar approach that I (briefly) propose here suggests the convergence of settlement nucleation and scale-free network growth as a more plausible alternative to a port-fee dependent trade balance model.

Demography and Bronze Age rural economies

Much of Jones's model rests on the demography and carrying capacity of Kea, Melos, and Thera, and the premise that the nucleated populations at principal sites could not have generated the wealth evident in these communities through agricultural activity alone. He largely dismisses other aspects of the rural economy, which would have included the rich mineral resources of each island: clays for pottery production, plus the island-specific resources of

miltos on Kea, obsidian on Melos, and other volcanic stones on Melos and Thera (not to mention the well-known silver and copper sources of the in-between islands of Siphnos, Seriphos, and Kythnos).

Demographic estimates in archaeology are notoriously difficult and wide ranging (*e.g.*, Chamberlain 2006; Bintliff 2020). Even the population estimates cited by Jones are highly variable: 280-1250 for Agia Irini; 360-1367 for Phylakopi; 1500-6000 for Akrotiri. These numbers are based on different formulas for population per ha at these sites, and different estimates of overall populated area. These models also do not account for rural populations (or they assume that rural populations did not exist). There are several problems with such estiamtes (and these are not exclusive to Jones's paper). First, each of these estimates is based on a different model. A comparative framework should base population estimates on the same set of clearly defined rules, or at least using the same baseline method. Moreover, these rules should probably vary by site, based on local conditions. Why should we expect the population density for Phylakopi to be the same as for Akrotiri? How are Jones's economic model and its underlying assumptions affected if the population of Agia Irini is 280 *versus* 1250? How do we account for rural populations, or archaeologically ephemeral activities in the landscape? Over the last 50 years, intensive landscape survey has provided insights into these problems, though no clear answers. More recently, archaeologists have sought to combine survey evidence and aggregated radiocarbon dates to provide demographic and land-use information for large areas, for example all of mainland Greece (Weiberg *et al.* 2019). Unfortunately, the history of excavation in the Cyclades would make the application of such a method uneven at best. Problems of coverage and sampling make demographic models in archaeology quite speculative; this does not mean that we should not engage in them, but it creates problems when these models are lifted wholesale into economic models that seek to aggregate demographic information without due recognition of the variable underlying assumptions.

An alternative method would be to consider long-term patterns of rural production and the carrying capacity of the island, based on populations known from the documentary record (*e.g.*, Sanders 1984; Davis 1991). We might also consider resource acquisition zones (catchments) for these sites, which must necessarily vary over time. Whitelaw (2019) provides an instructive example of minimum agricultural catchments for Knossos and how these expand, commensurate with the putative population of the site. We might do something similar here, by considering a simple, heuristic catchment model with 5 and 10 km radii, corresponding to about one and two hours in walking distance over even terrain (Vita Finzi, Higgs 1970). Of course, such a model does not account for actual walking time or effort, land viability, or different types of rural production. Nevertheless, such models illustrate the variable extents of likely resource extraction zones for ancient polities.

A next step is to consider the archaeological signature of such practices (if any). Regional survey is the best way of recovering information about rural practices, though the evidence generated by surveys is often ambiguous, and coverage is extremely uneven. Jones dismisses rural production as a source of wealth in suggesting an entirely nucleated population with a single center of habitation on each of the three islands examined. Nucleated habitation, however, does not necessarily signal lack of activity or production in rural areas.

For most early states and Bronze Age polities in the eastern Mediterranean, at least 70-80% of the total population was likely engaged in rural production (Trigger 2003, 155; Whitelaw 2019, 93). In later periods, when Linear B texts provide insights into urban/rural dynamics, the extraction of produce from the countryside is the chief concern of the administrative elite. This is safe to assume in Middle to early Late Bronze Age contexts as well, even in places that exhibit diverse external connections. We may therefore also assume that rural production was important for sustaining nucleated populations and that imbalances in access to resources contributed to the group building projects (*e.g.*, fortifications) and wealthy residences (with wall paintings) present at Agia Irini, Phylakopi, and Akrotiri.

All of the islands in question are small enough that farmers, pastoralists, and others involved in rural production could have worked in or otherwise inhabited various parts of the landscape (and seascape, in the case of fishing and other maritime activities). For each island, well over half of the total surface falls within ten kilometers of the principal site, and the entire island could be traversed in a day. However, many rural activities leave little to no archaeological signature, especially if they are not associated with an immediately proximate settlement. Indeed,

'off-site' artifact distributions associated with rural activities are much more apparent for classical Greek, Roman, and medieval periods than for prehistory. This does not (and in fact cannot) mean that rural activities were not taking place in the Bronze Age, though they are obviously less represented – as some say, "hidden" (*e.g.*, Rutter 1983; Bintliff *et al.* 1999). The small-scale evidence that does exist therefore must be examined with due consideration to visibility, coverage, and local-to-regional-level settlement systems.

The rural landscapes of Kea, Melos, and Thera

Kea has been subject to a number of archaeological surveys, most notably in the northwest part of the island, where Agia Irini is located. Agia Irini was certainly the most significant site on the island in the MBA, and is (probably rightly) considered the main center of population. Intensive survey revealed MBA-LBA finds at twelve separate locations throughout the northwestern part of the island, suggesting widespread activity in the landscape, even if not represented by more than a few sherds (Cherry *et al.* 1991, 23-34, 166-172). More recently, prehistoric finds have been noted also in the southern part of the island, at Karthaia, including MBA material (Mendoni 2004, 187-221; Belza 2018, 56). Only a few prehistoric finds have been noted by the survey that took place in the vicinity of Poieessa (Galani *et al.* 1987). A contemporary survey of the island as a whole reported several further locations with MBA and LBA material, but little detail (Georgiou, Faraklas 1985). A recent project on Kea is a resurvey of the same area covered in the 1980s by the Northwest Keos Survey (Murphy n.d.). No significant variation in rural assemblages has been reported.

From the Kea material, it seems that MBA-LBA ceramics are not well represented on the surface, even when activity is indicated by their presence. Such material is likely to be noticed and collected only in the course of intensive fieldwalking. The entire project area of the northwest Kea survey (30 km^2) fits within what might be considered an inner catchment of Agia Irini (a radius of about 5 km). However, we simply do not have relevant information for the rest of the island (150 km^2 in total). Further intensive coverage may reveal a more complex rural landscape, even if other major centers are unlikely to be present.

Melos occupies a special place in Greek landscape archaeology as one of the first testing grounds for systematic, sample-based surveys in the Aegean (Cherry 1982). In this survey, a sample of eight, 1 km-wide north-south transects were distributed across the island to cover about 32 km^2 (out of a total island area of *ca.* 160 km^2). Several previously unknown sites were discovered, to supplement previously known sites on the island. While there are several sites on Melos that were occupied during the EBA, by the end of the EBA and throughout the MBA and early LBA – coincident with the growth of Phylakopi – the settlement pattern of the island became highly nucleated, at least in terms of habitation (Cherry 1982; Whitelaw 2004). In discussing the development of the island through the Bronze Age, Renfrew (1982, 38) notes only a single site, Kapari, a possible kiln near Phylakopi, that can be reasonably considered a part of the wider MBA settlement pattern. Scattered finds that possibly date to this period (three additional sites), may still indicate limited activity in the landscape, as was the case on Kea. These all fall within an extended (10 km) catchment of Phylakopi.

As on Kea, we have more detailed survey evidence for Melos than for most islands in the Aegean. However, this evidence is not particularly well suited to reconstructing Bronze Age rural landscapes or demographic models for the island as a whole. Again, we might imagine a nucleated settlement pattern with rural activities that were more widely dispersed within an agricultural catchment. Jones notes that Sanders (1984) demonstrated that the real population of Melos recorded in the mid-20th century was far above carrying capacity estimates by Wagstaff and Gamble (1982), yet he does not cite this figure or provide his own. It is worth noting here that (1) over half of the surface of the island falls within a reasonable catchment of Phylakopi; (2) inhabitants of Phylakopi could have exploited land in a way that is archaeologically ephemeral; and (3) both the catchment and overall carrying capacity of the island is well beyond the subsistence needs of even a maximum population estimate for Bronze Age Phylakopi (and this catchment may have also included the nearby smaller islands of Kimolos and Polyaigos). The wealth exhibited at Phylakopi may still have come from its wider connections, but the population was more than capable of supporting itself locally. A subsistence-based economic-demographic model therefore does not

sufficiently explain the motivations for nucleation or connectivity. We might rather consider that preeminence of Phylakopi in long-distance networks, particularly involving Crete, provided motivation for nucleation and growth, which spurred a further influx of population from the rest of the island. In network theory this is the principle of scale-free growth, or the 'rich-get-richer' phenomenon. This may also apply to Agia Irini on Kea.

Thera exhibits a quite different settlement pattern and history of research (Davis, Cherry 1990). Four significant sites – Ptellos, Raos, Ioannis Eleaimon, and Koimissis (the last on the islet of Therasia, which would have been joined to the rest of the island in the relevant period) – have been excavated and have substantial architectural remains, links to Akrotiri, and grave goods demonstrating connections elsewhere in the Aegean (Marthari 2001; 2004; Sbonias 2020). The presence of substantial rural sites, or 'villas' in the hinterland of Akrotiri suggest a more complex, dispersed pattern of settlement, including secondary sites (though probably still not significant population centers) beyond the principal site of the island. It must be noted, however, that there is little history of systematic, intensive surface survey on Thera, with the exception of the recent work on Therasia (Davis 2015; Sbonias 2015).

It is also noteworthy that the nearby islets of Christiana (to the west) and Anafi (to the east) both have MBA sites (Belza 2018, 144, 151), which might have been important stopovers or other nodal points connecting Akrotiri to Crete and other destinations to the east and west. But what about other places in between?

The 'missing' islands in the Western String

The islands of Sifnos, Serifos, and Kythnos comprise a conspicuous absence in models involving the Western String. Geographically, they are relatively evenly spaced between Melos and Kea. They are on an even more direct line between Thera and Kea, which probably also serves to highlight the gravity of Phylakopi in the MBA-LBA. One would think that these would have been important stepping stones or stopovers between Kea and Melos or Thera (see also Mountjoy, Pointing 2000), but evidence ranges from limited to nonexistent.

While EBA remains are known from a few locations on Kythnos, MBA to early LBA material has been found only in the form of a few sherds from the site of Agia Irini in the small bay of Loutra in the northeastern part of the island (Scholes 1956, 12). Serifos is completely devoid of material from this period, and has only limited finds from the preceding Early Bronze Age (Pantou 2017). Sifnos has a small number of MBA to early LBA finds at Kastro (Brock, Young 1949, 31-33), and a few reported (though never published) finds at Agios Andreas, the principal phase of occupation of which is LB III. This lack of evidence is surprising, given the rich metal resources of all of these islands, and the fact that some were even subject to exploitation for minerals in the Early Bronze Age (*e.g.*, Matthäus 1985; Georgakopoulou *et al.* 2011).

We must also consider, however, that none of these islands has been subject to systematic, intensive regional survey. Kythnos has seen detailed survey work only at the ancient polis at Vryokastro (Mazarakis Ainian 1998). I know of no intensive survey work on Sifnos or Serifos. Some of the islets in between – Serifopoula and Kitriani – as well as Kimolos and Polyaigos, have been subject to extensive reconnaissance surveys, but not systematic fieldwalking (Pantou, Papadopoulou 2006). While material is reported from several periods in summary, including the Early Bronze Age and later Late Bronze Age, nothing has been reported for the Middle to early Late Bronze Age. Ongoing work by the Small Cycladic Islands Project in some of these locations may yield further information (see Knodell *et al.* 2020; Athanasoulis *et al.* 2021).

Large, fortified sites on the scale of Agia Irini, Phylakopi, and Akrotiri are likely to have been discovered by extensive survey, reconnaissance, and local knowledge. However, smaller-scale settlements or rural sites of the MBA-LBA period are likely to be represented only by artifact scatters, which could easily escape detection in previous site registers or extensive surveys. The limited findings we do have from the period in question probably do not reflect long-term settlement on these islands, and certainly not large-scale settlement. The sheltered, coastal locations on Kythnos and Sifnos may indeed suggest that these places served as occasional stopovers or were simply small coastal communities that did not participate directly in larger Aegean networks involving Crete and the mainland.

While we should interpret the large-scale absence with caution, given the lack of systematic survey work, we should also recognize the unlikelihood of the existence of other major sites (at least on the order of the big three) and consider this a part of the wider regional settlement pattern of the southern and western Cyclades. This probably also reflects the gravity of Agia Irini, Phylakopi, and Akrotiri. These sites were established population centers and points of convergence long before their MBA-LBA efflorescence; they experienced rapid settlement and network growth in the late EBA to early MBA, to the eventual exclusion of other communities. This, in combination with their large, deep, sheltered harbors, essential for the new, large sailing ships that first appeared in the MBA, is more than enough to explain the boom in connectivity and wealth we see at these three sites.

Beyond the Western String

In the final part of this response I turn to the wider context of Minoan and Minoanizing finds in the wider settlement pattern of the Aegean islands. As Jones points out, finds from excavations at Grotta and a surface survey of Mikri Vigla on Naxos include Minoan imports and imitations (Barber, Hadjianastasiou 1989, 86-106; Cosmopoulos 2004). However, imports and imitations from Melos are in fact more numerous than those of Cretan origin and influence, as noted by Belza (2018, 31-34). Mikri Vigla has also been interpreted as a Minoan-style peak sanctuary (Sakellarakis 1996; Vlachopoulos 2016, 119); recent finds from Stelida (also on Naxos) are also suggestive of such a site (Carter *et al*. 2021). MBA finds from Agriokastro on Antiparos include imitations of Cretan wares, along with Melian and Theran types, found in built chamber tombs (Papadopoulou 2018). Minoan, Cycladic, and mainland pottery has also been found in recent cave excavations on Paros (Mavridis 2018). Some 27 MBA to early LBA findspots have been reported on Syros (Aron 1979), though only Agios Loukas can be verified by published material that is clearly of this date (Tsountas 1899). A major, fortified site was recently documented on Gyaros, including a full suite of imported and Cycladic pottery (Marthari 2013). Considering Gyaros has probably never sustained a large population, and probably is not capable of doing so, the importance of this site must lie in its nodality, as has been demonstrated for small, uninhabited islands in the central Cyclades for other periods (Knodell *et al*. 2020). Limited MBA-LBA finds from Strongylo, southwest of Despotiko and Antiparos, may also suggest rare, smaller-scale sites in spaces around and in between the big three of the Western String (on the recent survey of Strongylo, see Athanasoulis *et al.* 2021).

MBA to early LBA sites are present on Andros and Tenos, but seem to be limited to Cycladic networks in terms of their external contacts (Scholes 1956; Koutsoukou 1992; Koutelakes 2012); the same can be said for southern Euboea, which has only a single MBA site at Agios Nikolaos Mylon and nothing from the LBA (Tankosić, Mathioudaki 2011).

The presence of other sites and routes through the Cyclades is to be expected, and need not reduce the significance of the Western String route (*e.g.*, Davis *et al.* 1983). The same can be said in answer to other refutations or modifications of the Western String model (*e.g.*, Schofield 1982; Neimeier 1984; Wiener 1990; Marthari 1993; Dietz 1998; Mountjoy, Pointing 2000; Berg 2006). Kythera, too, was clearly an important point of connection between Crete and the Peloponnese, with a much more elaborated settlement pattern than seen elsewhere (Bevan 2002). Recent finds at Pylos and Agios Vasileios also highlight connections between the Peloponnese and Crete (*e.g.*, Davis, Stocker 2016; Kardamaki 2017). The important question does not seem to be whether or not Akrotiri, Phylakopi, and Agia Irini were significant points along a trade route that connected Crete and the mainland, but how they fit into a larger context of complex, multi-directional networks. As to the question of Aegina, which Jones also raises, a recent, comprehensive quantification of the distribution of Aeginetan pottery has shown that there is relatively little Aeginetan material in the Cyclades, mostly limited to Agia Irini – the interests of Aegina were clearly much more in the Saronic Gulf, the Argolid, and Central Greece (Gauss, Knodell 2020). Quantifications of Minoan, Mainland, and Cycladic wares in the Cyclades show that the volumes of material consumption at Agia Irini, Phylakopi, and Akrotiri are far greater than anywhere else yet known, and reflect complex patterns of exchange both within and beyond the Cyclades (Cherry, Davis 1982; Abell 2016; 2020; Nikolakopoulou 2019). We must therefore return to the original questions of (1) did these places have special status in the Cyclades and (2) if so, how did they come by this status?

Conclusions

While the data concerning MBA to early LBA settlement and interaction in the Cyclades are increasingly complex, and are variable in quality and quantity, some patterns can nevertheless be drawn out. First, material interventions across geographical space are highly nodal, rather than involving some kind of continuous territorial spread. This was the core idea of the Western String model as originally developed (Davis 1979). Future research may add nuance to this, but only the discovery of large-scale sites like Agia Irini, Phylakopi, and Akrotiri are likely to reveal a comparable *scale* of Minoan (or mainland) interaction with Cycladic locales.

Second, the Western String should not be seen as an exclusionary force – a monopolized alternative to other routes through the Aegean – but in more inclusive terms as a group of places exhibiting different sorts of magnetic opportunity in a complex network of maritime interactions. Whatever the range of places exhibiting non-Cycladic activity, these three certainly have the most, and indeed do seem to be the largest, most significant sites (as well as, admittedly, being the most heavily excavated). So while the volume of data probably skews the relative significance of these sites somewhat, they still seem to have had quite special status in terms of their scale and level of connectivity. This also seems to have come at the expense of their surroundings. Indeed, basic principles of scale-free network growth suggest that well-established, well-connected centers are most likely to become more so by attracting further connections. This does not preclude other paths, however, for example through the central Cyclades. Indeed, the best opportunities for attracting new long-distance trade relationships may have been outside the ambit of the big three (*e.g.*, in places like Naxos, Antiparos, and Gyaros).

As to the basic argument of Jones's paper concerning port fees, this does not seem like a necessary explanation for the wealth exhibited at Agia Irini, Phylakopi, and Akrotiri. This does not mean some system of extracting resources for ships stopping over did not exist, but this is not defined in Jones' paper, and I know of no contemporary analogs from the eastern Mediterranean for which there is evidence of deployment in the Cyclades. For me, the explanation for wealth in these towns is much simpler, and comes largely from the magnetism of their long-term presence in their particular locations and their significance as nodal points in long-term networks. As these towns grew in the MBA – almost certainly related also to their large, deep harbors, well suited to the new arrival of sailing vessels – so did their significance, consumption, and capacity to contribute to wider networks. That these places were major ports – relatively isolated in their immediate regional context, and intermediaries in much wider exchange relationships – seems to me a sufficient explanation for wealth inequality and growth from the MBA to the LBA, without the need for a formal system of fees. More interesting questions concern the interface between the local dynamics of wealth generation (agricultural and specialist labor, for example), long-distance systems of imports and exports, and the apparently blank spots in between.

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MORE THAN PORTS OF CALL: REMARKS ON MIDDLE AND LATE BRONZE AGE ISLAND ECONOMIES IN RESPONSE TO D.W. JONES' MODEL

Cultural and economic change in Bronze Age Aegean island communities at the time of the early Neopalatial period in Crete has been a vibrant research issue during the last decades. In recent years, increasingly refined evidence is plotted in explanatory models aiming to provide an informed framework for the socio-political parameters of the special relations of Aegean communities with Cretan polities, and more specifically Knossos, conventionally referred to as the Minoanisation phenomenon. Jones reiterates in his paper one aspect of this change in the communities of Akrotiri, Phylakopi and Agia Irini (the nodes of the Western String trade route connecting Crete and mainland Greece), seeking to address the question "where did the affluence come from": his model unfolds the economic role of shipping services as an activity of primary interest and income for islanders (re)allocating labor time to "supply port services and charge enough for them to let the island populations accumulate wealth". The idea that the harbours of the three cities operated as ports of call for trading ships, especially in this particular period of intense mobility and integrated connectivity in the southern Aegean and beyond, is certainly not new. Whether this operation is, as suggested, the main occupation and the major source of increased income for these small island communities is open to debate. Moreover, a refined approach to evidence from the three sites highlights significant differences in strategies and practices adopted and materialised in various aspects of material culture.

Some remarks on Akrotiri economy

Jones adopts a top-down strategy in building his model, admittedly with many up-to-date references to published evidence. He anticipates the outcome (the port fees accounting for wealth) by removing specific variables. Agricultural endeavours, extractable resources and other economic activities are dismissed as insufficient sources of excess income for island communities. Along these lines, the recurrent assertion that island labour was drawn from agriculture into shipping services is used to support the argument (in a rather circular way, in my view). I propose to examine below the available evidence from Akrotiri relevant to the proposed economic model, and in particular specific aspects of (a) change and/or continuity between MC and LC I communities with reference to economic strategies (b) population, subsistence potential and level of autarky in the LC I community, (c) potential sources of income. I have looked into the first two aspects from a particular angle, that of storage facilities and storage function in LC I Akrotiri (Nikolakopoulou 2002). Certainly, the storage function is only one facet of economising in the broader sense; it represents an intermediate stage between production/acquisition and consumption of commodities. Its analysis within a specific spatial and temporal context cannot fully yield a reconstitution of social and economic structures; it can, however, provide essential primary information on subsistence strategies, exploitation of local resources, the administration of production and the nature and amount of imports.

From existing evidence, it appears that Akrotiri was the major settlement on Thera during the Middle Bronze Age (MBA) and Late Bronze Age (LBA) periods, with small-sized sites dispersed all over the pre-eruption island. The pattern of nucleated settlements in the Cycladic islands (not attested in the same degree on all islands) during the MBA and the LBA has been variously interpreted.[1] Whatever the reasons may be, external or internal, for the change in settlement patterns, the shift towards the apparent primacy of a single community in the three islands from the beginning of the MBA reflects transformations in societal group relations and subsistence strategies (Broodbank 2000).[2] For Thera, the study of Bronze Age settlement patterns and land use has been obstructed by the effects of the volcanic eruption.[3] Exploitation of the island's internal resources and the hierarchical scale and dependency relations between the sites are hard to reconstruct from present evidence. A closer look to the evidence for differential subsistence storage strategies in MBA and LBA Akrotiri could be a very interesting lead for exploring the administration of the island's internal resources. By the beginning of the LBA, domestic units at Akrotiri store staple products at a secondary and tertiary stage of processing (Sarpaki 2001, 31). The pattern of crops brought to the buildings after they had been coarse-sieved, as opposed to the practice during the MBA, led Sarpaki (1987, 206) to speculate on the possible difference between a primary producing site in MBA and a consumer site in LBA. The urban character of the settlement, especially the lack of large open spaces where crop processing at a primary stage could be performed, also supports this notion of consumer attitudes in subsistence (and not only) procurement. However, we need to emphasise that excavations have uncovered a densely populated part of the urban core of the settlement, where primary production activities (agricultural or industrial) were unlikely to have been hosted (although the retrieval of equipment such as a clay wine press suggests that wine or possibly also olive oil production was carried out within the settlement). This shift in subsistence procurement from the MC to the LC I horizon could reflect changes in power relations on an intra-island level and control over production means and strategies, with implications for the exploitation of production. At this later stage, Akrotiri could have appropriated

1 For example, the need to keep control of traffic and extract dues at certain fixed points (ports of call) (Schofield 1982, 19); defence against piracy (Renfrew 1972, 262-264); population aggregation for security and administrative reasons, related to the integration into the Minoan cultural and economical sphere of influence (Cherry 1979; Renfrew, Wagstaff 1982). In Melos, aggregation is suggested to have freed fields for extensive sheep-rearing to provide wool as an exchange commodity (Gamble 1979, 132).

2 Broodbank (2000, 320 ff) examines large scale and internal models of change in the late third-millennium in the Cyclades, the effects of some of which may have led to settlement nucleation. The maritime/insular model associated with innovations in seafaring and its effects on island life is in my opinion most convincing. Certainly, it is most probable that more than one factor operated, and different ones for each island.

3 For the area of the pre-eruption island see Aston, Hardy 1990; for an account of identified sites see Sperling 1973; Davis, Cherry 1990; Wagstaff 1978; Nikolakopoulou 2019a, 31-32 with references.

the production potential of the island by integrating a system of small-sized sites and farmsteads into a mechanism for the subsistence support of its increased population, who were not directly involved in cultivation and animal husbandry. This would mean that the agricultural/pastoral exploitation of the island's internal resources was not necessarily restrained when the Akrotiri community became more actively involved in maritime trade activities (of any nature), as suggested in Jones' model by the transfer of labour from agriculture in shipping services. Rather, it would indicate that Akrotiri became the major settlement on the island where products were accumulated and further mobilised.

Was the community driven to look for other sources of income by a practical need to ensure subsistence self-sufficiency? The working model for this approach would have to take into account all available evidence from population estimates,[4] estimates of the food producing capacity of the surrounding area[5] and calorific values/nutritional intake.[6] An integrated case study of all these correlates, based on available evidence and taking into account severe limitations, was carried out for Akrotiri (Nikolakopoulou 2002; 2011). For population estimates of LC I Akrotiri, I pursued three complementary paths: (a) the evidence from the excavated part of the settlement in terms of size and of use of space (overall area and distinct units) (cf. Whitelaw 2001) (b) the estimates for the subsistence potential of the storage facilities of the units of the settlement (cf. Christakis 1999; 2008) (c) the association of finds with land use and annual agricultural yields (cf. Warren 2004). Taking into account the particularities and function of representative individual multi-storied buildings, suggested to have housed either extended families or combined/institutional households as a working hypothesis, a rough number of 300 people was estimated in my study for the population of the excavated area. Considering that the area is densely inhabited, an average between the proposed figures for "core elite" (250 persons/ha) and "high density" (450 persons/ha) as estimated by Whitelaw (2001, fig. 2.8) for Neopalatial Knossos, would give a number of 385 persons for the 1.1 ha of Akrotiri, which is in general agreement with Wiener's numbers (1990, 133), suggested for Akrotiri to be 330-440 people. This is also more or less in general agreement with floor area/population calculations by Sarpaki (1987), who suggests a number of minimum 471 people for the excavated part of the settlement. Most proposed figures range between 300-450 people, which I consider to be a realistic approach. This range for the population was further cross-examined and confirmed in a model using estimates of subsistence potential based on the evidence from numbers and optimum capacity of storage facilities and their contents[7] and estimates of calorific values, in order to calculate the level of subsistence autarky of the inhabiting group of people in select domestic units with representative types of households (see Christakis 1999 and 2008 for Neopalatial Crete). The third approach, the estimation of population for Akrotiri based on annual agricultural yields, suffers from severe limitations, due to intrinsic problems related to the reconstruction of the pre-eruption islandscape. The size of the arable land, farming practices, land ownership patterns and extent of land allocated to animal husbandry are certainly difficult to speculate on.[8] A combined examination of the evidence from storage potential with indirect information on field cultivation, land use, annual agricultural yields and population estimates, taking into account the strong limitations, suggests that the inhabitants of LC I Akrotiri were, in theory at least, capable of a moderate/substantial level of subsistence self-sufficiency based on local land cultivation. Even if the inhabitants of the LBA settlement were not directly involved in agricultural production, they certainly had the means to control or acquire staple subsistence products and thus attain a decent degree of subsistence autarky.

Did the community exclusively rely on the mobilisation of local resources for subsistence autarky? I think not. While the subsistence potential of the land appears to have been enough to satisfy local needs, it doesn't mean that it was fully exploited. The residential units of the settlement enjoyed a reasonably moderate self-sufficiency

4 A culturally specific and notoriously difficult approach, cf. Naroll 1962; Sanders 1984; Wiener 1990; Whitelaw 2001; 2004.

5 Cf. Wagstaff, Cherry 1982; Warren 2004.

6 For the socio-cultural context and significance of dietary habits and factors see Fieldhouse 1986; Geissler, Oddy 1993.

7 For the archaeobotanical evidence from Akrotiri see Sarpaki 1987; 1990; 1992b; 2000; 2001; 2019.

8 See Sarpaki 1990 for an interesting discussion on field size and varied crop production.

level in terms of subsistence, judging from the storage capacity of the vessels found within the buildings. However, there is no evidence for bulk storage at a scale which would indicate surplus for relief in case of harvest failure or for further mobilisation. While a form of exchange or direct dependencies/ownership of land and animal herds from individual households could be operating on the intra-island level, the apparent lack of concern for surplus subsistence storage probably indicates that the community relied on and was capable of importing foodstuffs, as it happens in trade-oriented economic systems where excessive foodstuff production may be of a lesser significance or of a short-term nature. The integration of the Akrotiri community in a broad exchange network, well attested by material correlates, implies expanded possibilities of diversified subsistence strategies, such as bulk imports of staples by sea at almost any time in case of subsistence failure or increased demand and the provision of foodstuffs (similar to that of raw materials) not produced on the island.[9] This option is a choice, not a necessity as suggested by Jones in a circular argument that "an increase in export income from shipping services would most likely have resulted in an increase in non-food imports as well as the food imports required to compensate for reductions in food production required to increase shipping services". Furthermore, while there is no direct evidence for export activities of agricultural products and staples from Akrotiri, locally-produced, high-value commodities such wine, saffron and perhaps also fava (*Lathyrus Clymenum* L.), salted fish and honey/wax would be good candidates for export,[10] and their transportation means would not necessarily leave material remains. A local Theran pithos of large capacity with a Linear A inscription including a ligatured wine logogram (Karnava, Nikolakopoulou 2005) and a pithoid jar with an inscription citing a large quantity of wine shipped to Knossos from an island community probably located on Naxos, found together with large Theran/Melian jugs (Christakis 2010; Nikolakopoulou 2019b), are examples that warn us against sweeping generalisations.

What are the sources of income that allow not only subsistence buffer relief but also considerable surplus mobilised towards affluence? In Jones' model, dues for harbour services emerge as the only option for increased income, after having eliminated other sources, such as profits from trade of local raw materials, products of specialised craft workshops or the mass production of particular commodities for export. While it is true that there is not much evidence from raw material and waste products for local craftsmanship on a large scale, the production of textiles and pottery excluded, it has to be noted that workshops and industrial areas have not been found yet. Nevertheless, due to its excellent state of preservation, Akrotiri offers hints from the material remains for products and activities beyond the immediately obvious. The evidence for weaving in the West House has been extensively discussed;[11] what is of particular interest is its scale and the trade value of its products.[12] Large quantities of textiles (of the specific TELA+SE variety) are mentioned in the Linear A tablets found in D18a (Boulotis 1998; 2008). It is interesting to note that on a fragmentary tablet the ideogram for sheep (OVIS, A 306) was identified together with a numerical entry (46) (Boulotis 1998; 2008), a large number by comparison to contemporary textual references from Cretan archives.[13] Textile manufacture at Akrotiri, especially in the West House, seems to have operated at an unusually elevated scale of production by Aegean standards (Cutler 2016, 176).[14] The registration of flocks and

9 Cf. Broodbank 2000, 346-47, on the significance of increased cargo capacity achieved by the introduction of deep-hulled sailing ships in early MBA.

10 For archaeological evidence see Sarpaki 1987; 1992a; 1992b; 2000; 2019; Sarpaki, Jones 1990; Mylona 2020; Papageorgiou 2016; for a discussion of the value of the commodities see Michailidou 2008, 225ff.

11 Tzachili 1990; 1999; 2007.

12 On cloth producers and textile dealers see Michailidou 2008, 253-61.

13 The high number of sheep recorded and the zooarchaeological evidence for animal husbandry (cattle, sheep, goats, pigs) and the exploitation of animal products, both visible (sheep wool, goat hair, meat, leather/hides, horns) and invisible (milk, fat) in the archaeological record, draw our attention to a non-negligible economic parameter (see Trantalidou 2000; 2001). See also the iconographic evidence for herding livestock in the West House Miniature Frieze (Televantou 1994).

14 More than 450 loomweights have been found in Room 3 of the West House, comparable only to the number from the Loomweight Basement at Knossos (400 loomweights, Evans 1921, 220-224, 248-256).

textiles, the evidence for wool, linen and possibly silk processing (weaving)[15] and the use of a broad array of dyes,[16] all indicate that all stages of textile production took place on the island.[17] These products, apparently numerous and of high quality (including elaborate garments, see evidence for sewing on linen cloth in Muhlérat, Spantidaki 2004), were not meant only to satisfy local needs; most probably they were destined for profit-oriented exchange. Scales and sets of balance weights and the standardised properties of ceramic categories (which include storage and transfer vessels) suggest that the values of commodities were known, the result of active participation in a broader regulated exchange network. Different sizes of scales and balance weights may also point to other commodities of diverse nature destined for trade, such as the precious saffron, wine and other woven goods (ropes, sacks, baskets, fishing nets),[18] all of which were locally produced and highly valued in contemporary markets (Michailidou 2008, 225-236). In economic terms, specialised processing of local and imported raw materials and skilled manufacture of elaborate artefacts (such as stone vases and metal vessels), perhaps also transported and distributed by Therans themselves, would certainly result in profit and excess income.

The example of textiles and garments is illustrative and it may not be the only one affecting the economic life of the settlement. However, its profitable operation concerned specific people participating in the line of production and distribution. There is still a missing link in this story of the transformation of the MC community into a thriving 'cosmopolitan' centre (Doumas 1983; Doumas 2001) in the beginning of the Late Bronze Age. What is intriguing is that acquisition of imported/prestige objects and the adoption of new practices and technologies appear to have been widespread in the community in various degrees. How did the community of Akrotiri collectively participate in or had access to exchange networks? Was it the receiver of goods arriving at its harbour, paid for with income from port dues as suggested by Jones, or were its members more actively involved in maritime trade as merchants and skilled seafarers? I support the latter, for reasons outlined below.

Akrotiri, the Western String and other 'strings' and 'loops' of interaction

The prosperity of the settlement of Akrotiri at the beginning of the Late Bronze Age is usually credited to the outward economic orientation of the community and the position of the island in the southern Aegean. The first parameter appears to have been inherent in island economic strategies ever since the EBA, as testified by circulation of ceramics and metals indicating the bewildering activity of Therans and other islanders in the period of the 'international spirit' in EC II. The evidence for increased mobility of the islanders in the southern Aegean and relevant maritime iconography suggest technological skills in the production of longboats and seafaring. This specialised knowledge was further developed and upgraded in the following period, with the introduction of deep-hulled sailing ships with increased cargo capacity (Broodbank 2000). In Jones' own words: "people who knew how to design and build ships were most likely the people who knew how to sail them – *i.e.*, they were the people with the experientially gained knowledge of nautical engineering that could keep a ship afloat and obtain better performance". His argument that small boats were incapable of affecting exchange in economically significant ways is negated by the evidence for the EC period. Moreover, the assumption that limited timber resources on the islands inhibited the manufacture of large boats by Cycladic communities is not substantiated: on the one hand, islanders continue to be active in exchange during the MB and the LB I periods as evidenced by the circulation of ceramics and other goods on the intra-Cycladic level; on the other hand, there is increasing analytical evidence suggesting that wooded areas were present on Thera during the Bronze Age (Asouti 2003; Vlachopoulos, Zorzos 2014). In any case, provision of timber from neighbouring areas through exchange would not have been a severe obstacle. Access to wood sources

15 Mouhlérat, Spantidaki 2004; 2007; 2008; Tzachili 1997, 34-36; Panagiotakopulu *et al.* 1997.

16 Some of which were considered precious, such as the murex and saffron dyes, due to the cost of raw materials and processing (on the value of dyes see Michailidou 2008, 233-236, with references on the evidence from Akrotiri).

17 Spinning is an under-represented stage, due to the small number of clay and stone spindlewhorls (see Vakirtzi 2012); however, these could have been also of perishable materials.

18 Muhlérat, Spantidaki 2004; Beloyianni 2008; Vakirtzi *et al.* 2018.

was also necessitated for building purposes, as indicated by the common use of timber in architecture at Akrotiri. In fact, carpentry skills may have been transferred from the local shipbuilding tradition to architectural novelties (Palyvou 2005, 112), such as the reinforcement of walls with timber frames and the central columns. And finally, the long history of maritime iconography in the Cyclades (conspicuously rare in Crete and the mainland in these early periods), and especially the display in Theran frescoes of sailing ships, ship cabins and exotic creatures and landscapes, best advocates the case for locals taking pride in their sailing skills and journeys.

In the MBA, there is ample evidence for the operation of regional networks, with clusters of interacting sites plotted within the broader nexus, as inferred mainly by the quantities and distribution of specific ceramics.[19] On this meso-scale of analysis, we can detect 'special relations' forged within a regional/intra-cultural sphere, with communities interacting within a familiar coastscape and islandscape setting, bound together by various kinds of face-to-face social and economic ties (cf. Tartaron 2013). The number of Naxian imports at Akrotiri in the MC period, suggested by internal variations in composition and technology to represent the finished products of more than one production unit (Hilditch 2019), is evidence that points to a strong and special relationship between Naxos and Thera both in the MC and the LC I periods. Significant numbers of Theran/Melian imports are attested in assemblages from Agia Irini (Period V, late MC) and Mikri Vigla on Naxos, testifying not only to the strength of exchange relations but perhaps also to an inclusion strategy related to local identities (see Abell 2016 on the Melian/Theran imports in Agia Irini; on the evidence from Mikri Vigla see Barber, Hadjanastasiou 1989). Although a significant number of islands are regrettably underrepresented or even absent from the archaeological record for the better part of the Bronze Age, there is increasing refined evidence, mainly drawing upon the ceramic record, to allow us to recognise small worlds of interaction and connectivity patterns in the MBA Aegean.[20] The dynamics of inter-Cycladic exchange was strong and diachronic, probably constituting the most resilient pattern of interaction at least for the community at Akrotiri.

And this is where the Western String and other 'strings' and 'loops' of interaction are likely to be of particular relevance. I use 'strings' in this context to describe a trade route involving multiple agents/participants and 'loops' for exchange patterns of more balanced reciprocity between two partners (such as in the case of pottery exchange between Naxos and Thera). By the end of the MC period, the Neopalatial polities in Crete, and possibly more significantly Knossos, emerged as the prime movers of an integrative exchange system which appears to have followed more regulated paths in terms of connectivity lanes, metric/value systems and traded goods. In this context, distinct maritime routes operating at regional scale as links between coastal nodes and hubs upgraded to form an essential part of the connectivity puzzle in the Aegean facilitating circulation of high-value goods, technologies, practices and people. 'Becoming Minoan' was probably a one-way option for the partners involved, but this is certainly not to suggest that all communities under consideration followed similar trajectories. The position of the island of Thera in the southern Aegean certainly did not change; it was however apparently upgraded to "strategic",[21] as indicated by the diversification of the range and nature of imports in the LC I, from pottery originating in mainland Greece and the East/Southeast Aegean to raw materials and artefacts from areas in the east Mediterranean and beyond.[22]

Within this setting, the Western String, seen as a network from central Crete to the east Peloponnese and the mines of Lavrion in Attica via Akrotiri, Phylakopi and Agia Irini, certainly existed. But (a) it was not the only route

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19 See *e.g.* Nikolakopoulou 2007; Nikolakopoulou forthcoming.

20 See *e.g.* Knappett *et al.* 2008; Knappett, Nikolakopoulou 2005; 2015; Nikolakopoulou, Knappett 2016; Nikolakopoulou forthcoming. This approach highlights the entwined social and spatial nature of maritime networks, in that it integrates changing social and economic needs and configurations as decisive factors for the scale of connectivity and the agents involved (see Leidwanger *et al.* 2014 on an appraisal of research directions in maritime connectivity and network modelling; case studies in Leidwanger, Knappett 2018).

21 On the significance of topology and the physical setting of a settlement within interaction networks cf. Broodbank 2000; Knappett *et al.* 2011; Knappett *et al.* 2008. The crucial geographical position of Thera, at the crossroads between the western coast of Anatolia, Crete, Cyprus and mainland Greece may have given Thera a prominent position in the development of the metal trade between the eastern and western Aegean (Stos-Gale, Gale 1990; Wiener 1990).

22 A significant rise in imports from the mainland and the East/Southeast Aegean is attested from the LB I ceramic evidence from Sector Delta (Nikolakopoulou, Mathioudaki, Hilditch in prep.; see a preliminary discussion in Mathioudaki, Nikolakopoulou 2018); for 'exotic' imports see Bichta 2003; Dawson, Nikolakopoulou 2019.

of movement between Crete and the Greek mainland (and having achieved a decent degree of refinement in the research of polities, it is an over-simplification to discuss interaction patterns of Cretan, mainland and island polities collectively for each area); the examples of the Kythera route and the role of Aegina as a hub are illustrative for alternative routes. (b) Evidence suggests that the three island communities had distinct patterns of economic and trade transactions, suggested by ceramic exchange, and that they were not passively offering 'stop-over' or 'pit-stop' services in the trade route initiated by other "gorillas" in Jones' terms.[23] (c) With reference to Thera in particular, the emphasis on the rise in mainland (from scarce in the MC to numerous in LC I) and Minoan imports overshadows the varied nature of contacts with other Cycladic islands (most notably Naxos) and the southeast Aegean.[24] The Naxian connection as evidenced at Akrotiri goes back to the EBA. It extends and expands in LC I to include a range of vase types as well as loomweights, thus proving to be one of the most stable and enduring connections in the islandscape of the Cyclades. This picture of intense connectivity suggests that Akrotiri was important not because it was a node in the Western string only, but in other 'strings' as well, such as the routes to the north and east. Thanks to the informative work of Jill Hilditch, it emerges that lack of visibility in the ceramic record may overshadow the role of other significant hubs in exchange networks (as is the case with the production and distribution of vases from as yet unidentified major sites in Naxos), some of which may in the future alter our perceptions on fixed 'highways' and linear trading routes (Paros, Andros and Tenos being good candidates).

Ultimately, it appears that the Western String islands did have a special relationship with Crete, but it was not necessarily unique (Schofield 1982, 11) or exclusive of other island communities. More significantly, these communities were not passive recipients of goods and practices, which brings us back to the suggested model of the operation of the harbours of the three settlements as 'ports of call'.

'Ports of call'? Some thoughts on political and economic aspects

Harbour installations, such as shipsheds and structures housing port services of varied nature, have not as yet been identified in the three settlements. Their form and layout can be reconstructed only by comparative evidence from other Bronze Age sites, prominently from Kommos (cf. Shaw, Blackman 2020; Blackman 2011), and also from iconography (Shaw 1990, 430; Televantou 1994, 273). The extent, layout and nature of these facilities remains by necessity conjectural and perhaps it shouldn't be *a priori* considered directly comparable at the three sites; not all coastal Bronze Age sites qualify as sheltered harbours for safe anchorage. The evidence may be lost at Phylakopi and Agia Irini due to erosion and subsidence phenomena. In the case of Akrotiri, it is hard to imagine that the settlement lacked such facilities, possibly to be revealed in the future at the edge of the peninsula flanked by its two sheltered harbours (Doumas 2014). All available evidence converges to suggest that these two ports must have been extremely busy at the onset of the Late Bronze Age, as ports of call for transit ships but also most probably as the base of local Theran merchants, sailors and shipowners. While there is no obvious reason to flatly reject a model whereby port services were offered at the harbours to transit ships, I do not concur with the idea that port fees are the main source of profit accounting for the prosperity of the settlement. Rather, I would suggest from available evidence a model of a mixed economy, including the local production of staples and the operation of small-scale

23 See *e.g.* Davis 1977, on the role of Kea in creating contact and exchange between the Greek mainland and the Cyclades; Marthari 1993, on evidence for the trade route between Thera, Melos, and the northeastern Peloponnese; Berg 2006, 5, on the small number of Minoan imports in Phylakopi possibly implicating Melos as a trading centre geared towards other Cycladic islands, rather than to Crete.

24 Detailed qualitative and quantitative study of ceramic assemblages highlights interesting facets of inter-island ceramic exchange patterns (see *e.g.* Nikolakopoulou 2019a; Mathioudaki 2019; Hilditch 2019; Mathioudaki, Nikolakopoulou 2018; Abell 2016; Abell, Hilditch 2016; Gorogianni 2016). Most of the Naxian vases imported to Akrotiri are undecorated containers or cooking pots, imported for their contents and the specific fabric quality for fire-related use respectively, while Theran vases exported to Naxos were predominantly serving/drinking decorated fineware. Interaction between Agia Irini and Akrotiri perhaps involved processed materials and finished products, and their respective ceramic containers. Large vases in distinctive Kean Plain/Burnished and Yellow Slipped wares, perhaps with their contents, were traded for the distinctive Dark-on-Light or Bichrome serving jugs and cups so typical of Thera, most likely imported for their socio-cultural associations for the people of Agia Irini.

industries, with excess and most probably main income generated by the maritime activity of Therans as skilled seafarers and trading partners (see Doumas 1986).

In this suggested scheme, there is more than explaining away the source of prosperity by substituting one component of the model, Jones' port fees, with another, income from professional maritime services. I find Jones' assertion that "little is lost empirically and much is gained analytically by further simplifying the geographical setting into a single, small island and a much larger trading partner representing the combination of Crete and the Mainland" rather misleading: it ignores refined evidence and relevant studies on the complex nature of political and social organisation in each area, identity, inclusion and exclusion strategies, as well as the social dimensions of trading activities (see *e.g.* Berg 2006 on the notion of active Minoans *vs.* passive islanders). Crete and mainland Greece do not operate as entities, neither in geographical nor in socio-political terms. Admittedly, the scope of one paper is too narrow to discuss trade parameters (who initiates and regulates the exchange, who is travelling, what is the role of freelance merchants, what is the currency used); at the same time, oversimplification leads to false assumptions. With relevance to our specific topic and the suggested excess income from port fees, the question raised for Akrotiri is rather obvious: which are the (political) authorities charging, collecting and allocating the fees? Given that acquisition and conspicuous use of imported/prestige objects, considered together with other evidence for material culture of high quality/expertise, appears to have been generally affordable to various degrees by a wide cross-section of the population, it is hard to envisage individual entrepreneurship in managing the function of the port. And since there is no evidence as yet for the nature of the ruling person/institution/body and administrative practices,[25] I tend to favour the scenario that the source of the distributed wealth lies in maritime activities of skilled Therans operating either as freelancers or under a regulated scheme for the needs of a strong prime mover, as was Knossos in the Neopalatial period.

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25 For a recent discussion on the evidence from seals and sealings found at Akrotiri see Karnava 2018.

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A RESPONSE TO DONALD W. JONES, THE WESTERN STRING IN THE LATE MBA AND LBA I-II: POPULATIONS AND ACCOUNT BALANCES MODELS

I am very much in two minds about this exercise in modelling the late MBA-early LBA economies of the Western String communities of Akrotiri, Phylakopi and Agia Irini. I welcome attempts at formal modelling, accepting that models are not primarily intended as descriptions of reality, but are simplifications, to serve as tools for thinking. One of their particular strengths is challenging us to think clearly about the specific questions we are trying to address, the nature of the processes we are trying to understand, and the data most relevant to address the question. In this case, the question is clearly formulated: how were these communities in the western Cyclades so prosperous in this period? But the model is not clearly stated, though elements are defined mathematically in footnotes 14-33, potential alternative processes are only cursorily considered, and while much data is discussed in the article, little relevant to the model is adduced that can be incorporated into, or be used to test the model. The network model developed by Knappett and colleagues is criticised on precisely the grounds that no relevant data is specified (p. 109), yet I find that a more effective tool for thinking, while agreeing it would be more informative and convincing

if relevant data were explicitly explored. The present model also stays at a very intuitive level. But most problematic for me, it seems to assume most of what it should be trying to assess, and alternative processes tend to be dismissed by assertion, rather than through convincing arguments. The notional tests describe the situation, but do not actually test the model, since there are no criteria that monitor changes in port services.

A contrast is drawn between a model and an analogy, and the latter dismissed (p. 108 n. 13), though the real criticism is about how effectively the relevance of an analogy is established, not about analogical argument per se. But in fact, the present model is argued for the case study, as an analogy – there is no direct archaeological evidence for port services in the Aegean Bronze Age. These are assumed to be relevant by analogy with other, later contexts in other cultures, where such services were significant.

Archaeological evidence

The article assembles lots of quantified information, but little of this can be distilled into data directly relevant to the model. A particular problem is defining data that allow valid comparisons between the sites, or through time. Regularly, absolute values are used, but these presuppose comparable sampling. Often percentages will be more appropriate, but their value depends on being based on large, representative and reliable samples. As always, we have to work with the data available, but we also need to be critical about how we use them, recognising their limitations. Too often in comparisons in various arguments, absence of evidence (arguably because of inadequate samples), is treated as evidence for absence. As an example, at each site, far more of the late MBA/early LBA levels have been exposed than earlier contexts. The sudden increase in quantities in individual categories of material in these extensively exposed late phases cannot be assumed to be significant, so the abundance of balance weights in the later levels at Agia Irini or Akrotiri is hardly surprising. To be an effective comparison, some standardisation would be required. A first approximation might be by density relative to exposed trench area of each phase, or volume of excavated deposit, but in each case the formation processes of the deposits sampled, collapse debris vs floors gradually replaced and likely cleared in the process, would also be relevant. As another example, while large areas were cleared in the early campaigns at Phylakopi, an analysis of the weaving equipment, not surprisingly, indicates that recovery during the early excavations was very dependent on artefact size (Cutler et al. forthcoming). While the 1970s excavations had reliable recovery, and the sample of over 30,000 LC I-II sherds analysed gives us some confidence, in fact only a few small trenches were actually excavated, so we have little idea of how representative that sample is. The small amount of metallurgical debris recovered in that excavation is hardly surprising from such small trenches, and cannot be used in any direct comparison with the very extensive exposures at Agia Irini. It is extremely unlikely that such material would have been recognised and retained in the original, far more extensive excavations, so no useful comparisons can readily be made with other sites, or other phases at Phylakopi.

Similarly, with so little excavated area at any other sites of this phase on the other Cycladic islands, the dearth of Aeginetan wares, mostly only recognised recently, cannot be considered particularly conclusive. Or that no monumental architecture or fresco fragments have been recovered at any site of this date on Naxos is hardly surprising, when the only extensive excavation has been at Grotta, only exposing a small segment of that community.

Finally, the thrust of the investigation is about through trade between Crete and the mainland, but much of the discussion focuses on imports at the three main sites. These are essentially the pieces that escaped from the through trade under study. We have no effective way to monitor the through trade, and particularly, the volumes of that trade, necessary to establish its significance. Instead, a major trade in Attic silver is imagined, for which there is very little evidence. The volume of through trade and its significance, at the core of the argument for the demand for and value of port services and their contribution to local wealth, simply has to be assumed.

Without any direct evidence for port services, the structure of the argument is through a process of elimination. Two potential sources of wealth are proposed, port services and agriculture, though a third, local craft production for exchange, is also considered. Since port services and the volume of through trade that might justify these cannot be monitored, the argument is made by dismissing the other two options (p. 93). Further

possibilities, such as local trade of products within the Cyclades, the exploitation of other mineral resources (volcanic on Thera and Melos, widely exploited in antiquity; metals on other islands of the Western String), or even inter-island agricultural exchange (documented as significant in later periods, e.g. Reger 1994), are dismissed or not considered. So by a process of artificial elimination, port services are presented as the only explanation left standing.

Were these communities exceptionally wealthy?

The starting question is how to explain the wealth of these three communities. But were they really so wealthy? We have no excavated contexts where we could expect wealth to have been concentrated and deposited, such as rich elite graves. At Agia Irini and Phylakopi, house contents were likely salvaged after local destructions, so the only ideal context for recovering such materials would be Akrotiri, though even there, the ruins were in the process of being salvaged following the precursor earthquake(s). So the argument depends on the preserved architecture, and its embellishment, with frescoes and architectural details. House A is the largest so far defined at Agia Irini, and given its position, does seem likely to be the focal house in the community. It was elaborated through time, so investment was cumulative, and the investment of labour and skill in its construction is not demonstrably exceptionally greater than for other structures. The status came from demonstrating awareness of Minoanised architectural features, not the skilled quality of their execution. At Phylakopi, the Pillar Rooms Complex goes back to the MC period, so again elaboration was incremental and cumulative. The Mansion remains enigmatic, poorly preserved and disrupted with limited documentation in the 1911 excavations. Its identification relies on the Linear A tablet (discovered in a later context and it need not have been used anywhere near its recovery context), and the possibility that the court in front of the later Megaron, with its well, might go back that early as a public focus (Whitelaw 2005). There are no Minoanised features or architectural refinements in its construction, and no fresco fragments were recovered to indicate decorative elaboration. At Akrotiri, several houses stand out because of their ashlar construction, though most houses look prosperous to us because of their frescoes. In many cases, the frescoes and some Minoanised architectural elaborations appear to have been added during the refurbishment of earlier houses, so labour investment was again cumulative.

Frescoes were far more abundant at Akrotiri than at any other sites of this period, and they appear to have been valued differently. On Crete, representational frescoes are generally restricted to larger, more elaborately constructed houses. At Akrotiri, one wonders whether they were much more common because of different local sumptuary conventions, or simply to enable the maintenance of the specialised skill-set on the island. But it is not clear that we can so readily interpret these as demonstrating exceptional wealth in comparison with other communities.

In terms of construction potentially indicating wealth, we need to calibrate these structures against others in their communities, in which case they do not seem so exceptional, and in terms of the labour and skills to construct them (cf. Devolder 2013). Detailed analyses have not been done, but estimated labour inputs for Cretan examples correspond well with building footprint and storeys, so there seems no clear basis for considering these structures particularly exceptional. Any such assessment depends on the number of workers involved, and the period of time over which construction and elaboration took place. This applies equally to the estimates of the labour involved for the fortifications at Agia Irini and Phylakopi (pp. 115, 117-118, 123). The fortification at Agia Irini may originally have surrounded the peninsula (Mourtzas, Kolaiti 2016), requiring more labour, but could have been constructed in segments, over multiple years. At Phylakopi, we cannot at present date the construction of the fortification (Whitelaw 2005). It may go back into the MC period, and again could have been constructed in multiple phases over many years; certainly the internal casements are a later addition, as were some of the external bastions spreading the labour demands over time, not considered in Cook's quantification (2014).

So were these communities exceptionally wealthy, to a degree that cannot be explained in purely local terms? This is asserted, not demonstrated. It is worth bearing in mind the scale of palatial establishments on Crete, for example at Gournia and Petras, that could be supported from relatively small communities with limited agricultural hinterlands (Whitelaw 2017).

How important was the through trade between Crete and the Greek mainland?

This is argued to be based around the supply of mainland metals to Crete, from Attica. Much has been written about the importance of metals, particularly bronze, in the prehistoric Aegean (for a summary, see Wiener 1991; Stos-Gale 2000). But it is also worth tempering these arguments; little attempt has been made to estimate actual consumption levels. The Jn series of Linear B tablets at Pylos give us an idea of the palatial control over the distribution of at least some copper, though this does not demonstrate, as sometimes assumed, that this was a palatial monopoly. This may, arguably, be the disbursement of a single consignment or ship-load, but we do not know how many such consignments the palace acquired and distributed annually, so itself gives us no sense of the quantities of new metal introduced to the production system annually. But most activity by village smiths would be melting and recasting broken bronzework, requiring limited new metal. Metalwork was removed from the system through loss, and through purposeful deposition, for example on the mainland, in burials. This was not a traditional Cretan behavioural pattern, until a short phase involving limited numbers of warrior graves or burials with bronzes, particularly in LM II-IIIA1. So while assumed (along with an undocumented trade in silver) as the principal driver for through trade and port services, the volume of such trade is the crucial variable, is unknown, and needs further critical consideration.

How important were harbours on these islands?

In this period, Aegean ships appear to have been relatively shallow-draught vessels, usually assumed to have been pulled-up on the beach, rather than requiring built harbour facilities. The ship sheds documented on Crete were for protecting ships, for example over-wintering, not harbour facilities (Shaw 2019). The harbour claimed at Agios Theodoros near Nirou Chani on Crete (Marinatos 1925-1926), is a quarry, subsequently flooded by coastal subsidence.

More important for the development of sites as roadsteads or harbours may have been access to water and food for provisioning crews, so the limited on-board space could be used for cargo. The Great Bays of Melos and Kea were famous medieval and early modern harbours, because of the shelter they could provide to deep draught vessels, and for Kea, access to a perennial river behind Koressos. One of the few recent wells on Melos is near Phylakopi, and the well in the courtyard at Phylakopi indicates a high aquifer in that area in the Bronze Age, that may have been attractive for supplying ships. But both Melos and Kea were important in recent centuries, particularly because of their positions at access points to the Cyclades, for shipping coming from outside the Aegean to pick-up local pilots to navigate through the islands. But such knowledge would not have been so essential for local, island-hopping navigation.

So the significance of these sites is unlikely to have been as harbour facilities, requiring construction and maintenance, but as fairly low level provisioning services, requiring little or no infrastructure or organisation. How important such services would have been is directly dependent on the volume of such trade, for which no evidence is adduced.

Fundamental to the argument as stated, but not actually essential, is the idea that these were the only coastal communities along the proposed Western String route. It is further assumed that they were in competition with each other for custom. It seems much more likely that they were all used as stop-overs for island-hopping, along with as yet unknown coastal locations on Siphnos, Seriphos and Kythnos, islands that have not been as intensively investigated as Melos and Kea. In addition, multiple potential stop-overs would be necessary for sitting out storms and heavy winds, which in limited experiments, accounted for half of total travel time through the Cyclades (Cariolou 1997; Tzala 1989).

For Melos, Cherry's transect survey was selective, but in combination with Mackenzie's and Renfrew's earlier extensive explorations, we can be relatively certain that there are no other major sites of this period on the island. All of the sites that were more than 3ha, documented by the intensive survey, were already known. For Kea, the intensive surveys in the south of the island directed by Mendoni, have not been published, but I recall some reference in discussions at the Kea-Kythnos conference (Mendoni, Mazarakis Ainian 1998) to prehistoric sites in the south.

It would be surprising if there was not a significant site in the Poisses valley, and the existence of the Classical city at Karthaia indicates that a major community could support itself, even in that much smaller valley system. But much of Kea is dominated by steep slopes that could not have been cultivated without extensive agricultural terracing. The distribution of Archaic to Hellenistic sites in north-west Kea does not suggest that there was extensive terracing even then (Whitelaw 1998). While MBA to LBA terraces have been documented on Crete, they seem confined to very marginal landscapes, where there was considerable pressure for agricultural land. The distribution of small LC I sites, probably farmsteads, identified by the north-west Kea survey, indicates a direct association with low-slope land (Whitelaw 2000). Thera is documented as having additional communities (Davis, Cherry 1990), and its likely fairly low relief, probably allowed more extensive and dispersed occupation.

So this was unlikely to be a three-player, zero-sum game. Other coastal stops would not necessarily take custom away from these sites, but supplement them, facilitating island-hopping.

Alternative sources of wealth than port services

The model identifies three alternative options for wealth generation: supplying port services, agriculture, and given less attention, craft production (*passim*). These options are treated as competing for labour, but both sailing and agriculture in the Aegean are highly seasonal. There is overlap between some labour-intensive agricultural activities and the sailing season, but the severe conflicts will be for those adults actually involved in maritime activities taking them off-island for substantial periods. Shore-based activities could be scheduled around each other, so the principal difficulty would be if such port services were constant and engaged a considerable proportion of the available labour. Neither has been established, and seem extremely unlikely.

Craft production is far less seasonal, though potting is often seasonal in the Mediterranean, to ensure pots dry. But the sorts of cottage industries documented most clearly at Agia Irini, could well have been pursued seasonally around the other labour demands, as well as by diverse members of a household. So the fundamental assumption that these activities were in competition for labour, seems unrealistic and unjustified.

Agriculture as a contribution to community wealth

There are two elements to the author's arguments against agriculture as a local source of wealth. The first relates to the low populations of each island, and the second to the low surpluses possible from agriculture in marginal Mediterranean environments. Both are valid concerns, but neither is considered in detail and there are qualifications for both.

The survey of Melos, as noted above, probably gives us a pretty good idea of the overall settlement pattern on the island. It seems unlikely that more than half the site at Phylakopi has been lost to coastal erosion, given the minimal loss over more than a century since initial excavation, and doubling the site area would suggest a maximum population for Phylakopi and the island of perhaps 800-1,000 individuals. In this case, the limitations on island agricultural production will be labour, rather than land (Whitelaw 2000). For Kea, as I have noted, there will be other settlements of this period on the island. Excluding any villages on the scale of Agia Irini that might exist in the south of the island, the landscape, as in north-west Kea, will have seen farmsteads or small hamlets on pockets of low-slope land, which could have added several hundred more island inhabitants, to the 200-250 or so likely to have occupied Agia Irini. The extent of Akrotiri is not well documented, and published speculations about its population have little firm basis. But the island is likely to have been relatively heavily populated, relative to the other two islands. So what about the "skimmings from their production" (p. 91)? Traditional accounts of Aegean agriculture (*e.g.* Halstead 2014), indicate that taxation of subsistence farmers on the order of 10-20% was generally sustainable, suggesting that for Melos and Kea some 50-200 individual's worth of basic subsistence resources could be extracted annually as surplus. The question then is whether this could support the limited elite in each community in the style to which they were accustomed, as well as supporting the labour and other resources contributed to public works annually. Even if elite households were larger than average, due to better nutrition, increased infant survival and often younger marriage so longer reproductive periods, this surplus is not obviously insufficient for

the wealth actually documented in these communities. We can add to this supporting communal works, even for exceptional and very infrequent labour demands such as fortification construction, spread over multiple years.

It should also be considered that agriculture can be pursued through a variety of intensive or extensive strategies (Davis 1991), so productivity is not fixed, and can respond to changing requirements, inter-generationally even changing labour availability through increased or decreased numbers of offspring.

Historically, Cycladic island populations were able to pay taxes at these rates, as well as support local elites, and often multiple monasteries (Davis 1991). In the early modern period, this would have been supported by larger populations, cultivating heavily terraced landscapes. But considered from both sides (lower assessment of the exceptionality of wealth, and agricultural surpluses), the case needs to be made, rather than assumed, that local agriculture could not support the archaeological record of consumption and investment we have from these sites.

It is assumed that with competition for labour for port services (questioned above), these sites would all have had to import foodstuffs, also it seems, assumed from some distance. If true, this could actually be local provisioning within the islands (see Reger 1994 for the example of Hellenistic Delos). Long distance, large scale provisioning with staples seems unlikely, given the high bulk, relatively low value of goods involved. Some shipment through the southern Aegean of agricultural produce seems to be documented from the Early Bronze Age, given the Cycladic transport vessels found at Poros on Crete (Wilson *et al.* 2008), and from Amorgos on Samos (Menelaou, Day 2020), and represented by the coarse ware stirrup jars shipped from Crete to the Greek mainland in the LM IIIB period (Haskell *et al.* 2011). But the examples of the latter inscribed with place names in Linear B, suggest this is a distinct or value-added product, with the inscription essentially serving as branding, distinguishing locality-specific products. Earlier transport containers demonstrate a longer history for such trade (Pratt 2016; Day *et al.* 2011).

Craft production as a contribution to community wealth

Craft production is recognised, but not considered a likely contributor to community wealth. I expect that most sites probably were able to provide most of the craft items that most individuals required, that they could not make themselves. These would be basic products produced by local potters, metalsmiths, leather tanners, and perhaps limited finer carpentry and basic stone vases. Anything more complicated, including any elite fine goods, would almost certainly need to be imported, since there would not be sufficient demand in an island population of 500-1,000 to sustain the volume to enable a crafter to learn and maintain their expertise. We might expect each household to undertake basic textile production for most of their everyday needs, but interestingly, this seems not to have been the case by the period under study, with each household not equipped with their own set(s) of loomweights (Cutler 2012). So some village-scale specialisation is implied, with one household supplying at least several others. But recent work has demonstrated that like potting on the wheel, fine textile weaving on the warp-weighted loom would have required an extended period of learning (Cutler 2019). The evidence from Akrotiri that a few households had concentrations of loomweights and that more than one loom may have been in use in a house at the same time, may indicate some degree of specialisation (Tzachili *et al.* 2015).

The possibility for trading such craft products seems to be dismissed, on the grounds of a 'coals to Newcastle' argument, that there would be too little differentiation between local products to generate any value. The concentration of light loomweights for producing fine textiles at Cretan north-coast communities, suggests a focus on production aimed at export (Cutler 2012). While sail production has been suggested at Akrotiri (Vakirtzi 2019) and might apply to other coastal communities, historically, looser and heavier weaves are used for sailcloth (*e.g.* Wild, Wild 2001). In addition, the widespread adoption of Minoan styles of products and production, indicates there was extensive demand for novel or simply different products. For pottery, this may have been satisfied, once local potters on individual Cycladic islands adopted the new production techniques, though we see a continuing trade in non-container vessels, suggesting such imports were valued in their own right. Interestingly, the pattern of exotic clay fabric loomweights continues through the period; it does not drop-off once the new weaving technology was widely adopted throughout the southern Aegean (Cutler 2012). This suggests a continuing significant degree of mobility among weavers, moving novel ideas among communities. The fact of the exchange of such mundane

products as everyday pottery indicates this was a source of value. While documented that this occurs, there is only limited quantification of the volumes of such trade, which will be necessary to argue for, or as the author does, against, assuming this trade was significant.

The case of widespread evidence for metalworking at Agia Irini is noted, but the quantities involved are not considered sufficient to account of the wealth of the community. But this pattern is exceptional among contemporary Aegean communities, so the occupants involved considered it worth investing the labour. But how significant it was, depends on the amounts processed, which we have no evidence for – we simply know it was undertaken widely (Abell 2020). We do not have a basis for assessing how significant it was to the community or an individual household's economy, but equally, without such information we cannot, as the author does, dismiss it as unimportant.

Conclusions

For the reasons stated at the start, I laud the author's approach, but for the reasons laid out in the remainder of this comment, I do not find the actual exemplification convincing. I think it sets too high a bar, in assuming rather than demonstrating a high level of wealth in these communities. The explanation of choice (port services) is never clearly explained, and some alternatives are considered but over-readily dismissed, with the presumption that this therefore only leaves the explanation of choice. Since port services cannot be monitored directly through the archaeological data, but are simply assumed, this is only a valid approach if all other alternatives have been thoroughly considered and eliminated, which they have not. In this short comment, I have not developed an alternative interpretation, but I have pointed at ways that one might be able to develop better understandings of the options.

Returning to my original point about models, they are intended to be simplifications, that provide tools for thinking. In this case, by making a generally explicit argument, the author has identified an interesting question and opened it up for serious consideration. But I think the assumptions involved in the present argument need to be more explicitly and systematically spelled out, so they can be addressed critically, and more effective investigations defined and relevant arguments developed. Whether it will ever be possible to slot evidence-based values into the formal model, I am doubtful. But there is also value in the author's approach to use such a model more heuristically, to explore the relative contributions of different components. Some of the suggestions sketched here may point at ways to explore some of these further considerations.

Note: Unfortunately, this comment takes the form of an essay, rather than documented argument, due to difficulties accessing specialist literature during the Covid lock-down of 2020-21. While apologetic, I would note that most of the points I am particularly critical about, are where the author himself asserts his view, rather than arguing it in detail, so in a sense this is something of a reaction in kind.

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A REPLY

Two themes run through these comments. First, the model doesn't include enough – where are the craftspeople at Agia Irini? What about all of the evidence for specialized industrial activity at Akrotiri, especially the textile production, and what about Theran seafarers? Phylakopi doesn't rate such what-if treatment, possibly because of extensive erosion. Second, the assumptions aren't true. Of course they aren't. If they were, I wouldn't have needed to assume them. Milton Friedman's article, The Methodology of Positive Economics (1953), published nearly 70 years ago, codified the long-held tradition in economics of judging models by their predictive ability rather than their realism.[1]

But before turning to the commenters' discussion of the model's predictive performance, I address some reasoning behind what is and isn't in the model beyond the explanations presented in the paper. In their industrial and craft activities, these small populations were competing against quite a number of equally small as well as larger populations. Competition drives down profits, the lower limit being virtually nothing beyond what is required to stay in business. Even if we believed that some of these craft/industrial activities faced no off-island competition, opening the possibility of their earning rents, we need to consider two factors: 1) they may have competed among themselves in a single town, driving down rents; and 2) to assess the importance of this source of wealth, we would need unobservable evidence on the relative magnitude of the sources of rents: craft profits and port profits. The competition these three islands' port services experienced was primarily among themselves, with locational differences offering something between monopolistic and oligopolistic profit opportunities. The ports were used by many more people than there were residents of the islands, increasing the scope for pure profits to someone on the islands.

Most of the comments devote less critical attention to the model's predictive performance than to its comprehensiveness or fidelity to reality. The principle objection is to my measurement of wealth, primarily the architecture and wall paintings. Those remains distinguish these three island towns from other island towns as well as many mainland towns of the time. What alternative indicators of wealth should or could I have used, or is the concept unmeasurable even in the non-quantitative method I adopted? Abell offers some direct attention to the model's predictive performance: expansion of House A at Agia Irini during LC II and wall paintings in several houses dated to the same period; and the construction of the megaron at Phylakopi during LC III, the largely Mycenaean period on that island. Cummer and Schofield report some 10 rooms constructed in House A early in Period VII, but it is not clear to what extent they added to net usable floor space or even continued in use, with the basement in "too

1 InvisibleHandWaving (2015) offers an accessible explanation of Friedman's arguments.

ramshackle a condition to entrust with the large-scale storage of supplies" (Cummer, Schofield 1984, 32-33). The new wall paintings indicate some kind of remaining optimism and ability to pay. As I said, it can take a while to run down accumulated wealth. At Phylakopi, the Reshef figurines suggest that the new Mycenaean occupants of the town likely had searched out new trading venues, propping up the town's economy for a while. Neither my model nor my application of it to these two islands implies a temporal uniformity in response to the Thera explosion, particularly as I noted the intervention of other influences outside the model. I brought up the reference to multiple regression in the summary as an example of a method of holding constant the influence of factors outside or at the perimeters of a model – although the data requirements are far beyond what we could hope for in archaeological work (with the exception of some commodity price data from Neo-Babylonian sites).

The stubborn preference for the Knappett and Rivers network model of the entire Aegean shipping map over my model of the very specific issue of three islands' apparent wealth baffles me in light of my precise descriptions of, shall we say, its "limitations."

A theme that is absent from these comments is, "How can archaeologists use this model to study the economics of these three islands?" And, "Are there other issues that could benefit from such single-case modeling?"

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