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UNIVERSITY OF SOUTHAMPTON

FACULTY OF HUMANITIES

Archaeology

Examining Late Antique Trade Through Geospatial and Network Analysis: A Case Study Using Marble Chancel Screen Panels.

by

Nicholas W. Dugdale

Thesis for the degree of Master of Philosophy

November 2017

UNIVERSITY OF SOUTHAMPTON

ABSTRACT

HUMANITIES

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EXAMINING LATE ANTIQUE TRADE THROUGH GEOSPATIAL AND NETWORK ANALYSIS: A CASE STUDY USING MARBLE CHANCEL SCREEN PANELS.

Nicholas W. Dugdale

In this thesis, geospatial, network, and statistical analysis techniques are applied to a dataset of marble chancel screen panels in order to investigate the relationship between transaction costs—specifically, shipping cost and transit time from the quarry—and the distribution of marble objects across the Mediterranean world during the Late Antique Period (roughly, the 4th-6th c. A.D.). The aims of this thesis are (a) to better understand the roles of private enterprise and the state in the production and export of marble in Late Antiquity; and (b) to test the utility of geospatial modeling programs such as *ORBIS*: *The Stanford Geospatial Network Model of the Ancient World* as tools for analyzing patterns of economic interaction and connectivity.

First the quantitative data generated using geospatial and network analysis tools can be used to analyze the relationship between market considerations and transaction costs and the demand for a particular economic commodity—here, worked marble objects. The results of this case study, although preliminary, suggest that the distribution of some types of marble architectural elements was correlated with transport cost and time from the quarry, with the majority of exports falling within clearly defined cost/time thresholds. These findings lend support to the argument that private enterprise and the laws of supply and demand played a more important role in the Late Antique economy than has been suggested, and hint at the existence of a thriving non-imperial market for marble operating alongside—and often overlapping with—the imperial system.

Second, this thesis represents one of the first attempts to utilize a geospatial analysis tool like *ORBIS* in concert with archaeological evidence to assess patterns of economic interaction and connectivity in antiquity. Accordingly, it is hoped that the methodology developed herein can be applied in future studies to analyze the distribution of other types of marble architectural element as well as a variety of archaeological materials for which there are existing datasets, such as ceramics, metal objects, shipwrecks, and foodstuffs.

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DECLARATION OF AUTHORSHIP

I, Nicholas W. Dugdale

declare that the thesis entitled

Examining Late Antique Trade Through Geospatial and Network Analysis: A Case Study Using Marble Chancel Screen Panels.

and the work presented in the thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

- this work was done wholly or mainly while in candidature for a research degree at this University;
- where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
- where I have consulted the published work of others, this is always clearly attributed;
- where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
- I have acknowledged all main sources of help;
- where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
- none of this work has been published before submission.

Signed: ……..

Date:……

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Marble chancel screen panel discovered during excavations on the Marzamemi B Shipwreck, July 2014. Courtesy of Justin Leidwanger/ Marzamemi Maritime Heritage Project.

Chapter 1. Introduction

1.1 Statement of Purpose

This thesis applies a combination of geospatial modeling and network analysis techniques to a locational dataset of marble chancel screens in order to investigate the relationship between market-based considerations—namely, shipping cost and transit time—and the distribution of these objects across the Mediterranean world during the reign of the Emperor Justinian I (r. 527-565). This approach is intended to accomplish several distinct aims. First, geospatial modeling and network analysis tools can effectively "connect the dots" between marble quarries and consumers across the Mediterranean, and thereby serve as a window onto the complex network of ports and communities that comprised the distribution network for marble in late antiquity. Second, the quantitative data generated using these tools can be used to statistically analyze the relationship between transportation costs (specifically, shipping expense and transit time from a known point of origin) and the demand for a particular economic commodity—here, worked marble objects. It is hoped that these findings will shed new light on the respective role of the state versus that of private enterprise in the market for worked marble, as well as the role of the state in the Late Antique economy in general. Lastly, while this thesis focuses on marble, it is hoped that the methodology developed herein can be applied in future studies to analyze the distribution of many other types of archaeological materials for which there are existing datasets, such as ceramics, metal objects, shipwrecks, and foodstuffs.

1.2 Background

Marble was a valuable economic commodity over which the Roman state exerted significant influence, both as a primary producer and consumer.[1] From the reign of Augustus (r. 27 B.C.- A.D. 14) through the 7th century, the Roman imperial administration controlled a network of at least eleven imperially-owned quarries across the Mediterranean (the '*ratio marmorum'*) where vast quantities of valuable stone, including purple porphyry from Egypt, *africano* and *giallo antico* from North Africa, green *breccia* from Thessaly, *pavonazzetto* from Phrygia, and various types of white marble from Carrara, the Aegean islands, and Asia Minor, were quarried under the supervision of Roman quarry administrators.[2] This material was then exported by ship—first to Rome, and later to

[1] See, e.g., Fant 1988c.
[2] Id. at 152.

Constantinople—for use in imperially-financed building projects including forums, triumphal arches, municipal buildings, temples, and, later, churches. As J.B. Ward-Perkins has shown, these monuments played a vital role in establishing and conveying a shared, coherent language of imperial authority throughout the Roman world. [3] Starting in the High Imperial period (1st to 2nd centuries A.D.), a familiar panoply of marble columns, capitals, porticoes, and decorative motifs referred to by Ward-Perkins as the "marble style" could be found virtually anywhere one travelled in the Roman Empire, from Britain in the West to the deserts of Jordan in the East, serving as a visible, tangible expression of the broad reach of Roman authority. [4]

Marble continued to play an equally pivotal role in the articulation of a Roman imperial ideology in the Late Antique period (roughly, the 3rd through the 7th centuries A.D.). Although an economic and political crisis triggered a decline in marble production in the first half of the 3rd century, demand for marble, particularly in the East, resumed as the economy regained momentum under Diocletian (r. 284-305).[5] Marble took on new significance in the 4th century as part of a new imperial ideology based on the Christian faith promulgated by Constantine I (306-337 A.D.), who adorned a number of imperially-sponsored churches and monuments across the Roman Empire with marble architectural elements carved with Christian iconography.[6] Much like the "marble style" of the 1st and 2nd centuries, by the 6th century certain types of marble architectural elements including acanthus leaf and basket capitals and ecclesiastical furniture (e.g., ciboria, altars, and ambos) as well as marble panels decorated with Latin crosses, christograms, and geometric, floral, and animal motifs comprised a distinctly Constantinopolitan iconographic repertoire that was immediately recognizable as an articulation of Roman authority.[7] The use of these marble architectural elements in imperially-sponsored building projects reached its apex under Justinian I, who used vast quantities of imported marble, columns, capitals, and chancel screens to decorate the Hagia Sophia in Constantinople (532-537 A.D.) as well as hundreds of other churches and public buildings

[3] Ward-Perkins 1951.
[4] Id.
[5] Sodini 1989.
[6] For example, Constantine I constructed the porphyry Column of Constantine (330 AD), which was surmounted by a marble statute of Constantine holding an orb said to contain a fragment of the True Cross, as well as the churches of the Holy Apostles (c. 330 AD) in Constantinople, the Holy Sepulchre in Jerusalem (335 AD), and St. Peter's Basilica in Rome (c. 326-360 AD). Eusebius Caesariensis, *Vita Constantin.*
[7] Sodini 2002; Alpaslan 2001.

across the Mediterranean world as part of an ambitious vision of a "unified empire pleasing to god."[8]

Economic historians have frequently pointed to the linkage between state-sponsored quarries and these types of imperially-financed building projects as an indication of a high degree of state intervention in the marble trade.[9] However, the attention paid to this state-level activity has meant that the private market for marble has largely been overlooked by much of the extant literature. Although imperial consumption undoubtedly accounted for a sizeable proportion of demand for marble during this period, the archaeological and textual evidence indicates that a thriving commercial market for marble also existed throughout the Roman and Late Antique periods. For example, Roman elites (many of whom were also members of the Imperial administration) chose to decorate their personal villas with imported marble from the 1st century A.D. onwards, while wealthy Romans also developed a voracious appetite for mass-produced marble sarcophagi from quarries in Asia Minor and the Aegean beginning in the 2nd century A.D.[10] There is also abundant evidence for the mass-production of certain types of architectural elements (e.g., capitals, columns, chancel screen panels) alongside custom elements intended for monumental architectural projects.[11] This indicates that there was a market for cheaper, standardized (rather than custom-produced) marble objects, many of which not only were used in imperially-funded buildings, but were also incorporated into a wide range of privately or locally-sponsored projects across the Empire.

Due to this heterogeneous nature of the marble market, the study of marble objects and the ways they were distributed can therefore shed light on the respective roles played by private consumers and the state both in the marble trade, as well as the Roman and late antique economy more broadly. The marble trade in the Roman Imperial period has seen a significant rise in academic interest in recent years, and archeological excavations of quarries and advances in archaeometry mean the exact quarries from which individual marble artifacts originated can now be identified.[12] However, significantly less scholarship has been devoted to understanding the dynamics of the marble trade in late antiquity (roughly, the 3rd to 7th centuries A.D.), after the Empire's capital moved east from Rome to Constantinople. Accordingly, this thesis aims to fill the gaps in what is still a relatively

[8] Maas 2005: 14; Procopius, *De Aedeficiis.*
[9] See, e.g., Harvey 2008.
[10] See, Ward-Perkins 1992; Walker 1988.
[11] See, e.g., Asgari 1988; Pensabene 2002.
[12] See, e.g., Russell 2013b.

understudied area of Late Antique economic history, while also serving as a case study for the application of geospatial modeling techniques to archaeological datasets.

1.3 Research Methodology

The primary assumption upon which this thesis is based is that the private exchange of a given commodity—in this case, marble— would have been more sensitive to cost considerations than large-scale imperially-funded transfers, particularly those in which the state acts both as the supplier and consumer. This assumption is based on several underlying principles. First, in the case of a state-controlled industry, a private consumer would have had to pay the going market price for a given piece of marble, while the only expense the state would have incurred when obtaining marble from its own quarries were the costs of extraction, carving, and export.[13] Thus, the cost of a given marble object to the state would be significantly less than the cost to a private consumer. Second, the principle of "economies of scale" holds that the cost per unit of output of a given commodity generally decreases with increasing scale, as fixed costs of production are spread out over more units of output. These costs are then reflected in the price charged to the consumer. Thus, the cost of producing one individual object—e.g., a column capital— for a private consumer would have been much higher than the cost per unit of producing 500 of those same capitals for an imperial building project. Lastly, while the amount of marble that individual consumers—even the most well-off of Romans—could afford was necessarily limited by the size of their personal wealth, the massive tax revenues that flowed into the Imperial coffers allowed the state to fund projects that would have been far too expensive for any one private citizen to bankroll. Accordingly, in a market driven purely by private exchange, it is anticipated that the geographical distribution of a commodity would be inversely correlated with cost and transport time (that is, the quantity of a commodity will decrease as transport cost/travel time from the center of production increases), because private consumers are more sensitive to incremental increases in price. Conversely, in a market in which all consumption is driven purely by state subsidies or coerced exchange, it would be expected that little to no correlation would be observed between cost/transit time and the distribution of a commodity, because these factors would have little to no influence on the state's demand for marble. The reality is most likely somewhere in between these two extremes; however, some preliminary conclusions may be drawn based on how closely the actual observed distribution patterns fit either of these two templates.

This thesis tests the hypothesis that while the state accounted for some of the consumption of worked marble during this period, the private market accounted for the majority of marble exports. Based on the assumptions outlined above, we would therefore expect to see an inverse correlation between distribution and cost (that is, the quantity of marble objects will decrease as transport cost/travel time from the quarry increases), albeit with a few notable outliers that are potentially indicative of imperial, "no-expense spared" consumption (here, defined as greater than five chancels at any given location, although this distinction is, of course, somewhat artificial).

To test this hypothesis, this thesis employs a combination of geospatial modeling and network analysis to investigate an existing dataset of one type of 6th century A.D. marble chancel screen panel, of which hundreds of examples have been identified at 96 sites throughout the Mediterranean basin. The decision to focus on marble panels, as opposed to other architectural objects (e.g., columns, capitals, etc.) was made for multiple reasons. First, the relatively large sample size makes it a useful dataset for statistical purposes; second, a number of examples have been subjected to chemical provenance testing;[14] third, the Early Christian iconography that differentiates this type of screen is highly recognizable, making them easy to identify and dateable to the middle of the 6th century A.D.; and, lastly, the relatively small size of each screen (roughly two meters long by one meter high) means that no expensive specialized equipment (e.g., cranes, wagons, etc.) would have been required to load or offload them from a ship, as would have been necessary for large columns or other bulky objects.

Using the locations and quantities of the artifacts contained in this dataset, a specialized geospatial modeling tool called *ORBIS* was used to generate the optimal route by which each of these objects would likely have travelled from the center of production (in this case, the island of Thasos) to the centers of deposition where they were found, as well as to estimate the journey distance, transport time, and relative financial expenditure associated with the export of each shipment.[15] This data was then aggregated to generate a complete distribution network for this type of marble object, which could then be aggregated and quantitatively analyzed using a variety of methods including betweenness centrality, a network analysis metric that measures the extent to which a node lies on paths between other nodes in a network.[16] Finally, the "cartogram" function of *ORBIS* was used to

[14] See, e.g., Attanasio et al. 2008.
[15] Accessible at: http://www.orbis.stanford.edu.
[16] Preiser-Kapeller 2013.

generate network visualizations distorted by either time or cost from the center of the network as well as heat maps in which each color band represents an increment of time or expense. Using the data from the route simulations, combined maps could be generated showing the geographical location, quantity, and travel time/cost from Thasos for each chancel screen site. These maps provide a much more useful visual representation of the connectivity costs associated with marble transport than could be provided by conventional means.

1.4 Preliminary Findings

The results of this case study suggest that the distribution of marble chancel screen panels is closely correlated with overall transport cost and trip duration from their center of production, with the majority of specimens falling within a clearly defined cost/time threshold. Beyond this boundary, the number of specimens drops off dramatically, with the exception of a few outliers lying well outside these thresholds. Some other notable anomalies that emerged from this case study include sites with extremely large concentrations of panels (for example, Constantinople, Ravenna, and Venice), as compared to the majority of sites at which only a few individual chancel screens were identified. These results must, of course, be qualified by the inherent limitations of using archaeological datasets, which are often corrupted through looting or spoliation—that is, the removal of marble architectural elements or other materials for use in another building—as well as destruction by war, vandalism, forces of nature, or any number of other factors.[17] Accordingly, while archaeological datasets can serve as a rough proxy by which to investigate "big picture" questions given a large enough sample size, they cannot be considered to represent true indications of the quantity and range of material that would have existed in antiquity.

With these caveats in mind, these findings lend support to the hypothesis that the private, non-state market actually accounted for a much greater percentage of marble production and exchange than has previously been thought. Although there are examples of conspicuous imperially-sponsored consumption of marble in this case study (for example, the Hagia Sophia in Constantinople), the general picture that emerges is one of a thriving non-imperial market for marble, in which many cost-conscious private (or ecclesiastical) consumers were purchasing and importing small quantities of pre-fabricated marble

[17] See, e.g., Greenhalgh 2009.

objects from the quarries and workshops at Proconnesus and Thasos to sites across the Mediterranean basin. At this non-state level, the production, exchange, and distribution of marble appears to have been highly responsive to market pressures, including the cost and time involved in the transport of goods from the producer to the consumer. Against this backdrop of relatively low-level, market-based exchange, the type of conspicuous, state-level activity that has traditionally been seen as the norm perhaps ought instead to be regarded as distinctly anomalous, both in terms of scale and expense.

These results, although limited to one dataset, (1) present a new methodological approach for analyzing trade and connectivity in antiquity using archaeological datasets, (2) provide grounds to revisit the question of state versus private involvement not only in the marble trade, but in the late antique economy, generally, and (3) underline the need to undertake more analyses using similar methodologies on other kinds of archaeological datasets, such as other types of marble elements, ceramics, metal objects such as coins, shipwrecks, and even foodstuffs.

1.5 Roadmap

The remainder of this thesis proceeds as follows. The next three chapters seek to situate this thesis into the current academic discourse on the Late Antique period (2nd- 7th c. A.D.), the Late Antique economy, and the marble trade. First, *Chapter 2* presents the rationale for studying late antiquity, discusses recent scholarship concerning the Late Antique period and its economy, and provides a brief survey of some of the major events and trends in during this period that relate to the focus of this thesis—namely, the distribution of marble in the 6th c. A.D. *Chapter 3* then discusses major developments in study of the ancient and Late Antique economies, and argues that this thesis should be understood against the backdrop of a moderate expansion of trade and economic activity in the 4th through 6th centuries, which resulted from decreasing transaction costs and a growing network of land and sea routes. *Chapter 4* summarizes existing scholarship on the marble trade in antiquity and late antiquity. Next, *Chapter 5* makes the case for why a geospatial modeling approach to the ancient and Late Antique economy is appropriate, and discusses some of the most promising archaeological applications of network analysis tools such as *ORBIS*, the program used for this case study. *Chapter 6* presents the chancel screens case study that forms this thesis' original contribution to the field, offers some preliminary conclusions that have emerged from this research, and identifies further directions in which this work could be taken in the future.

Chapter 2. Recent Trends in Late Antique Studies

2.1 Introduction

This dissertation focuses on the trade in worked marble in the Eastern Roman, or "Byzantine," Empire during the reign of the emperor Justinian I (r. 527-565). There is significant disagreement amongst academics as to what nomenclature is most appropriate when referring to this transitional period in history. While some scholars have used the term "Byzantine" to refer to the period following the founding of Constantinople in A.D. 303 at the site of the Greek colony of Byzantium until the fall of Constantinople in 1453, some Roman historians instead describe the 4th and 5th centuries as the "later Roman Empire," and only use "Byzantine" starting with Justinian's reign. Others have argued that the true beginning of the Byzantine Empire should be fixed as late as the 7th century, when the cultural and institutional restructuring of the Empire after the Arab Invasions caused a decisive break in eastern Mediterranean "Romanness."[18] In order to avoid such confusion, this thesis seeks to avoid using the term "Byzantine" where possible, and instead follows Averil Cameron and others who refer to this period as "late antiquity."[19] Late antiquity is typically defined as the age lasting from the reign of Diocletian (r. 284-305), who partitioned the Roman Empire into two halves, until the death of Maurice in 602, which marked the start of a century of political and economic turmoil.[20] As Cameron argues in *The Mediterranean World in Late Antiquity*, using the term "late antiquity" consciously invokes the significant cultural and political continuity linking classical civilization and the centuries thereafter, and invites the reader to look more broadly—both geographically and chronologically—at the complex forces, events, and trends that defined this fascinating period in history.

The first half of this chapter presents the rationale for studying late antiquity and discusses recent scholarship on late antiquity and the Late Antique economy. Although late antiquity was dismissed for many years as the beginning of an economic and cultural 'dark age' in Europe, the nascent field of Late Antique Studies has witnessed a surge in popularity as a new generation of scholars including Averil Cameron, John Haldon, Michael McCormack, Cécile Morrisson, Paul Magdalino, and Angeliki Laiou worked to revitalize the period's

[18] See, e.g., Heather 2006.
[19] Cameron 1993; 1996.
[20] The death of Maurice in 602 marks the end of the Justinian Dynasty in the East, and has been traditionally used by Byzantinists to signify the historiographical boundary between the Early and Middle Byzantine Periods. Cameron 1993.

tarnished image. This thesis seeks to build on their foundational work and further advance the development of the field by applying new quantitative methodologies to investigate the role of the state in the Late Antique economy. The second half of this chapter contains a brief survey of the major geographical, political, and social developments during this time period that relate to the focus of this thesis—namely, the distribution of marble in the 6th c. A.D.—beginning with the institutional reorganization of the Roman Empire after the so-called "Crisis of the 3rd Century" (235-284) and ending with the Arab invasions in the early 7th century, which saw the closure of the marble quarries as part of a wider decline in trade and shipping throughout the region.[21]

2.2 Trends in the Study of Late Antiquity

Thanks largely to its relatively recent rise in popularity, Late Antique Studies constitutes one of the "last frontiers" in which exciting and valuable new information is constantly being discovered in a wide variety of areas, from literature and epigraphy to archaeology, which has seen a huge surge in interest in the Late Antique period, particularly in the Eastern Mediterranean. For example, at any given excavation a half-century ago, material from the 4rd to 6th centuries would often be discarded into the spoil heap in order to reach the deeper, "more interesting" Roman and Greek layers that lay below. However, in the last few decades, archaeologists have begun to pay much greater attention to Late Antique material culture. For example, an accurate chronology can now be established as a result of a concerted effort to date and identify Late Roman pottery at a number of sites across the Mediterranean, including Caesarea Maritima[22] (Sebastos), Portus and Ostia, Alexandria, Corinth, and Carthage.[23] This growing body of material evidence indicates that the Late Antique period was hardly "a mere appendage to classical glories," but was actually "a period of spectacular prosperity and splendor" that deserves the type of serious scholarly attention that has long been reserved for classical antiquity.[24]

The relative lack of interest in late antiquity until recently can largely be attributed to the influential English historian Edward Gibbon (1737-1794), who argued that the dissolution of the Western Roman Empire in 476 marked the end of the Roman Empire, and dismissed

[21] While the economic impact of the Arab invasions is touched on again briefly in subsequent chapters, it should be noted that thesis is concerned primarily with the political economy of the Late Roman Empire at its height in the centuries before (rather than after) this major turning point in its trajectory, and thus any historical events or developments beyond the mid-6th century are dealt with only in passing (if at all).
[22] See, e.g., Blakely 2013.
[23] See, e.g., Reynolds 1995.
[24] CAHXIV xvii.

the Eastern Empire as ruled by despots and "in a state of premature and perpetual decay" from the reign of Arcadius in A.D. 395 to the taking of Constantinople by the Turks in 1453.[26] Gibbon's narrative was largely unchallenged until well into the 20th century,[27] when Belgian historian Henri Pirenne argued that the real break in Roman history occurred as a result of the Arab invasions in the 8th century, which put a halt to international trade and commerce in the Mediterranean.[28] But while the so-called "Pirenne thesis" was revolutionary, it was also controversial and failed to attract a major following during his lifetime.

In the 1960s and 1970s, the publication of several foundational works on late antiquity signaled the beginning of a renewed interest in the period. The first of these, A.H.M. Jones' exhaustive and carefully researched political and economic survey *The Later Roman Empire, 284-602* (1964), examined the workings of all areas of Late Roman society, politics, and economy, including the government, central administration, and judicial institutions, courts, the army, the church, cities, education, and religious observance.[29] Jones' magnum opus was hailed as an "intellectual triumph" when it was first published, and remains the most extensive study of the Late Roman Empire half a century after its publication.[30] Jones' work was followed several years later by Peter Brown's cultural history-focused *The World of Late Antiquity* (1971), which revolutionized the way late antique history was studied, taught, and perceived. In contrast with Gibbon's stark portrayal of late antiquity as a period of widespread economic and political decline, Brown painted a vibrant picture of the Late Antique as a period of intoxicating cultural and social transformation.[31] Brown can be also credited with popularizing Pirenne's controversial claim that Roman cultural traditions had endured in the Western provinces well beyond 476, even under their new "Barbarian" rulers. But where Pirenne's earlier

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[26] Gibbon 1804. Gibbon's narrative of progressive decline was informed both by his own distaste for Byzantine history and literature as well as by the 18th century Enlightenment philosophers, who saw the Byzantine Empire as corrupt, despotic "other" against which the "enlightened," Western, civilized Romans were to be contrasted. For example, one of the most vociferous critics of Byzantine history was Voltaire (19769), who declared it to be a "worthless collection [containing] nothing but declamations and miracles. It is a disgrace to the human mind." Voltaire's view was shared by Montesquieu (1734), who described the Byzantine Empire as "a tissue of rebellions, sedition and treachery," and determined that the only way such a corrupt and backwards Empire could have survived for so long was due to "unusual outside causes."

[27] Runciman 1933: 109. While J.B. Bury's *History of the Later Roman Empire,* published in 1923, challenged Gibbon's argument that Christianity was the cause of Rome's decline, it still adhered to the same overarching "decline and fall" narrative proposed by Gibbon over a century earlier.

[28] Pirenne 1939.

[29] Sarantis 2008: 1.

[30] Brown 1967.

[31] Cameron 1993: 6.

work had met with a great deal of resistance, the release of *The World of Late Antiquity* came in the midst of a broader movement both in classical studies and academia toward a more socially and culturally-based understanding of history, and inspired a new generation of Late Antique and Byzantine historians whose innovative work has given us a deeper understanding of the political, social, and economic contours of the fascinating period of history known as the Late Antique period.

In the years since Brown's *The World of Late Antiquity,* some scholars have adopted a similar, cultural history-based approach to argue for a more optimistic conception of late antiquity. For example, the Marxist historian Chris Wickham has argued that many Roman institutions endured in the West well into the 7th century, and were gradually assimilated into the political and social fabric of successor states in Western Europe. [32] A number of other scholars have also expanded upon—as well as challenged—Jones' arguments in *The Later Roman Empire* through their work on trade and the economy. Important works in this area include Michael Hendy's scholarship on Byzantine money, which has shed light on the role of the state in the economy,[33] Cécile Morrisson's publications on coinage, trade, markets, and transaction costs in the Byzantine period, [34] Alan Harvey and Michael Kaplan's work on the Byzantine agrarian economy,[35] Michael McCormick's work on ships, traders and markets,[36] and John Haldon's numerous articles and books on roads, commerce, and the state administration in the Late Roman world. A great deal of scholarship on the Late Antique economy by these authors and many others was compiled by Angeliki Laiou in the *Economic History of Byzantium from the Seventh through the Fifteenth Century* (2002-2008), a three-volume study that examines the structures and dynamics of the economy and the factors that contributed to its development over time.[37] There have also been several colloquia devoted to trade and the economy in late antiquity in recent years, including two at Oxford in 1999[38] and 2004,[39] in Vienna in 2005,[40] and at Dumbarton Oaks in 2008, which brought archaeologists and historians together to share their work on the movement of goods within the Byzantine world on markets at various

[32] See, e.g. Wickham 2010.
[33] Hendy 1985; 1989.
[34] Morrisson 2012a, 2012b.
[35] Harvey 1989, Kaplan 1992.
[36] See especially M. McCormick 2001, 2012.
[37] Laiou 2002.
[38] Kingsley and Decker 2001.
[39] M. Mango 2009.
[40] Kislinger et al. 2010.

levels, especially at the regional scale.[41] The consensus that has emerged from these conferences is that the Late Antique and Byzantine economy was a network of interconnected relatively "free" markets, which lasted—albeit in reduced form—well into the "dark" 8th century.[42]

2.3 Historical Survey of the Later Roman Empire, c. 235-602 A.D.

The network of interconnected markets that comprised the Late Antique and Byzantine economy were limited by government regulation and controls (e.g., taxation), as well as geographical and ecological constraints. These constraints changed dramatically over the course of the Late Antique period due to the contraction and expansion of the Empire's borders, as well as instability caused by a number of political and social upheavals. Thus, before moving on to a discussion of the Late Antique economy (*Chapter 3*) and the market for marble during this period (*Chapter 4*), it is helpful to first undertake a brief survey of some of the major geographical, political, and social developments that shaped the environment under which these markets operated.

2.3.1 Crisis of the 3rd Century (235-284)

Many scholars have argued that the major reorganization of the Roman Empire under the emperor Diocletian (r. 284-305) marks the "beginning" of late antiquity; however, in many ways, this transitional period began half a century before Diocletian came to power, when the murder of the emperor Alexander Severus by his own troops triggered a period of severe political turmoil and economic depression that threatened to destroy the empire. Severus' violent death in 235 was followed by a period of infighting between generals of the Roman army, leading to a series of emperors whose domestic power struggles left the provinces vulnerable to frequent raids by the Carpians, Goths, Vandals, and Alamanni in the West and the Sassanians in the East. For a brief period beginning in 260, the empire even split into three competing states, until Aurelian (r. 270–275) embarked on a series of reconquests that culminated with the reunification of the Roman Empire in 274. But while Aurelian managed to restore the empire's borders to their previous extent, a number of major challenges to imperial rule remained. In addition to ongoing uncertainty regarding the rules for succession, the unwieldy size of the empire made it extremely difficult for a single ruler to assert far-reaching control. This was compounded by a spiral of inflation due to the debasing of coinage by the various rival Emperors and usurpers, who had minted their own coins to pay soldiers and public officials for their loyalty by using base

[41] Morrisson 2012a.
[42] Morrisson 2012b.

metals to reduce the underlying metallic value of coins. This resulted in a reduction in the silver content of coins from about 40 percent in A.D. 250 to less than 4 percent in A.D. 270.[43] As Keith Hopkins has shown, this debasement and inflation was not matched by an equivalent increase in taxation, which led to a total breakdown in the Roman fiscal system. As the central government found itself unable to meet its obligations of paying soldiers and government officials at inflated prices, they had taken it upon themselves to secure their own supplies, meaning that the central government could no longer control local rates of taxation through its agents. This, combined with the general insecurity posed by border instability, almost certainly resulted in a decrease in the volume of inter-regional trade and a "period of economic depression" in the mid-3rd century. This argument is supported by a significant drop in the number of shipwrecks found that date to this period as compared to the previous century, as well as a decrease in number of charitable foundations, incised tombstones, and new public buildings (except for defensive town-walls) in provincial towns.[44]

2.3.2 Diocletian and the Tetrarchy (284-305)

In response to these challenges, the emperor Diocletian (r. 284-305) embarked upon a series of radical reforms that drastically changed the organization and administration of the Empire and restored central control over the economy. In 286, Diocletian appointed Maximian as co-emperor ("Augustus"), who would govern the western half of the empire while he oversaw the eastern half from Nikomeideia, in what is modern-day Turkey. In 293, Diocletian further delegated power to two junior co-emperors ("Caesars"), Constantius I under Maximian and Galerius under Diocletian, with the intention that they would eventually succeed Maximian and him as Augusti. Thus was born the "Tetrarchy," or rule of four, who would rule over the empire for the next decade.

While it lasted, the Tetrarchy was quite successful in restoring and maintaining political stability, despite the foreseeable problems that one might expect to emerge from such a power-sharing arrangement. In practice, each of the emperors ruled over their zones of influence with relative autonomy from their respective seats of government at Nicomedia (Diocletian), Sirmium (Galerius), Mediolanum (Maximian), and Augusta Treverorum

[43] Hopkins 1980 at 123.
[44] Id.

(Constantius); however, laws issued by one emperor were also implemented throughout the empire, thereby ensuring a degree of uniformity of administration.[45]

In addition to the division of power amongst the four tetrarchs, this period saw a major reorganization and expansion of the imperial bureaucracy. Among other reforms, Diocletian and his co-emperors greatly reduced the geographical area of the provinces, meaning that they roughly doubled in number, while the number of soldiers and imperial officials increased significantly.[46] The imperial taxation system was also greatly reorganized during this period in order to offset the costs of the expanded military and civil bureaucracy. Many of the institutional reforms implemented by the tetrarchs, as well as the *de facto* quartering of the Empire into four distinct administrative regions, would endure well beyond the demise of the Tetrarchy itself. However, many of Diocletian's efforts at economic reform—for example, the Edict on Maximum Prices and Currency Decrees issued in 301 to combat rising inflation—were essentially ignored by the end of his reign due to the continued mass minting of coins of low metallic value, as well as the Edict's disruptive effect on trade and commerce, especially among merchants.[47]

2.3.3 Constantine I (r. 306-337)

In 305, Diocletian and Maximian voluntarily abdicated their positions and were succeeded by Galerius and Constantius, as Diocletian had planned; however, Constantius died just one year later, triggering a new struggle for succession in the West. Eventually, Constantius' son Constantine I emerged victorious from the fray, having defeated Maximian's son Maxentius at the battle of the Milvian Bridge in 312. Constantine went on to seize control of the Eastern provinces from Licinius in 324, thereby becoming the sole ruler of the entire Roman Empire. Soon thereafter, Constantine began the construction of a new political and administrative capital on the Bosphorus, signifying a major shift in political and economic influence from West to East. While the tetrarchic emperors had established provincial administrative capitals outside of Rome (e.g., Galerius at Thessalonica; Diocletian at Nicomedia), the new city of Constantinople was intended to be a "new Rome," equipped with its own senate and all the trappings of a true imperial capital. Constantine also developed a centralized bureaucracy, expanded the army, and

[45] Greatrex 2008: 233; Jones 1964: 41; Carrie and Rousselle 1999: 148.
[46] Greatrex 2008: 324; Jones 1964: 37-60; Campbell 2005: 120-6; Carrie and Rouselle 1999: 160-90; Garnsey and Hunfress 2001: 36-41.
[47] Corcoran 2000.

created a new set of tax collection procedures across the Empire.[48] In the area of imperial finances, Constantine's most notable contribution was the creation of a stable gold coin, the solidus. However, even this failed to fully halt the inflationary pressures that had plagued the Empire for most of the last century.[49]

In addition to his administrative reforms and the founding of Constantinople, Constantine I is best known as the "first Christian Emperor." Although a great deal of controversy still surrounds the timing and reasons behind Constantine's own conversion to Christianity, he can be credited with initiating an official imperial policy of tolerance towards Christians, who had previously existed as an illegal and often persecuted minority, as well as undertaking an extensive church construction program across the Empire (particularly in Constantinople). Constantine was also not averse to involving himself in church affairs, and on occasion called together a council of Bishops to pass judgment on matters of Christian doctrine. The most important of these was the first ecumenical council of Nicaea in 325, which resulted in the first uniform declaration and summary of the orthodox Christian faith (the "Nicene Creed"). Constantine's enthusiastic involvement in ecclesiastical affairs redefined the role of the Roman Emperor in society, who "came thus to function not only as the secular ruler of the Empire, but also as the head of the Church."[50] Although the religious function of the Emperor had declined in the West by the 5th century, Constantine's successors in the East continued to act as the final arbiter of theological disputes, convene ecumenical councils, and issue doctrinal edicts until the final collapse of the Byzantine Empire in 1453.[51]

2.3.4 Theodosius I (r. 379-395) and Successors

The death of Theodosius I (r. 379-395) was another pivotal period in the history of the Later Roman Empire. Initially appointed as co-ruler by Gratian, Theodosius eventually became sole ruler of the Empire after defeating the usurpers Magnus Maximus and Eugenius. As well as building a number of churches, public buildings, and forums in Constantinople[52] (see especially the forum of Tauri, Theodosius' historiated column, and the obelisk of Theodosius, which still stands today), Theodosius' enduring legacy was the

[48] Greatrex 2008; cf. Carrié and Rousselle 1999.
[49] Jones 1964: 97-109; Barnes 1981: 255-8; Bagnall 1985; Hendy 1985: 426-7; Carrié and Rousselle 1999: 259-63; Chastagnol 1994: 197-202.
[50] Greatrex 2008: 237.
[51] Greatrex 2008: 237; Frend 1972: 54-62; Barnes 1981: 208-44; Millar 1977: 577-607; Lane Fox 1986: 609-62; Dagron 1996: 141-8; Drake 2006.
[52] Dagron 1974: 436-87; Meyendorff 1989: 179-84; Maraval 1998: 102-4; Leppin 2003: 188-201; Errington 2006: 229-30.

establishment of Nicene orthodox Christianity as the official state religion, as decreed in the Edict of Thessalonica. Theodosius also convened the first ecumenical council of Constantinople in 381, which denounced Arianism and other heresies and pronounced the Bishop of Constantinople to be second in precedence only to the Bishop of Rome. In addition to these attempts to unify the East and West under Nicene orthodoxy, Theodosius also came down hard on those who had not converted to Christianity, breaking up pagan associations, authorizing the closure and destruction of pagan temples, and issuing a law banning the public practice of all non-Christian religious customs.

But while Theodosius' reign is remembered primarily for his persecution of Christianity, it was his death in 395 that would have the greatest impact on the future of the Empire. From the time of Diocletian (r. 284-305), the Empire had been a unified entity spanning from Britain, Germany and Gaul in the west to the borders of the Sassanian Empire in Persia to the east.[53] But upon Theodosius' death, these territories were divided into two distinct administrative entities, with his youngest son Honorius (r. 395-423) ruling the western half from Milan (and later, Ravenna), and his eldest son Arcadius (r. 395-408) ruling the eastern half from Constantinople. From this point forward, the two halves of the empire responded very differently to a number of external as well as internal pressures. Most significantly, the Greek-speaking eastern half of the Empire proved to be much more resistant to incursions by the Germanic tribes to the North than the already-weakened government in the West. The result was that "the institutional and administrative structure of the 4th century empire remained more or less intact in the east" until the Persian and Arab incursions in the early 7th century.[54] In contrast, the western provinces had already been destabilized by a spate of invasions and civil wars in the 3rd century, as well as by the disastrous defeat of the Roman army at Adrianople in AD 378. Centuries of mounting barbarian pressure finally culminated when the last Roman emperor to rule from Ravenna, Romulus Augustus (r. 475-476), was deposed by a coalition of Germanic tribes in 476.[55] By onset of the 6th century, the two prefectures that had once made up the Roman Empire in the West (Italy, including North Africa, and Gaul, including Britain) had been lost entirely, leaving just two praetorian prefectures under Roman control: Oriens, which

[53] Cameron 1993: 2.
[54] Id.
[55] The year 476 has often been fixed as the "end date" of the Roman Empire in the West; however, as a number of scholars have shown, AD 476 has no significance in the context of the economic and social changes that were taking place in the period, and indeed it is doubtful whether even the population of Italy at first noticed much difference. Jones 1964; Cameron 1993: 33; See also Kagan 1978; Rollins 1983; Tainter 1988: 128-52.

extended from the Balkans through Asia Minor and the Levant to upper Libya in Africa; and Illyricum, encompassing what is now Greece and the Balkans.[56] Yet despite these major losses, generations of emperors at Constantinople continued to see the lost western territories as an integral part of their realm, albeit one that was temporarily outside of their direct authority.[57]

2.3.5 Justinian I (r. 527-565)

The desire to reassert Roman control over the entire Mediterranean prompted the Emperor Justinian I (r. 527-565) to expend vast sums of state resources in an ambitious attempt to reconquer the lost territories in the West. Justinian's *renovatio imperii* began with his general Flavius Belisarius' recovery of North Africa and Carthage from the Vandals in 533-34, followed by a prolonged and extremely expensive effort to subdue the Goths in Italy (c. 535-550). These military campaigns in the West brought significant territory back under imperial control: at its maximal extent at the middle of the 6th century, Justinian's Empire had expanded to include much of North Africa, Sicily, Italy, Sardinia, Corsica, the Balearics, and southern Spain. These new territories were re-incorporated into the Empire as the praetorian prefectures of Africa (*Africae*) in 534, with its capital at Carthage, and Italy (*Italiae*) in 537, with its capital at Ravenna. As such, these regions were again subjected—although in some places only briefly—to Roman imperial authority, rule of law, and taxation.

In addition to his territorial ambitions, one of Justinian's primary goals as Emperor was to establish uniform belief throughout the realm, based on the interpretation of Christian doctrine established at the Council of Chalcedon (A.D. 451). Although Justinian never fully succeeded unifying the Roman Empire under Chalcedonism, he "went a long way to define a resilient Byzantine religious culture…rooted in Greek foundation text and intimately linked to imperial authority."[58] The physical manifestation of this effort was an ambitious imperial and ecclesiastical building program, both in the Eastern core of the Empire and across the newly reconquered territories, which articulated his vision of a "unified empire pleasing to god" in a medium accessible to all citizens, regardless of class.[59] This venture was documented by Procopius in *De Aedeficiis*, who wrote that Justinian "built many churches to the Mother of God in all parts of the Roman Empire"

[56] Haldon 2005: 44.
[57] Haldon 2008: 252.
[58] Mass 2005: 15
[59] Id. at 14.

that were so magnificent and expensive that one could be excused for thinking that the Emperor had "spent the whole time of his reign occupied with this alone."[60]

In addition to commissioning thousands of new churches, Justinian is credited with the construction of a plethora of military installations, public buildings and forums, and infrastructural developments (e.g., harbors, roads, bridges, and aqueducts) across the Empire during his reign. However, the costs of Justinian's projects were a major financial drain on the Empire's coffers, and the rural and urban economies of the Italian peninsula were devastated by the constant military campaigns, rendering the region increasingly marginal to imperial interests.[61] Justinian's territorial expansion proved to be short lived: even within his own lifetime, the Empire's borders were already under significant pressure from hostile forces in both the West and the East, and Justinian's expensive territorial expansion in the West had rendered the Empire financially and militarily overextended. Just three years after his death in 565, the Lombards had already regained much of Italy, while the territory that Justinian had conquered in southern Spain was retaken by the Hispanian Visigoths in 624.

2.3.6 The Arab Invasions (7th Century)

By the reign of Heraclius (r. 610-641), a series of ongoing wars with the Sassanians in the East and the residual financial burden of Justinian's largess had left the Roman Empire increasingly vulnerable to invasion, and a sequence of military defeats over a ten-year period resulted loss of North Africa, Syria, Palestine, Mesopotamia, and Egypt to the Rashidun and Ummayad Islamic Caliphates. The loss of these strategically vital territories—which had provided the majority of the Empire's grain supply and tax revenue—dealt a crippling economic blow to the eastern Roman Empire, which was forced to dramatically restructure its fiscal and administrative apparatus in response.[62] The new Arab presence in the Eastern Mediterranean also had a major impact on Roman trade and shipping in the region, and essentially cut Constantinople off entirely from its primary export and import markets around the Mediterranean.

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[60] Procopius, *De Aedeficiis* 1.3.14.
[61] Haldon 2005: 54.
[62] Haldon 2008: 256.

Chapter 3. Contours of The Late Antique Economy

"Le commerce et les échanges ont existé à toutes les époques. Ce qui est en question, c'est leur importance et leur nature."

—H. Pirenne[63]

3.1 Introduction

Any consideration of trade, exchange, or markets in late antiquity must necessarily take place in the context of a broader discussion regarding both the existence and the function of these institutions in ancient and medieval societies.[64] Accordingly, the first half of this chapter discusses major scholarship and developments in this larger debate, particularly as they relate to the role of market versus non-market exchange in the Late Antique economy. The second half of this chapter synthesizes recent work on the Late Antique economy using the analytical framework set out in the *Cambridge Economic History of the Greco-Roman World*, which focuses primarily on the role of transaction costs and underlying social and political institutions. It is argued that the trade in worked marble should be understood in the context of a moderate expansion of trade and economic activity in the 4th through 6th centuries, especially in the eastern Mediterranean. This resulted from decreasing transaction costs, a growing network of land and sea routes, and a period of relative political stability that lasted until the Arab Invasions in the 7th century. This view accords with the argument made by Angeliki Laiou, Jean-Michel Carrié, and Peter Temin that the Byzantine economy was a network of interconnected, relatively "free" markets in which commercial exchange contributed to an increase in productivity, production, and urbanization.[65]

3.2 The Modernist/ Primitivist/ Anti-Primitivist Debate

Economic history is a relatively new and underdeveloped branch of Late Antique and Byzantine studies, but has been significantly influenced by scholarship on the Greek and Roman economies in Classical Antiquity, which has been dominated by the longstanding debate between the so-called "modernists," "primitivists," and more recently, "anti-primitivists" over the nature of the Classical Greek and Roman economies. The disagreement between these camps centers upon two distinct questions: first, does a sector

[63] *Mahomet et Charlemagne* 1937: 219.
[64] Laiou 2002: 681.
[65] Laiou 2002: 688; See also Jean-Michel Carrié, Cécile Morrison, and Peter Temin in *Trade and Markets in Byzantium* 2012.

of the economy exist that is affected primarily by market mechanisms (e.g., the setting of prices through supply and demand) and economic incentives, as opposed to political, social, or administrative considerations? And, second, what is the extent and significance of such a sector in the broader economy?[66] In broad terms, those in the modernist camp believe in the functioning of a market economy in the Roman economy, while primitivists do not. However, within each camp, a number of more nuanced positions have been proposed regarding the extent and significance of the market in the Roman and late antique economy, particularly regarding the role of private enterprise in relation to the role played by the State. Accordingly, this section will outline each of the main positions in this debate, before turning to their application to the Late Antique economy in particular.

3.2.1 The Modernist Position

The debate concerning the relative modernity versus primitivism of the ancient economy dates to the early 20th-century, when proponents of the modernist school of thought argued that the ancient economy could essentially be characterized as a relatively advanced economic system in much the same mold as that of early modern Europe. The modernists, led by Michael I. Rostovtzeff[67] (1872-1952) and Eduard Meyer (1855-1930), pointed to the progress of civilization and the growth in trade in the later stages of classical antiquity as evidence that the Roman economy "cannot be considered modern enough," with the corollary being that the formerly Roman world post-476 was characterized by a decline in economic growth, widespread corruption and patronage, and general economic stagnation.[68]

3.2.2 The Primitivist Position

The modernist approach remained the status quo until the 1960s and the 1970s, when the field was turned on its head, first by A.H.M. Jones' *The Late Roman Economy,* which argued that the Roman economy was driven primarily by rents and taxes derived from farming, and then by the work of his successor at Cambridge, Moses Finley, who is generally viewed as the father of the "primitivist" school of thought. Finley's view was heavily influenced by the work of the sociologist Karl Polanyi, who famously distinguished between "reciprocity," or the movement of goods and services induced by social obligation, "redistribution" of goods and services collected by a center (e.g., a government) to its subordinates, and "exchange," which he defined as a two-way

[66] Laiou 2002: 688.
[67] See especially Rostovtzeff 1926.
[68] Meyer 1924: 141.

movement of goods between people, each of whom seeks to derive profit.[69] Whereas redistribution involves administered trade in which all rules and aims are regulated by the government exchange involves market trade, in which the market is self-regulating and prices are set by supply and demand. Polanyi argued that exchange did not come into existence until the 19th century Europe and North America, and thus modern market-oriented economic theory is fundamentally inapplicable to pre-modern societies.[70]

Finley incorporated many of Polanyi's ideas in his landmark text *The* A*ncient Economy* (1973), in which he rejected the notion that social and economic forms of antiquity were in any way comparable to those of early modern Europe, and instead envisioned the ancient economy as primarily a subsistence economy in which wealth was derived primarily from agricultural production rather than manufacturing or trade, individual farms and towns were highly self-sufficient (*autarkeia*), and interregional commerce was virtually non-existent due to prohibitively high transport costs. In Finley's view, goods were redistributed mainly for social or political reasons rather than traded for profit, while there was minimal division of labor, regional specialization, or technical innovation. Finley argued that market-centered, modern economic theory was fundamentally inapplicable to the study of antiquity, and instead proposed a more socially and anthropologically oriented approach to the ancient economy in which consideration of markets and economic motivations played a very minor role.[71] Together, these tenets make up what is known as the "new" or "Cambridge orthodoxy."[72]

In the years immediately following *The* A*ncient Economy,* a number of Greco-Roman historians adopted and built on Finley's model*,* including Paul Veyne[73] (*Le Pain et le cirque*, 1976), Ramsay McMullen (*Roman Social Relations, 1974*), and Peter Garnsey, whose work focused on the role of the Roman state in the grain trade as evidence of non-commercial exchange.[74] Many of these scholars sought to draw comparisons between the ancient world and other 'archaic' societies, including Richard Saller (*Patronage under the Early Empire*, 1982) who drew comparisons with the Ottoman and Chinese Empires and C.R. Whittaker (1994), who used a model of Chinese history to study the Roman imperial frontier. However, by the mid-1990s there was a growing desire by many in the field to

[69] Polanyi 1944.
[70] Polanyi 1977: 93-6.
[71] Silver 2003.
[72] Andreau 2002.
[73] Veyne 1976.
[74] Garnsey 1983: 118-30; See also Garnsey et al. 1983.

move beyond the primitivist paradigm altogether: as Jean Andreau wrote in 1995, "to continue to contrast, term by term, everything pre-industrial with everything modern, and endlessly to scour antiquity for all possible and imaginable signs of archaism" would result in a reductionist view of history that risked not only "impoverishing historical analysis," but also "providing present day institutions and situations with an intellectual justification which they do not always merit." Accordingly, a new model was needed to "try to define the great original features of the Greek and Roman worlds, whose economies were without doubt historical, pre-industrial and non-capitalist, but could in no way be confused with those of China, medieval Islam or the western Middle Ages."[75]

3.2.3 Alternative Perspectives on the Ancient Economy

Keith Hopkins (a former student of Finley's, and his successor at Cambridge) offered a somewhat different perspective to that of his predecessor in his article *Taxes and Trade in the Roman Empire* (1980).[76] In contrast with Finley, Hopkins allowed for a certain degree of market-based economic growth in his model of the ancient economy. Hopkins argued that while agriculture was the primary driver of the Roman economy, the collection and expenditure of taxes by the Roman state was also an important stimulus to trade. Because the rich inner provinces of the Empire bore the majority of the tax burden, they had to sell produce to the city and the army to raise cash, leading to a massive expansion of trade in the late Republic and early Principate. In contrast with Finley, Hopkins' model of the Roman economy posited an increased monetization of the Roman economy, the commercialization of exchange, an elongation of the links between producers and consumers, the growth of specialist intermediaries (traders, shippers, bankers), and an unprecedented level of urbanization.[77]

Another notable assessment of the role of market versus nonmarket exchange in the Roman economy was offered by C. R. Whittaker, who introduced the concept of "tied trade"—that is, exchange and distribution that is "tied to" centers of authority and economic power that operate outside of the market.[78] In his influential article *Late Roman Trade and Traders*, Whittaker argued that while there may have been some entrepreneurial, for-profit activity in the Late Roman period, this was limited by the intervention of institutions that either bypassed the market or distorted it through

[75] Andreau 2002: 36.
[76] Hopkins 1980.
[77] Hopkins 1980: 102; See also Hopkins 1978.
[78] Whittaker 1983.

discriminatory taxation, privilege and protection.[79] In particular, Whittaker argued that the state, the church, and aristocratic landowners controlled production, received tax advantages, transferred commodities between estates, and sold surpluses through tied agents rather than entrepreneurial merchants.[80] Accordingly, he concluded that the nature of "trade" in the later Roman Empire "turns out frequently not to be either entrepreneurial or strictly commercial," but may rather be described as "exchange and distribution," while traders were "fundamentally agents, dependents or clients of the rich, whose requirements, not abstract economic forces, dictated their activities."[81]

3.2.4 The New Institutional Economics meets the Ancient Economy

Hopkins' work in particular served as the bridge between Finley and the "true" primitivists and a new generation of economic historians including Walter Scheidel, Ian Morris, and Josiah Ober, who have advanced a more nuanced, cautiously optimistic model of the ancient economy that emphasizes the structure of underlying institutions as well as economic performance, and situates Greco-Roman economic developments into a more suitable pre-industrial comparative context. This approach draws heavily upon the work of Nobel Prize-winning economists Ronald Coase,[82] whose work focuses on transaction costs, and Douglass North, who argued that social and cultural institutions shape economic activity, and thus a detailed historical study of institutions is necessary to explain why or how a particular economy developed in the manner that it did.[83] The advantage of situating Greco-Roman antiquity into this broader macroeconomic framework is to show that "[Greco-Roman] economic developments need not be fitted analytically into a context of modernity, of which they generally fall far short when questioned more deeply."[84] Instead,

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[79] Id. at 173.

[80] Id. Whittaker argued that the state controlled long distance trade through *comites commerciorum*, controlled the manufacturing of certain commodities (e.g., cloth and weapons), and gave tax exemptions to *negotiatores*, or traders tied to the court, that were not available to the entrepreneurial merchant. He also pointed to the transfer of commodities between church estates, the commercialization of surpluses by shippers, traders, and *negotiatores* who were tied to the services of the church, and tax exemptions given to the church as evidence of the church's role as an institutional agent of redistribution and exchange. Whittaker made similar arguments in regard to noble landowners, who also received tax exemptions, exchanged the products of their own estates, and sold their surpluses through tied agents, rather than merchants.

[81] Id. at 173.

[82] See, e.g. Coase 1988, 1992, 1994; http://nobelprize.org/nobel_prizes/economics/laureates/1991/coase-lecture.html

[83] North 1990; 2006.

[84] cf. North, et al. 2009: 48-9 on Rome and the absence of a further evolutionary drive towards modern conditions.

"Roman developments can be relocated in a context which allows a more realistic assessment of their 'merits.'"[85]

The "New Institutional Economics" ("NIE") emerged in the early 1990s as a challenge to classical economic models, which Coase and North argued were unable to account for transaction costs as well as the roles played by culture and social organization in affecting individuals' economic choices. Coase and North recognized that markets do not necessarily equilibrate themselves in the manner suggested by mainstream economic theory. Instead, as Coase argued in *The Firm, the Market and the Law* (1988), a number of burdensome "transaction costs"—for example, the expense required to transport goods to market, or information about the relative price and quality of goods—can render it too expensive for economic actors to participate in market-based exchange, meaning that they seek alternative forms of social organization (e.g., a firm) in which transaction costs are less. Accordingly, the transaction costs in a given society can have a major impact the size and makeup of the market; for example, the lower the transaction costs, the greater the degree of market participation one would expect (and vice versa).

Another major flaw in classical neoliberal economic theory, North argued, is that it fails to account for the central role that institutions play in shaping individuals' economic choices and incentives. In *Institutions, Institutional Change and Economic Performance* (1990), North argued that the task of economic history is to explain the structure and performance of economies over time. "Performance," he explained, refers to the typical concerns of economists, such as productivity, the distribution of costs and benefits, or the stability of production. What the NIE added was a focus on "structure," meaning the basic determinants of performance, including political and economic institutions, technology, demography, and ideology. North defined "institutions" as the "humanly devised constraints that structure political, economic and social interactions."[86] Institutions can take the form of formal rules—for example constitutions, laws, or property rights—or informal constraints—for example, sanctions, taboos, customs, or traditions—which help to establish and maintain order in a market or society. These institutions serve as the "rules of the game" that govern individual economic actors' decisions. As all societies exhibit their own unique sets of social and cultural institutions, it follows that no economy ever develops in exactly the same manner as any other.

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[85] Bang 2009: 199.
[86] North 1990.

The NIE framework has primarily been employed to analyze and explain the rise of the modern economy in Europe and the Americas from the Middle Ages through the present era,[87] although it has also been successfully applied to re-examine economic growth in medieval Europe (see especially Avner Greif's comparative study of institutions in Genoese and North African trading societies).[88] Until fairly recently, though, Greco-Roman Antiquity had only been addressed tangentially by the NIE as part of a broader macro-historical discussion concerning the economic development of pre-industrial societies, more generally.[89] This gap was filled by the publication of the *Cambridge Economic History of the Greco-Roman World*, (henceforth "CEHGR") in 2007, which represents the most comprehensive attempt to demonstrate the utility of applying the NIE to analyze economic development in the ancient world. Using the framework developed by North and Coase, Walter Scheidel, Ian Morris, Richard Saller, and their co-authors build a theoretical model of ancient economic behavior based on historical patterns of institutional development, and seek to provide rough estimates of economic performance in antiquity. Unlike the modernists of old, the authors also make a concerted effort to avoid drawing inappropriate comparisons with modernity, but instead emphasize that the relative performance and development of Greco-Roman antiquity is best understood in the context of other pre-industrial societies.

In the introduction to the CEHGR, Scheidel et al. paint a cautiously optimistic picture of the Greco-Roman world as an economic system characterized by moderate long-term expansion, albeit with relatively limited short-term economic growth. In their estimation, the economy of the Greco-Roman world involved "much larger movements of staples through markets, concentrations of people in cities, extensive monetization, and investment in the stock of knowledge." While hardly comparable to the Industrial Revolution in Europe, the editors argue that these developments were unprecedented, and Greco-Roman antiquity should be understood as "one of the strongest economic efflorescences in pre-modern history."[90]

One indicator of economic growth that the editors of the CEHGR highlight in support of this claim is that of population. According to Scheidel et al., the population of the

[87] See, e.g., North and Thomas 1973.
[88] See, e.g., Greif 1994; 2006.
[89] See, e.g., E.L. Jones 1981 for a discussion of technological innovation in the pre-industrial world; North 1981, Ch. 8.
[90] Scheidel et al. 2007.

Mediterranean doubled in classical antiquity, swelling from 20 million people in 800 B.C. to upwards of 40 million in A.D. 200. Certain areas, including the Aegean and Italy, saw even more rapid population growth, while many urban centers (e.g., Athens, Rome, Syracuse) grew exponentially. The editors partially ascribe this growth to a favorable climate and improvements in agriculture, particularly the spread of increasingly intensive dry-grain farming and animal husbandry, but argue that institutional developments aimed at buffering the risk posed by variations in inter-annual rainfall —for example, fragmenting landholdings, diversifying crops, and trading surpluses—can be credited with helping Mediterranean populations to avoid the Malthusian checks of declining living standards and starvation. Indeed, the editors argue that as a consequence of these developments, the Greco-Roman world actually witnessed a slow, but marked, increase in per capita consumption for over a millennium, resulting in a significant increase in living standards throughout the region as well as growing income inequality as the upper classes consolidated their wealth.

Scheidel et al. also argue that, *contra* Jones and Finley, diminishing transport and communication costs resulted in a significant increase in the volume of seaborne trade of staple goods (i.e., food, metals, and stone) in antiquity, meaning that "goods moved around the Mediterranean more efficiently than ever before, and more efficiently than they would do again for several centuries to come" (10). This reduction in transaction costs paved the way for the exploitation of comparative regional economic advantages through private enterprise and markets. However, the editors caution that despite moderate advances in exchange and commercialization, "states remained major economic actors; markets were fragmented and shallow, with high transaction costs; investment opportunities were limited; and money and markers generated intense ideological conflicts," and the ancient economy remained minuscule by modern standards.[91]

3.2.5 The Primitivist/Modernist Debate Applied to Late Antiquity

Although Roman economic history has been the primary battleground for the modernist/primitivist debate, the study of the Late Antique and Byzantine economy was hardly immune. Like their Romanist counterparts, historians of the Byzantine economy can be divided into two broad categories: (1) those scholars who ascribe a preponderant role to nonmarket factors, and (2) those who stress the existence of markets, merchants, and

[91] Scheidel et al. 2007.

economic factors in exchange or in the segment of the economy connected with exchange.[92]

In the 1990s, several Byzantine scholars reacted against the dominant "innocently modernist approach" to Late Antique economic history,[93] and instead sought to apply the so-called "primitivist" paradigm popularized by Moses Finley. For example, Évelyn Patlagean was a staunch supporter of primitivists such as Karl Polanyi, Moses Finley, and Marcel Mauss in her work on social and economic inequality in the Byzantine period.[94] Similarly, in *Studies in the Byzantine Monetary Economy* (1985), Michael Hendy argued that trade was extremely limited, and played no role whatsoever in the Byzantine state's monetary policy nor in its resources and only a minor one in monetary distribution and circulation. [95] In Hendy's view, the primary actor in the economy was the state, which collected surpluses in the form of taxes and redistributed it to the army and the civil administration, while the economy was marked by a very low degree of monetization. Hendy also opposed the application of contemporary economic reasoning to the interpretation of Byzantine monetary policy.[96]

Today, Hendy's view of the Late Antique and Byzantine economy has been largely rejected in favor of a moderately optimistic model that largely mirrors that put forward in the CEHGR. One of the primary advocates for this model was Angeliki Laiou, who edited the hugely influential *Economic History of Byzantium* before her untimely passing in 2008. Like the editors of the CEHGR, Laiou's approach to the Byzantine economy emphasized the role of structures such as institutions, technology, ecology, demography, and ideology. Laiou also recognized the utility of contemporary economic analysis, and argued that basic economic factors that are present in modern economies such as supply and demand, market mechanisms and the profit motive, are "useful in understanding the articulation of the Byzantine economy of exchange."[97] In Laiou's view, all economies are comprised of both market and non-market forms of exchange in varying proportions, and "the difference between [the Byzantine economy] and modern commercial economies was one of degree

[92] Laiou 2002: 690.
[93] Carrié 2012.
[94] Patlagean 1993; 2004.
[95] Hendy 1985; 1989.
[96] Id.
[97] See also Lopez 1959; Oikonomides 1986; Laiou-Thomadakis 1980; Laiou 1995; Morrisson 1994, among others. Significant differences in detail exist in the work of scholars who share this general viewpoint.

rather than of kind."[98] Laiou recognized that the state played a major role in the Byzantine economy through price fixing, taking a portion of production outside the market, as well through auto-consumption.[99] However, she argued that a market economy had also existed since antiquity, and commercial exchange was "the most important aspect of exchange," even if it comprised a relatively small proportion of the overall economy, because it contributed to an increase in productivity, production, and urbanization.

Similarly, in his article in *Trade and Markets in Byzantium*, Jean-Michel Carrié argued that the Byzantine economy was a network of interconnected, relatively "free" markets, in which private actors engaged in commercial exchange for profit.[100] In support of this argument, Carrié pointed to a number of factors that indicate the existence of a market economy, including a high degree of monetization in the 4th century, efforts by the state to limit prices and prevent currency speculation, technological and management innovations (e.g., new techniques for processing glass and producing sigillata ceramics), and the increased professionalization and specialization of handicraft production (e.g., textiles) in urban workshops.

3.3 Markets and Exchange in the Late Antique Economy (4th-6th centuries)

The following section examines the performance and structure of the Late Antique economy using the analytical framework set out in the *CEHGR*, which considers the effect of institutions (including the changing nature of transaction costs and the role of the state), demography (including urbanization as well as settlement density in rural areas), and the "stock of knowledge" (including technological advances and communication and transport costs) on economic development.[101] Applying this approach, it is argued that the 4th through 6th centuries witnessed a moderate expansion of trade and economic activity, which resulted from decreasing transaction costs, a growing network of land and sea routes, and a period of relative political stability that lasted until the Arab Invasions in the 7th century. This view agrees with the argument made by Angeliki Laiou and Jean-Michel Carrié, that the Byzantine economy was a network of interconnected, relatively "free" markets in which commercial exchange contributed to an increase in productivity, production, and urbanization.[102] Finally, it is argued is that relative performance and

[98] Laiou 2002: 688.
[99] Id.
[100] See especially Carrié 2012, Morrisson 2012b, Temin 2012.
[101] Morris et al. 2007, in Scheidel et al. 2007.
[102] Laiou 2002; See also Carrié, Morrison, and Temin in *Trade and Markets in Byzantium* (Morrison 2012).

development of the Late Antique economy is best understood in the context of the moderately optimistic model of the Greco-Roman economy set out by the *CEHGR*. Such a comparison is beneficial because many of the parameters that bounded economic activity in the period covered by the CEHGR (e.g., geography and climate) remained the same in late antiquity—thus, effect of changes in non-fixed variables such as demography, institutions, and the stock of knowledge on economic development can be more readily discerned.

3.3.1 Transaction Costs

Compared to the volatility and economic uncertainty that characterized the 3rd century, the relatively stable conditions that prevailed in the eastern part of the Late Roman Empire from the 4th to the mid-6th century were highly favorable for economic activity.[103] As was discussed in *Chapter 2*, the 3rd century (235-284) was plagued by ongoing political instability and the threat of foreign invasions. The resulting uncertainty and lack of security caused a major increase in transaction costs: farmers did not know if their crops would be destroyed by barbarian invaders or rival armies, while traders did not know if their goods would be seized while in transit by sea or by land. As a result, there is evidence of a marked decrease in the volume of inter-regional trade and a "period of economic depression" in the mid-3rd century. By the beginning of the 4th century, economic conditions had begun to improve.[104] Transaction costs decreased significantly as a degree of political stability and security returned under Diocletian and the Tetrarchy, while a growing network of secure land and sea routes in the eastern Mediterranean facilitated greater interregional commerce.

3.3.2 Role of the State

The state directly intervened in the Late Antique economy in at last three respects: by levying taxes, by providing services (primarily through maintaining an army), and by issuing coinage.[105] However, the ability of the state to intervene in the economy fluctuated significantly over the course of the Late Antique period, which had major repercussions for commercial exchange and economic development as a whole. For example, the debasement of the Roman currency in the 3rd century made commercial exchange increasingly difficult, because prices fluctuated so drastically.[106] Public spending also

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[103] Id.
[104] Harvey 2008; Cf. Chapter 2 of this thesis.
[105] Laiou 2002: 685.
[106] Cf. Morrisson 2002.

shrank due to the government's inability to collect taxes during this period. Although it did not fully curb inflation, Constantine's re-monetization of the economy using the gold *solidus* as its basis introduced a standard measure of value that was transferable across markets, which had the effect of reducing information asymmetries between economic actors and increasing consumer confidence.[107]

It has also been argued that the state intervened in the economy price fixing, taking a portion of production outside the market, as well through auto-consumption—that is, by consuming the goods that it produced on its Imperial estates.[108] For example, it has been argued that large quantities of African pottery found in Italy and southern Gaul are the the product of internal exchanges of oil, garum, and other commodities between Imperial estates, rather than external market-based transactions.[109] The question of just how great of an impact this less direct form of State intervention had on the economy is particularly relevant when discussing the marble trade, because the State was both a primary producer of marble through its network of Imperial quarries (See *Chapter 4*, below), as well as a major consumer of the material produced at these quarries.

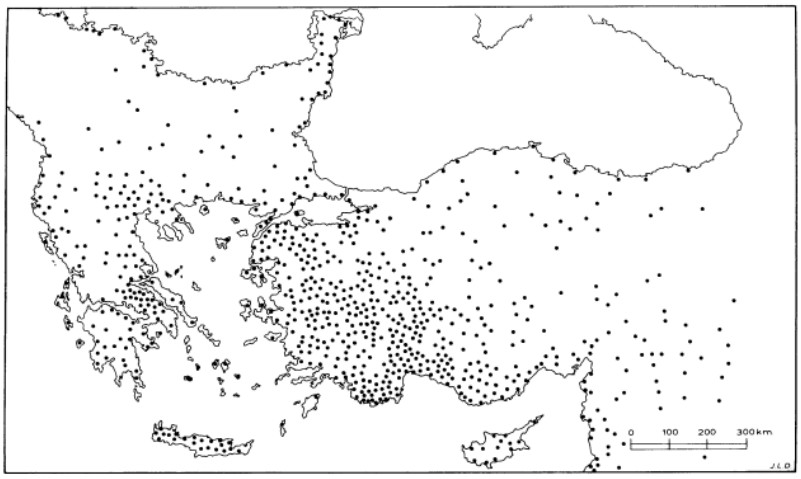
3.3.3 Population Growth and Urbanization

Demographic evidence suggests that the reduction of transaction costs translated into moderate economic expansion and increased prosperity throughout the eastern Mediterranean from the 4th to the mid-6th century. Despite some regional variations, rural populations seem to have expanded across the region as a whole, while urbanization also increased. Surveys conducted in a variety of different areas including Boeotia, the Argolid, southwestern Turkey, Cyprus, Palestine, and Transjordan show a steady rise in the number of rural villages and farmsteads starting in the 4th century, which is accompanied by the disappearance of large privately owned villas across the Eastern provinces.[110] In the Argolid, the number of sites in the 4th century A.D. approached that of its peak in the 4th century BC,[111] while surveys in Lycia in Asia Minor also indicate a major increase in the prevalence of villages, farms, and farmed terraces beginning at roughly the same time.[112] There is also evidence for the development of wealthy villages in the hinterland of Cilicia

[107] See Hendy 1985.
[108] Laiou 2002.
[109] Whittaker 1983: 176-178.
[110] Morrisson and Sodini 2002: 177-8.
[111] Jameson et al. 1994.
[112] Foss 1994.

beginning in the 4th century.[113] Several hundred villages proliferated in the limestone massif in northern Syria between 300 and 550,[114] while the region to the northeast of Hama also experienced a major increase in the number of villages and small cities during the early Byzantine period.[115] Late Roman settlements multiplied in Cyprus from the 5th century onward,[116] while surveys in Transjordan and Palestine also indicate a significant density of early Byzantine sites.[117] Taken as a whole, these surveys point to a significant increase in settlement density in the countryside of the eastern provinces from the 4th to the mid-6th century, a pattern that is particularly acute in coastal regions bordering the Aegean Sea.

Figure 3.1 Distribution of Cities in Balkans and Anatolia, ca. A.D. 450



Source: Morrisson and Sodini 2002; after M. Hendy 1985: 71, map 14.

Substantial population growth also occurred in many urban areas in the 4th and 5th centuries. Constantinople's population had expanded to somewhere around half a million people by the mid-6th century,[118] while the population of Antioch was likely around 200,000.[119] Thessalonica, Apameia, and Alexandria probably supported populations of around 100,000 inhabitants each,[120] while Caesarea, Jerusalem, and Sardis would have had

[113] Hild and Hellenkemper Salies 1984.
[114] Tate 1992.
[115] Lassus 1935.
[116] Fejfer 1995; Rautmann 1996; Rautman and McClellan 1992; Manning et al.1994; Aupert 1996.
[117] Tsafrir 1996; See also Bar 2004.
[118] Estimates for the population of Constantinople at this time vary, but most scholars agree that it was upwards of 400,000 people. Morrisson and Sodini (2002) give a conservative estimate of at least 400,000 (See also C. Mango 1985: 51; Jacoby 1975; Croke (2005, p. 67) gives an estimate of 500,000, while Zuckerman (2004) estimates closer to 700,000.
[119]Liebeschuetz 1972: 92-100.
[120] Morrisson and Sodini 2002: 174; Balty 1989.

between 50,000 and 100,000 inhabitants.[121] It has also been suggested—although these numbers are likely on the high side—that the populations of provincial capitals, for example Nicopolis, Gortyn, and Scythopolis, would have numbered as high as 30,000 to 35,000,[122] while smaller provincial cities would have had something closer to 16,000 inhabitants.[123] Late Antiquity also saw the rise of large towns (*komai, metrokomiai, komopoleis*) that would have fallen somewhere in between rural villages and cities in the urban hierarchy. This category included *emporia*, or "satellite towns," where fairs (*panegyreis, nundinae*) were held and merchants circulated.[124] Other trades whose presence is attested at these large market towns included textile makers,[125] blacksmiths,[126] goldworkers,[127] carpenters,[128] and stone carvers: for example, the marble workers at Proconnesus had close ties to the *emporion* at Cyzicus, on the mainland of Asia Minor.[129]

3.3.4 Agricultural Intensification

As Late Antique cities grew, they became increasingly dependent on imported foodstuffs to feed their burgeoning populations, which quickly surpassed the agricultural capacity of their own hinterlands.[130] By the mid-6th century, all of Constantinople's grain was imported from overseas, the majority of which (8 million artabas annually) came via ship from the fertile Nile delta in Egypt.[131] Other sources of grain included Italy, Sicily, and North Africa, while oil and wine were largely imported from Syria and Palestine, where there is abundant evidence for the intensification of agricultural production (particularly of olives) during this period.[132] These developments should be viewed as part of a broader pattern of increasing agricultural intensification across the Eastern Mediterranean in the Late Antique/Early Byzantine period, which was supplemented by modest technological

[121] Russell 1986: 139 states at least 100,000 for Sardis. Russell refers to Hanfmann and Waldbaum 1975: 22-3.
[122] Tsafrir and Foerster 1994: 106.
[123] Bagnall 1993: 53.
[124] Dagron 1979; 1985.
[125] Robert and Robert 1979.
[126] Festugiere 1970.
[127] *Nessana Papyri* 1958: 92, 230, 272.
[128] Id., 275; Dagron and Marcillet-Jaubert 1978: 373-420.
[129] Robert and Robert 1979; Morrisson and Sodini 2002: 180.
[130] On provisioning generally, see Dagron 2002; Sirks 1991a.
[131] On Egyptian grain imports to Constantinople, See, e.g., Sirks 1991b. On agricultural production in Egypt, see Bagnall 1985.
[132] Bar 2004: 307-320; See also Hitchner1993: 499–508. This is also supported by pottery excavated at Saraçhane, where Late Roman Amphora 1 amphoras produced on the Cilician coast, probably in northern Syria, and also in Cyprus, constitute 3/4 of the amphora fragments. Hayes 1992; Morrisson and Sodini 2002: 210.

innovations including the development of watermills[133] and counterweighted olive and grape presses, which increased output efficiency and put oil and wine production into the hands of small-scale producers.[134]

3.3.5 Professionalized Production of Goods

Another indicator of increased commercial activity comes from the increased specialization and professionalization of craft production during this period. For example, Jean-Michel Carrié points to the professionalization and specialization of production (e.g., textiles, ceramics, and glass) in urban workshops as evidence of increased commercialization during the Late Antique period. Carrié notes that there was a considerable decline in homemade fabrics during this period as fabrics became increasingly diverse and complex. Such fabrics required professional expertise to weave, which gave rise to a class of specialist weavers who targeted specific markets. Based on the evidence regarding the production of fabric at Oxyrrynchus from the *P.Oxy.Hels*. 40 (second half of the 3rd century A.D.), Carrié concludes that the quantity of fabric produced "bears comparison with that of medieval Europe, and suggests the existence of a very large regional and international market for textiles."[135] Technological and management innovations also resulted in new patterns of commercialized mass-production in the glass and sigillata ceramic trades during this period: for example, the excavation of glass ovens and shipwrecks indicates that the production of glass was highly concentrated, and required a high degree of organization to produce massive quantities of glass "cutlets" at primary workshops in the east, which were then shipped to secondary workshops in the west to be transformed into retail artifacts.[136] Similarly, the work of Maurice Picon and Jean-Paul Morel indicates that production of sigillata ceramic during the Imperial period evinces a high degree of commercialization, which can arguably be extrapolated into late antiquity: for example, the ovens excavated at la Graufesenque indicates average castings of thirty thousand pieces per firing, suggesting an annual production of nearly one million vessels.[137] Additionally, there is evidence that some manufacturing centers adapted their production to suit the cultural habits of certain markets, while the shift away from black-glaze ceramic to sigillata necessitated new modes of production and distribution.[138]

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[133] Sodini 1979; 1993.
[134] Bruneau and Fraisse 1984: 717; Brun 1993a,1993b; Hirschfeld and Birger 1991; Roll and Ayalon 1981; Dar 1986: 147-63; Quilico 1994; Frankel 1987: 63-80.
[135] Carrié 2012: 19; 2004.
[136] Id.; See also Foy and Nenna 2001.
[137] Picon 2008: 204-9.
[138] Id. at 209.

3.3.6 Economic Impact of Construction

The increase in urbanization and prosperity in late antiquity was also accompanied by a sharp increase in the construction or restoration of defensive installations, infrastructural developments, and civic/religious buildings in cities throughout the eastern Mediterranean.[139] Most cities at this time were surrounded by fortified walls, many of which were strengthened during this period. For example, we know that Justinian refortified the Balkan cities of Serdica, Naissus, Pautalia, Trajanopolis, Augusta Trajana, Bononia, Oescus, Novae, and Durostorum, while Anastasios I rebuilt the walls at Histria, Tomis, and Ratiaria.[140] In the province of Syria, both Justinian and Anastasios invested considerable sums of money to construct defensive walls around Anastasiopolis (Rusafa),[141] Zenobia,[142] Dara,[143] Chalcis,[144] and Antioch to protect those cities against the Persians. These walls (the ruins of which can still be seen today) were built using typical Byzantine masonry techniques (vaults and alternating stone and brickwork), which were adjusted to better suit local conditions by architects dispatched from Constantinople to oversee their construction.[145] Other major construction projects undertaken during this period included cisterns, such as the so-called "basilica cistern" constructed in Constantinople under Justinian; aqueducts, like that from Kythrea to Salamis in Cyprus; and porticoed streets, agoras, and tetrastyles, as at Sardis, Ephesus, Halabiye, Bostra, Jerusalem, Caesarea Maritima, Beisan-Scythopolis, Hermopolis, Ptolemais, Durres, and Gerasa.[146] Finally, this period witnessed the construction of thousands of churches and monasteries across the Empire, a subject that will be covered in greater detail in subsequent chapters.

The line between religious and imperial architecture in the Late Antique period was often blurry, particularly in Constantinople and other major cities (e.g., Ravenna, Ephesus, Antioch, and Thessalonica), where imperially-funded churches proliferated; however, the financing of religious architecture in late antiquity was not limited to the emperor: "princes, and dignitaries, large landowners, and the faithful (even in the villages that came

[139] On defensive walls, see e.g. Gregory 1982; Wozniak 1988.
[140] Gregory 1982, Wozniak 1988; Feissel 1988.
[141] Karnapp 1976.
[142] Lauffray 1983.
[143] Croke and Crow 1983; Whitby, 1986; Zanini 1990.
[144] Fourdrin and Feissel 1994.
[145] Morrission and Sodini 2002: 185; Deichmann 1982; Ulbert 1989.
[146] Morrisson and Sodini 2002: 186-7; Roueché et al. 1989; Tsafrir and Foerster 1994.

under the watch of civil leaders and the clergy) also contributed lavishly."[147] One of the most prominent examples of privately sponsored religious architecture during this period was the Basilica of St. Polyeuktos, built in Constantinople between 524 and 527 by the wealthy noblewoman Anicia Juliana, while in Ravenna a wealthy Greek banker named Iulius Argentarius is thought to have sponsored the construction of both the Basilica of San Vitale and the Basilica of Sant' Apollinare in Classe in the mid-6th century. These projects mobilized huge sums of both public and private capital: according to Gregory of Tours, Anicia Juliana used up all of her gold to build the vaults of St. Polyeuktos,[148] while Argentarius supposedly expended some 26,000 solidi of his own money on San Vitale.[149] Yet no matter how impressive this sum may have been at the time, it pales in comparison to amount that Justinian spent on the construction of the Hagia Sophia (built 532-537), which E. Stein puts at a staggering 1.04 to 1.3 million solidi in total.[150] In the course of just one year (532), the praetorian prefect Phocas spent 288,000 solidi towards the construction of the Hagia Sophia,[151] while Marlia Mango has estimated that the silver revetment alone would have cost 166,000 solidi.[152]

Construction projects of this nature stimulated demand for stone, bricks, wood, and other raw materials that were imported from across the empire.[153] Marble was particularly highly valued and was extracted in vast quantities from quarries including Proconnesus, Thasos, and Docimium in Phrygia during this period, while timber was either sourced locally when available or imported from the forests of Macedonia and Thrace. There is also evidence for the widespread transport of terracotta roof tiles and bricks during this period, suggesting that these commodities were frequently imported from overseas as well as being produced locally. Lastly, construction provided a source of income for large numbers of seasonal workers drawn primarily from local populations,[154] as well as a variety of skilled craftsmen including marble workers, stonecutters, brickmakers,[155] masons, specialists in stone facing

[147] Morrisson and Sodini 2002: 187.
[148] Harrison 1986.
[149] Barnish 1985 citing Agnellus, *Liber pontificalis Ecclesiae Ravennatis*, MGH, 59, 77).
[150] Stein 1949: 459-60.
[151] Morrisson and Sodini 2002: 188.
[152] M. Mango 1990.
[153] See Bardill 2008.
[154] Temporary construction workers were often employed on a per-day basis: for example, we know that at Dara (Syria), construction workers were paid 4 keratia per day, or 8 if they had a donkey at their disposal. (Zacharias of Mytilene, *Historia Ecclesiastica Zachariae rhetori vulgo adscripta*, ed. E.W. Brooks, 1924. 7.6, p. 25).
[155] See, e.g., Bardill 1995: 28-9.

and opus sectile, mosaic layers,[156] plasterers, carpenters, metal and glass workers, engineers, and architects.[157]

3.3.7 Expansion of Maritime and Overland Trade Networks

The Early Byzantine period was characterized by a marked increase in maritime trade, particularly in the eastern Mediterranean, which constituted Byzantium's "inner sea."[158] However, it should also be noted that, "Byzantine trade also extended to the west as far as England, and, to the east, reached India by way of the Red Sea, and Central Asia (albeit with greater difficulty) by land."[159] Despite the extensive range of Late Roman and Byzantine commerce, two main maritime trade routes into Constantinople can be identified. The first, which linked the Egypt and Palestine in the south by way of Asia Minor and Cyprus to Constantinople in the north, was the "backbone of the Byzantine Empire's domestic commerce in the 6th century," and was the primary route by which staple goods including grain, oil, wine, dried legumes, and salt pork were transported to Constantinople.[160]

The second main trade route connected Constantinople and the east to the western territories of Italy, Gaul, and North Africa, and can largely be traced through pottery distributions. Archaeological evidence reveals a marked presence of products from the Eastern Mediterranean in the west beginning between 420-430. Analysis of amphorae recovered at Narbonne, Arles, and Marseille—one of the most important Mediterranean ports in late antiquity—indicates that some 30 to 40 percent of all amphorae were Eastern imports. Most of these can be dated to the 5th century, although a substantial Eastern presence continued throughout the 6th century, before a precipitous drop in the first half of the 7th century.[161] A similar trajectory can be observed at Rome and Carthage, where large quantities of Eastern amphorae further attest to the strength of this East-West trade route (see table 3.1).[162] Additionally, high-quality African Red Slip tableware made in Africa Proconsularis and lamps from Byzacena (both of which would likely have been shipped together with heavier products now absent from the archaeological record) were distributed

[156] On mosaicists, see Asemakopoulou-Atzaka 1993; Alpi 1992 for the mosaicists Klaudianos and Immanouel; and Feissel et al. 1992: no. 644 for the mosaicist Thomas.
[157] On architects and engineers, see Kretikekou 1990.
[158] Morrisson and Sodini 2002: 210.
[159] Id.
[160] Id.
[161] Pieri 2012; Bonifay and Pieri 1995; Keay and Abadie-Reynal 1986.
[162] Pieri 2012; Panella 1986: 21-3, 431-59.

widely throughout the east. Distribution patterns of these items vary slightly by region;[163] however, the prevalence of African Red Slipware not only at Constantinople, but also at sites throughout Asia Minor, Southern Greece, and the Black Sea region attests to "the existence of lively east-west relations that, by way of Crete, directly united Africa with the urban centers of Syria-Palestine, Antioch and Caesarea."[164]

Table 3.1 Comparative data on amphorae from several areas of the western Mediterranean

		Amphora Type		
Site	*Date*	Eastern	African	Unclassified
Rome Crypta Balbi, sond. IIIEX	410 –480	14.5 % NMI	52.0 % NMI	
Rome Magna Mater, sond. I–L	420– 440	20.0% NMI	40.0% NMI	
Tarragona Vila-Roma	425– 450	26.0% NMI	24.5% NMI	
Rome Schola Praeconum I	430– 450	46.4% sherds	42.5% sherds	
Rome Magna Mater, sond. P	440– 480	27.0% NMI	32.5% NMI	
Naples Carminiello ai Mannesi	430-450	10.1% sherds	44.4% sherds	45.4% sherds
Naples Carminiello ai Mannesi	490-510	16.5% sherds	21.0% sherds	52.8% sherds
Rome Schola Praeconum II	500-530	40.7% sherds	40.4% sherds	
Carthage Michigan Excavations, "deposit" XV	550	68.8% sherds	12.0% sherds	
Naples Carminiello ai Mannesi	late 6th– early 7th c.	34. 6% sherds	18. 8% sherds	46. 8% sherds

Source: Pieri 2012.

In addition to ceramics, shipwrecks are a strong indicator of ongoing commercial activity throughout the Mediterranean, and particularly in the East, during the 6th century. A geodatabase of some 724 datable shipwrecks compiled by Michael McCormick shows that a decline in datable shipwrecks during late antiquity is nowhere near as steep as it once appeared (see fig. 3.2).[165] By the 8th century, the number of datable wrecks drops off significantly, although a modest recovery begins in the 9th century. The data also shows a significant shift in the distribution of wrecks over time that closely tracks the swing in

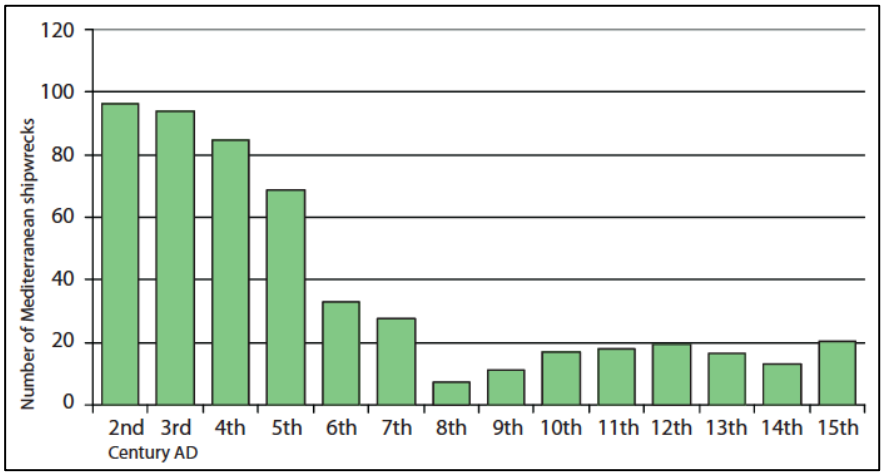
[163] "While it competed against Phokaian Sigillata ware, which clearly dominated the market in the northern Aegean (80% at Demetrias), in Constantinople, and in Asia Minor, African Red Slip ware assumed an increased importance over the years 500–550 in Argos (in which it constituted 40% of high-quality ware), as well as in Athens, Kenchreai, and Sparta." (Morrisson and Sodini, 2002, p. 210).

[164] Morrisson and Sodini 2002: 210.

[165] Cf. Parker 1992: 549; See also the Oxford Roman Economy Project's Shipwreck Database (Strauss 2013).

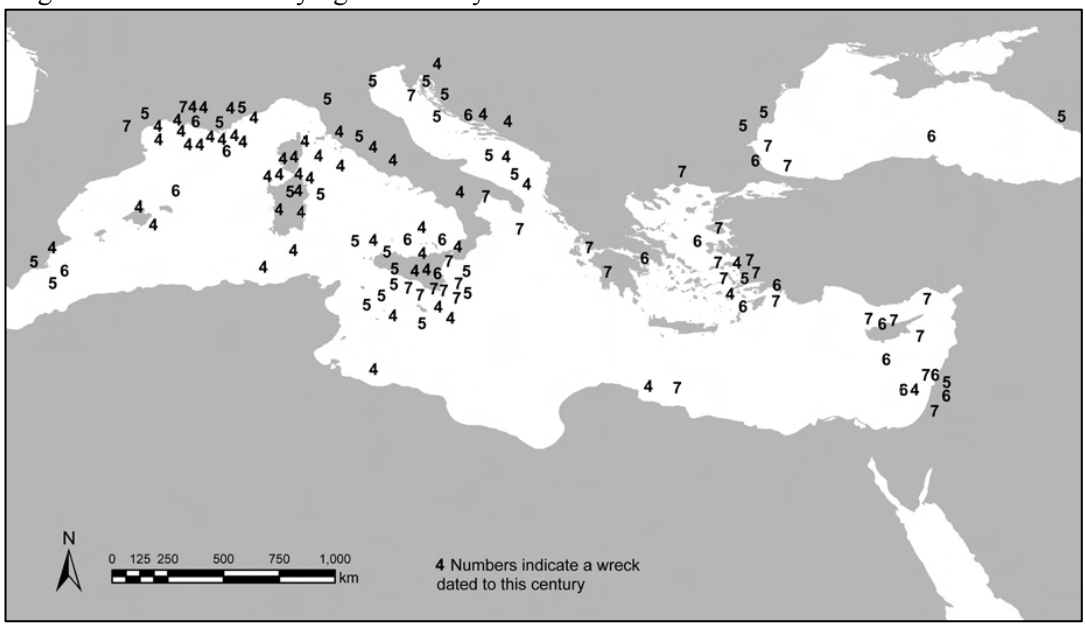
economic and political power from Rome to Constantinople in the Late Antique period: whereas 4th and 5th century ships overwhelmingly predominate in the western Mediterranean, the East is dominated by 6th and 7th century wrecks (see fig 3.3). McCormick argues that the distribution of wrecks can also attest to more subtle economic shifts: for example, he suggests that the appearance of 5th century wrecks on the southeastern coast of Sicily reflects the growing flow of African grain and oil East to Constantinople at Rome's expense, because ships sailing to Rome from North Africa would instead have passed to the northwestern side of the island.[166]

Figure 3.2 Total number of shipwrecks by century as of April 2008 (does not include the 37 additional wrecks found at Yenikapı). Wrecks dated over multiple centuries are pro-rated; e.g., a wreck of 400–600 is counted as half a wreck in the 5th c. and half in the 6th c.



Source: McCormick 2012: 84.

Figure 3.3 Dated shipwreck sites, ca. A.D. 300–700; these 132 sites contain 174 ships. Each is assigned a number identifying the century to which it is dated.



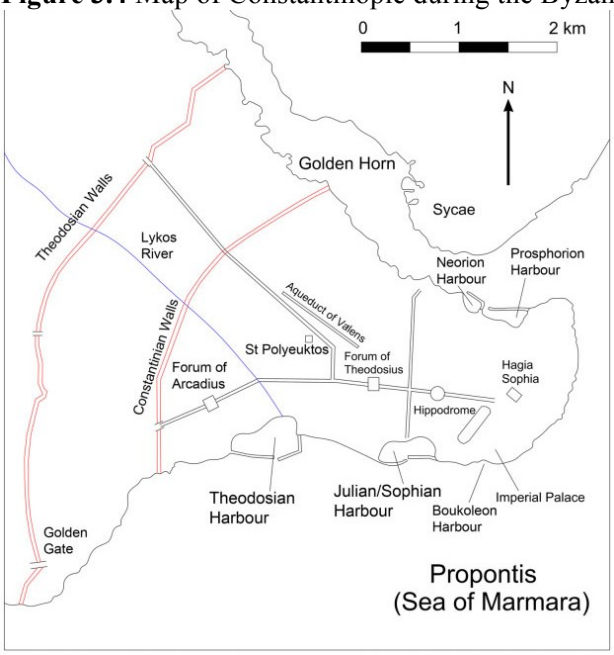
Source: M. McCormick 2012; drawn by A. More.

[166] McCormick 2012: 86.

In addition to the much-reduced threat of piracy, the increase in maritime trade during this period was also facilitated by the construction or expansion of a number of port installations across the Mediterranean beginning in the 4th century. Constantinople in particular benefitted greatly from the addition of two new harbors (the harbor of Julian on the Propontis and the much larger harbor of Theodosius), which increased its docking capacity to something around 4 kilometers of quays that would have been capable of handling roughly five hundred mid-sized vessels at any one time.[167] The Theodosian Harbor continued to be used at a significant scale, at least for small and mid-sized vessels, until at least the late 20th or early 11th century, as the recent excavation of 37 shipwrecks dating to the 5th through the 11th centuries confirms.[168] The Notitia of Theodosius II lists two Imperial granaries, the Horrea Alexandrina and the Horreum Theodosianum, between the harbors of Julian and Theodosius, which confirms that these harbors accommodated the large vessels that carried grain to feed the population of Constantinople.[169] However, there were fewer grain storage facilities on this side of the city compared to those near the ports of Neorion and Prosphorion along the Golden Horn, which has led Paul Magdalino to conclude that the new harbors were also built to handle other traffic including the timber, bricks, and Proconnesian marble used for the Imperial building programs of the late 4th and early 5th centuries.[170]As further evidence in support of this theory, Magdalino notes that the largest constructions during this period—namely, the Theodosian palaces and monuments—were primarily located along the southern coast, rather than near the harbors of the Golden Horn to the north.[171] This interpretation is supported by the excavation of a medium-sized merchant vessel at Yenikapı dated to ca. the 5th- 6th century, which was contained baked-clay brick fragments, mortar residue, and marble fragments that can be traced to Proconnesus. The thick ceiling planks in the hold further indicate that the vessel was designed to carry a heavy cargo, such as bricks, tiles, and marble needed for construction work.[172]

[167] C. Mango 1986b: 38.
[168] Pulak et al. 2015; Kocabaş 2015.
[169] C. Mango 1986b: 121; Magdalino 2000: 211.
[170] *Notitia* (Bury 1920), Magdalino 2000.
[171] Id.
[172] Kocabas 2015: 5-38, 19.

Figure 3.4 Map of Constantinople during the Byzantine period



Source: Pulak et al. 2015, drawn by M. Jones. After Mango 2002.

There is also evidence of ongoing seaborne trade elsewhere in the Empire during this period. Vast granaries were built at Casearea Maritima, while Alexandria (where Egyptian grain was loaded onto ships bound for Constantinople) retained two large docks dating from Hellenistic times. Other active export ports in the East during this period included Laodicaea, Tyre, Dor, and Gaza, while Antioch's port of Seleucia Pieria accommodated ships from Phoenicia, Cyprus, Cilicia, Palestine, and Egypt.[173] In the West, the silting up of Ravenna's old harbor necessitated the construction of a new port (*novus portus*) in nearby Classe,[174] while Rome's port of Ostia also went into decline during the 3rd century, shifting the majority of trade up the coast to Portus. However, imports to Rome overall were greatly reduced compared to its height in the 2nd century A.D., and Portus also went into decline sometime after the late 5th century A.D.[175]

In addition to these major ports, many of the smaller cities and *emporia* that dotted the shores of the Eastern Mediterranean (e.g., in Cyprus (Paphos), Crete, and Rhodes) would have had their own docks or harbor facilities. In the case of Thasos, for example, we know that the harbor was fitted with cranes used to load marble onto ships.[176] But despite the large number of active ports during this period, archaeological evidence suggests that at

[173] Dagron 1985: 437-8.
[174] Keay 2015; Maioli 1983.
[175] See Keay et al. 2005; Keay 2015.
[176] Sodini et al. 1980.

Late Roman/Early Byzantine harbors may have been smaller in capacity than those in the early Roman Empire, although this assumption has recently been called into doubt.[177]

Late Roman and Byzantine ships were generally smaller than their early Roman predecessors on average, although there were still a number of large merchant ships during this period. As McCormick's analysis of shipwrecks indicates, the longest "normal" ancient vessel in the database measured 45 meters in length, while the longest late Roman ship ran about 50 meters. [178] However, the modal length of 25 meters for ships from the first three centuries A.D. is 25% greater than that for ships dating to the later period (20 meters), while 12 early Roman ships were 30 meters or longer.[179] This difference is also attested to by the textual evidence: for example, ships with a tonnage capacity of 2,000 modioi of wheat (approximately 12 tons burden)[180] and as small as 1,000 modioi (6 tons)[181] are mentioned in several mid-5th century texts, as opposed to 50,000 modioi (300 tons) in the 2nd century.[182] The medium-sized (20 meters long by 5.22 meters wide) Yassi Ada shipwreck carried a cargo of some 800 amphorae weighing roughly 40 tons in total,[183] or roughly five times that of the small ships attested to in the 5th century texts, but still was significantly smaller than a typical early Roman vessel. There were still a few large ships during this period including the mid-6th century Marzamemi B shipwreck, which was transporting a cargo of somewhere around 200–400 tons of Proconnesian and Thessalian marble,[184] and the Alexandrian grain ships, which had a capacity of between 20,000 and 70,000 modioi (160 to 560 tons);[185] however, most harbors by this point would not have had the facilities to accommodate such large vessels, and they should be seen as the exception rather than the norm.

Further evidence regarding the decreasing size of Byzantine merchant vessels after the 7th century can be derived from the excavation of some 37 wrecks of early to mid Byzantine ships from the port of Theodosius at present-day Yenikapı, which more than doubled the number of known Byzantine shipwrecks. These wrecks span the 5th through the mid-10th centuries and represent a wide range of vessel types between roughly 7 and 15 meters in

[177] Morrisson and Sodini 2002: 202. See, e.g. Ladstätter and Pirson 2015.
[178] McCormick 2012. One giant ship of 104 meters (Fiumicino 12) is believed to have been specifically constructed to transport an obelisk from Egypt, and is clearly an aberration.
[179] Morrisson and Sodini 2002.
[180] Novel repeated in Justinianic Code.
[181] Novel of Valentian III.
[182] Morrisson and Sodini 2002: 209.
[183] Parker 1992; See also Van Doorninck 2002.
[184] Parker 1992. First published by Kapitän, 1969; 1980.
[185] Rougé 1961.

extant length,[186] from small coasters and fishing boats to the largest class of late antique cargo carriers and the only known well-preserved hulls of early medieval seagoing galleys. The five large merchant vessels excavated at Yenikapı of have been dated to ca. the 5th through the 7th centuries, while the medium merchantmen are primarily dateable to the mid-7th to late 9th centuries. By the 10th century, the only vessels visiting the Theodosian Harbor were smaller merchantmen of roughly 7 meters in length. It should be noted that this does not necessarily mean that larger ships did not exist by the 10th century, but rather that the harbor had become so silted up that it was no longer accessible to larger vessels.[187] However, the corollary to this observation is that smaller vessels would have been more desirable during this period for the very reason that they could access silted-in ports like the Theodosian Harbor. Additionally, McCormick argues that shipowners who participated in the state-subsidized grain trade were incentivized to have smaller ships, which were easier and faster to unload, so they could quickly return to sea—and to business—after unloading their portion of the grain supply.[188]

The majority of interregional transport of goods and people in late antiquity would have occurred over water rather than land, due to the relatively cheap cost and fast speed of maritime transport: A.H.M. Jones estimated that the transport of cereals via water was roughly seventeen to twenty-two times cheaper than by land,[189] which is a relatively conservative number compared to more recent studies that use advanced geospatial modeling tools to comparing transport costs and speed in the Roman World.[190] For example, *ORBIS* (the model used in this thesis) suggests that the price ratio for moving a given unit of cargo over a given unit of distance during the Roman period would have been roughly 1 (sea) to 5 (downriver)/10 (upriver) to 52 (wagon). This model takes into account more recently discovered information regarding river transportation, and also improves on earlier models that were generally unable to establish average maritime charges per kilometer, and instead relied on supposedly representative routes.[191]

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[186] It must be noted that these vessels are in varying states of preservation, and thus the "extant length" is often not the same as the true length of the vessel as it existed in antiquity. Accordingly, the relative size of these vessels is based on the construction methods used (e.g., the thickness of planks and frames).
[187] Pulak et al. 2014, 2015; Kocabaş 2015.
[188] McCormick 1998: 103-5; 2012: 91.
[189] Jones 1964: 841-2.
[190] Scheidel 2013a; 2013b.
[191] See, e.g., Duncan-Jones 1982: 368; Hopkins 1983: 104; DeLaine 1997.

However, despite its relative expense, overland travel was either preferable or necessary in some situations: for example, the difference in cost between transporting certain high-value products (e.g., silk; spices) that could be packed in small, light containers overland, rather than by sea was relatively small (at least for short distances),[192] while roads were essential means of access and communication for communities with no coastal or navigable river access (e.g., the Anatolian and Syrian highlands) or in the winter, when weather conditions would have made sea travel more difficult.[193] The maintenance of an extensive road network was essential not only for short and medium distance trading, but also for the movement of military units sent to protect the inland borders of the Empire (e.g., along the eastern border with Sassanian Persia). We know that the state invested heavily in road construction and repair throughout the east as well as in Macedonia from the 4th and even into the 7th century: for example, Procopius tells us that Justinian repaired and built roads near Rhegium and in Bithynia, Phrygia, and Cilicia,[194] while the Via Sebaste in Pamphylia and the roads that linking Tarsos to Podandus and Antioch to Beroea and Chalcis were also restored during this period.[195]

3.4 Conclusion

The 4th to 6th centuries A.D. were unquestionably a period of economic expansion and commercial activity, at least in the Eastern Mediterranean. As barriers to trade (e.g., the threat of invasion or piracy, political instability) fell, rural settlements proliferated, urban populations grew, and interregional commerce (particularly via sea) increased significantly as a result. Crop cultivation intensified, craft production became increasingly professionalized, and, a spate of construction projects increased demand both for human capital as well as for raw materials (e.g., marble, timber, and brick) that were imported from across the Late Roman world. While the volume of trade never reached the same level as it had before the Crisis of the 3rd Century, this period should be seen as one in which decreasing transaction costs resulted in moderate economic growth, particularly in the new urban centers of the East. However, by the second half of the 6th century, this economic resurgence had slowed significantly. Archaeological evidence of amphorae distributions at Marseille, Rome, and Carthage indicates that trading volume dropped significantly, while trade routes became less well defined.[196] Constantinople became

[192] Mattingly 1988: 52, citing Greene 1986.
[193] See Avramea 2002.
[194] *De Aedeficiis*.
[195] French 1993.
[196] Morrisson and Sodini 2002: 212.

increasingly isolated as the borders of the Empire shrank in the period after Justinian's conquests, and by the end of the 6th century it is evidence that the Byzantine empire "maintained scarcely any contacts with Western Europe beyond Southern Italy (Otranto), Sicily, Ravenna, Venice, and certain points along the Adriatic, as well as Naples, Rome, and the ports of the Ligurian coast."[197]

By the 7th century, ongoing wars with the Sassanians and the Arabs and Justinian's renovation had already stretched the Empire's financial resources extremely thin, and a number of devastating territorial defeats (most significantly, the loss of Egypt to the Arabs in 639) dealt further blows to the economic fortunes of the empire. Evidence for this decline comes in many forms, including a marked decrease in rural settlements, the deterioration of cities across the East, and a marked decline in maritime exchange due to the new Arab presence along the major shipping lanes in the eastern Mediterranean. This decline in commercial exchange can be seen in the sharp drop in eastern imports to Western ports such as Marseille, Carthage, and Rome and the shrinking number of known shipwrecks from the 7th century onward.[198]

[197] Id.
[198] Pieri 2012; McCormick 2012.

Chapter 4. The Marble Industry in Late Antiquity

"Mountains …were made by Nature for herself to serve as a kind of framework…We quarry these mountains and haul them away for a mere whim…Ships are built specially for marble. And so, over the waves of the sea, Nature's wildest element, mountain ranges are transported to and fro…"

—Pliny, N*aturalis Historia* 36.1[199]

4.1 Introduction

The first part of this chapter provides a critical analysis of the current state of scholarship on the Roman and Late Antique marble trade. It is argued that the study of ancient marble has largely focused on the early Imperial period, and remains poorly integrated into the wider academic discourse concerning the structure and performance of the late antique economy. The second half of this chapter (*Sections 4.3* to *4.6*) draws on this body of work to develop a model of the marble trade in the Roman and Late Antique Mediterranean that takes into account both the Imperial as well as the private market for marble. *Section 4.3* outlines the major chronological and regional developments in the marble industry beginning with the origins of Roman demand for marble in the Late Republican Period (2^{nd}-1^{st} c. B.C.) and ending with the decline of the quarries in the East in the 7^{th} century A.D. *Section 4.4* examines the demand for marble in late antiquity: who was consuming marble, and for what purpose was it used? In *Section 4.5*, the supply side of the marble industry is analyzed: which quarries supplied marble in the Late Antique period? Who owned these quarries, and how were they organized during this period? Lastly, *Section 4.6* discusses the mechanics and logistics of the marble trade: how was marble extracted, carved, and transported from these quarries to consumers—both public and private—across the Empire?

The overarching picture of the Late Antique marble industry that can be gleaned from these inquiries is one of declining supply and demand for marble in the Western Mediterranean, as evidenced by a decline in exports from Carrara (Luna) and a drop in imports of fresh marble to Rome by the 4^{th} c. A.D. Conversely, the Imperial quarries in the East, particularly Proconnesus and Thasos, saw a dramatic increase in production, which was linked to large-scale municipal building programs at Constantinople that were undertaken by Constantine, Theodosius, and Justinian. These quarries provided custom pieces of marble for Imperial projects, but also manufactured highly standardized products designed to appeal to both public and private consumers (e.g., columns of standard size, column bases and capitals, and chancel panels), that were distributed across the Empire.

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[199] Trans. D. E. Eichholz, 1962: 3-5.

It should be noted at the outset that while the focus of this thesis is the marble trade from the 4th to the 6th centuries, much of what is known about the Imperial quarrying, production, and distribution of marble pertains to the marble industry at its height during the early Imperial period in the 2nd century A.D., for which there is significantly more textual and archaeological data. The challenge, therefore, is to gauge how far models for understanding the early Imperial Roman marble trade remain relevant to late antiquity.

4.2 State of the Field

The last few decades have witnessed a veritable explosion of interest and scholarship on ancient marble. Much of this vibrant state of affairs can be traced to J.B. Ward-Perkins' pioneering work on the use of marble in Roman Imperial architecture. As director of the British School at Rome beginning in 1946, Ward-Perkins chaired the Committee for the Study of Marble and Similar Stones in Antiquity and conducted extensive research on topics including the technical aspects of Roman construction and architecture, the trade in marble sarcophagi, and the organization of the Roman marble trade more broadly.[200] Ward-Perkins argued that the Roman marble trade was characterized by a factors including imperial ownership and centralized administration, rationalization, the standardization of practices including the dimensions of quarry products (e.g., columns), the prefabrication of objects (e.g., sarcophagi), and stockpiling rather than production for individual projects.[201] Ward-Perkins' work stimulated a generation of research on ancient marble, and his collected papers, posthumously assembled into a volume entitled *Marble in Antiquity* (1992), remain the benchmark for scholars interested in Roman stone some two decades after their publication.[202]

Many advances in the study of ancient stone have resulted from a series of international conferences convened by the Association for the Study of Marble and Other Stones in Antiquity (ASMOSIA) that have brought together archaeologists, art historians, conservators, geologists, chemists, and physicists in an interdisciplinary effort to study and identify stones used in ancient monuments and artifacts.[203] These conferences have provided a unique forum at which to present and discuss new research in a number of areas

[200] See, e.g., Ward-Perkins, 1971a; 1971b.
[201] Id.
[202] Dodge and Ward-Perkins 1992.
[203] The published ASMOSIA volumes to date are Herz and Waelkens 1988; Waelkenset al. 1992; Maniatis, et al. 1995; Schvoerer 1999; Herrmannet al. 2002; Lazzarini 2002a; Maniatis 2009; Jockey 2009; Gutiérrez et al. 2012.

relating to the use of marble in antiquity, including studies of quarrying and production techniques and archaeological surveys of quarries. Scholars whose work is of particular relevance for this thesis include T. Kozělj and M. Wurch-Kozělj, who have conducted extensive investigations into marble quarrying methods and stone transport techniques in late antiquity; N. Asgari, whose surveys of the marble quarries and workshops at Proconnesus have shed a great deal of light on the production of standardized architectural elements in late antiquity; and scholars including J.J. Hermann, W. Barbin, A. Metzos, J.P. Sodini, and A. Lambraki, who have studied the marble quarries at Aliki and Cape Vathy on the island of Thasos in great detail.[204]

The ASMOSIA conferences have also greatly advanced the field by contributing to the development of new archaeometric techniques to determine the provenance of marble artifacts.[205] In particular, the development of Electron Paramagnetic Resonance (EPR) spectroscopy has given scientists the ability to differentiate between different types of white marble from quarries in the Eastern Mediterranean, using only a small sample.[206] This methodology has now been used to investigate the provenance of Roman and Late Antique marble artifacts from museums, archaeological sites, and quarries throughout the Mediterranean region.[207] Before EPR was developed, other methods used to determine the provenance of marbles included petrography, X-Ray powder diffractrometry, neutron activation analysis, trace elements analysis, and stable isotope analysis, each of which have a variety of associated advantages and disadvantages. For example, traditional petrographic analysis (essentially, the visual examination of a thin slice of stone under a microscope) requires a large sample of marble and is not very informative on its own, while neutron activation analysis has exhibited only limited capability in quarry discrimination and is generally only used in conjunction with petrographic data. In the late 1980s and early 1990s, stable isotope analysis became an increasingly popular method for determining marble provenance, as it only requires a relatively small sample; however, the isotopic signatures of many white marble quarries overlap with one another, necessitating a multi-method approach.[208] As a result, stable isotope analysis is usually used in conjunction with cathodoluminescence, which measures the color of light given off by the excitation of a

[204] Koželj 1988; Sodini et al. 1980.
[205] On the evolution of archaeometric studies of stone, Craig and Craig 1972; Coleman and Walker 1979; Herz and Wenner 1981; Herz 1990; Lapuente et al. 2009; Lazzarini 2002b; Antonelli and Lazzarini 2004; Attanasio 2003; Attanasio et al. 2006.
[206] Polikreti and Maniatis 2002.
[207] See, e.g., Maniatis et al. 1988.
[208] Herz 1988b.

mineral (in the case of marble, calcite and/or dolomite) by an electron beam.[209]

Despite these advances, the study of ancient marble remains poorly integrated into the wider academic discourse concerning the structure and performance of the ancient economy. In particular, while archaeometric studies of marble artifacts and archaeological studies of quarry sites in recent years have greatly expanded the dataset available to economic historians, much less work has been devoted to synthesizing and interpreting how this new information pertains to the role of commercial exchange in the marble trade, as well as to broader questions concerning the nature and organization of the economy. This omission is unfortunate because marble is an extremely hard-wearing material, and thus remains visible in archaeological contexts where other commodities that are used as indicators of ancient economic activity (e.g., foodstuffs or other environmental materials) are less likely to survive. Accordingly, as Ben Russell points out, "the study of marble objects and the distribution systems though which they moved, traded, and were redistributed as economic commodities presents a unique window" by which to examine the mechanisms of the wider late antique economy.[210]

The relative lack of scholarship in this area does not mean that the role of economic considerations in the marble trade has gone completely unnoticed: notably, J. Clayton Fant has published several influential articles on Imperial marble yards and the role of the state in the Roman marble trade, in which he argued that the motives for forming the Imperial quarry system were non-commercial at the outset, but became increasingly commercial in nature by the 2nd century A.D.[211] More recently, Russell's book *The Economics of the Roman Stone Trade* (2013) argues that imperial activity needs to be examined against a background of more normal, localized patterns of stone use, and suggests that Ward-Perkins' model of the ancient economy fails to adequately consider the role of specific consumer demand in determining the form and quality of individual stone objects.[212] Also of note is a recent article by Leah Long that applies economic rationality theory, resource economics, and statistical methods to analyze the prices for marble recorded in Diocletian's Edict, Roman jurists' writings about exploitation on private land, and newly discovered quarries at Aphrodisias.[213] Long's use of regression analysis indicates that the overall price of stones listed in the Edict reflected the aggregated costs of production,

[209] See, e.g., Barbin et al. 1992.
[210] Russell 2013b: 6-7.
[211] Fant 1988c; 1993; 2001.
[212] Russell 2013b: 6-7.
[213] Long 2017.

difficulty of transport, market availability, rarity, and aesthetic appeal, while the exchange of local building stone at Aphrodisias took place in a competitive market in which entrepreneurs targeted marbles with inconsistent physical properties at increasing distances from the city in response to shifts in demand and rising prices.[214] But while these scholars' work has begun to reshape our understanding of how the marble trade was integrated into the Imperial Roman economy, far less work has been conducted on the economics of the marble trade in late antiquity, particularly the 4th to 6th centuries. This thesis therefore seeks to begin to fill this gap in the literature.

4.3 Contours of the Marble Trade, 1st c. BC- 7th c. AD

4.3.1 The Origins of the Roman Marble Trade

It has often been said that Augustus (r. 27 B.C.- 14 A.D.), the first emperor to rule the Roman Empire after the collapse of the Republic, "found Rome a city of bricks, and left it a city of marble."[215] However, while Augustus can be credited with undertaking a major public building project in Rome, the Romans' taste for marble actually predates Augustus by several centuries to the Late Republican Period (2nd-1st c. B.C.), when vast quantities of stone began to be imported to Rome for Julius Caesar's public building projects as well as for private commissions by wealthy citizens eager to display their affluence. [216] Nonetheless, Augustus can still be credited with the development and institutionalization of the Roman marble trade, which began when he sent out Imperial agents across the Mediterranean to locate and secure a network of quarries to provide a constant supply of marble for his building projects.[218] This marked the beginning of the imperial institution that was apparently called the *ratio marmorum*, or marble bureau.[219] By the 2nd century A.D., this institution oversaw a network of at least eleven imperially-owned quarries across the Empire from Egypt to the Balkans, which provided a steady stream of architectural marble for the imperial building projects in Rome.

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[214] Id.
[215] Greenhalgh 2009: 3.
[216] Hopkins 1978.
[218] Fant has convincingly argued that Augustus' motives for founding this system were more strategic than commercial: the Emperor recognized that by controlling the supply of marble he could also control the influence of the Roman elite by limiting their access to a material synonymous with wealth and power (Fant 1988c, p. 151).
[219] *CIL* 6.8631, 301, 8482, 33790; 11.3199; Fant 1993: note 3.

4.3.2 The Commercialization of the Ratio Marmorum

In the 2nd century, the *ratio marmorum* underwent a major reorganization and shifted away from the "command" model toward a decidedly more commercial model of operation that gave imperial quarry administrators, or *procurators,* much greater autonomy. While Ward-Perkins suggests this shift was a response to a rise in building activity in Rome, Fant argues that this resulted not from increased demand for marble, but rather from a deliberate decision by the Emperors to loosen their hold on supplies.[220] But whatever the motive behind this reorganization may have been, scholars agree that it resulted in a great increase of production in the Imperial quarries in the 2nd century AD, particularly in Asia Minor. The quarries at Proconnesus and Docimium in particular began to export large quantities of small marble goods such as sarcophagi throughout the Mediterranean world during this period. As the work of Ward-Perkins, Asgari, and Waelkens on these objects has shown, these quarries appeared to be "canny commercial enterprises" that were highly cognizant of their relative market advantages or disadvantages (e.g., proximity to harbors, quality of material, etc.), and accordingly "designed products to make the most of their situation and aimed them at specific geographical and economic markets."[221]

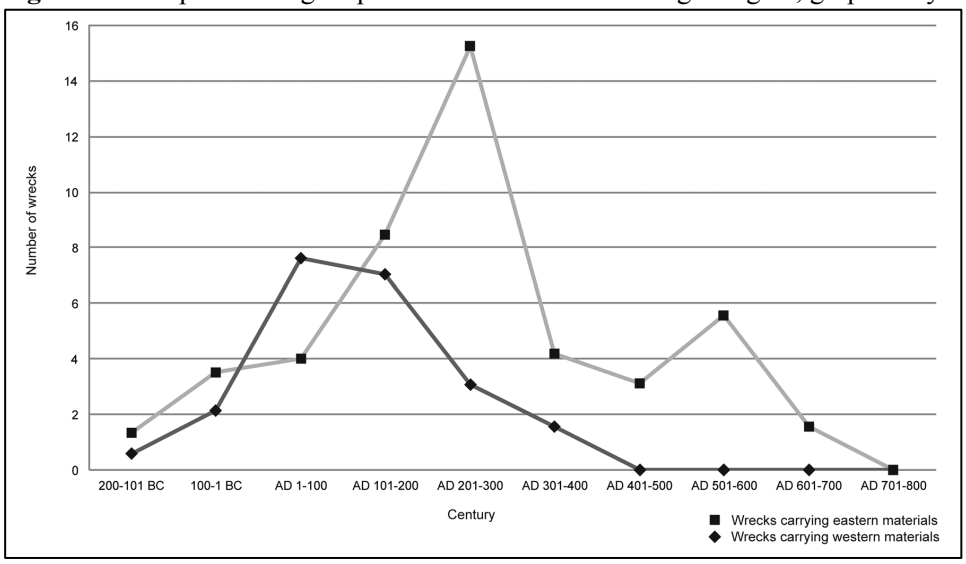
4.3.3 The Shift from West to East

The waning of Roman political and economic power in the West starting in the 3rd c. A.D. triggered a period of marked discontinuity for the marble industry. Archaeological evidence indicates that a fundamental shift in the demand for marble from quarries in the West to those in the East took place in the early part of the 3rd century during the reign of Septimus Severus (A.D. 193-211).[223] Isotope analysis of sarcophagi indicates the white marble quarries at Carrara (Luna) lost their prominence in the market during this period, while inscriptions carved into the rockface at quarries also ceased.[224] This shift from West to East is supported by the evidence from stone-carrying shipwrecks with identified material in their cargo: while the bulk of the ships which sank in the 1st c. A.D. were carrying Luna marble, a marked shift in the balance took place in the 2nd century as increasing quantities of eastern materials (Proconnesian, Pentelic, Thasian) were imported to Rome in its place, and by the 4th century, not a single wreck has been found that was

[220] Fant 1988c: 151.
[221] Id.; Ward-Perkins 1951.
[223] Walker 1988: 188.
[224] Id.

carrying Luna marble when it sank (Fig. 4.1).[225]

Figure 4.1 Graph showing shipwrecks with identified cargo origins, graphed by century



Source: Russell 2013a.

Proconnesian products (most notably, sarcophagi) dominated the private market for marble in the eastern Mediterranean and Adriatic by the 2nd and 3rd centuries A.D.,[226] and architectural elements (e.g., marble capitals and bases) from Proconnesus were exported for use in major building projects in a number of cities in Lebanon (i.e., Tyre, Byblos, and Beirut), Pamphylia in southern Asia Minor, as well as Lepcis Magna in Libya during this period.[227] Susan Walker proposes several explanations for this shift, including the silting up and abandonment of the harbor at Luna in the 2nd century and the decline in monumental sculpture at Rome under Severus, who focused his attention on his native city of Lepcis Magna. Notably, there is also no evidence of Lunese marble used in Severus' major building projects at Lepcis, while the Severan Forua at Cherchel reused old Luna marble architectural elements from a century earlier rather than fresh material.[228] It may also be telling that Luna does not even appear in the Price Edict of Diocletian *(edictum de pretiis)* issued in 301, which lists the maximum prices that could be charged for material from a number of quarries, while Proconnesian, Docimian, and Thasian marbles do appear (Table 4.1). This may indicate that Carrara had ceased to be a player in the market.[229]

[225] Russell 2013a.
[226] Karagianni 2011/2012.
[227] Karagianni 2011/12: 3; Pensabene 1998: 328.
[228] Walker 1988: 188.
[229] Diocletian Price Edict, reprinted in Russel 2013b.

Table 4.1 Prices in denarii for decorative stones in Diocletian's Price Edict, per RF² or RF³[230]

Listed Name	Identification	Price (denarii)
Πορφυρίτης	Porfido rosso/Porphyry	250
Λακεδαιμόνιον	Serpentino	250
Νουμηδικόν	Giallo antico	200
Λουκούλλιον	Africano	150
Πυρροποικίλον	Aswan granite	100
Κλαυδιανόν	Granito del Foro	100
Ἀλαβαστρήσιον	Egypitan alabaster	75
Δοκιμηνόν	Pavonazzetto	200
Εὐθυδημιανόν	?	60
Ἀνακαστηνόν	?	40
Τριποντικόν	?	75
Θεσσαλόν	Verde antico	150
Καρύστιον	Cipollino	100
Σκυριανόν	Breccia di Settebassi	40
Ἡρακλειωτικόν	Herakleian marble	75
Λέσβιον	Lesbian marble	50
Θάσιον	Thasian marble	50
Προκοννήσιον	Proconnesian marble	40
Ποταμογαλληνόν	?	40

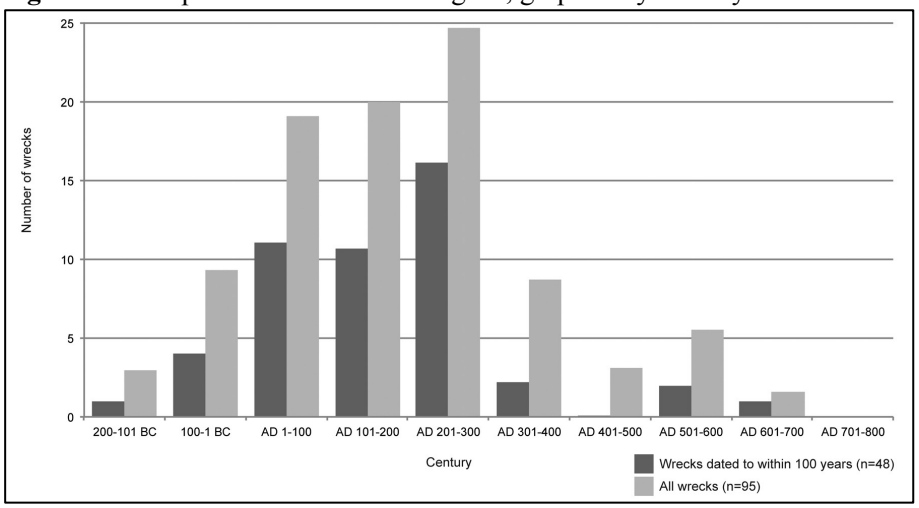
Source: Russell 2013b: 33.

As discussed in *Chapters 2* and *3*, the Crisis of the 3rd Century (235-284) triggered widespread hyperinflation and severely disrupted Rome's internal trade network, which resulted in a period of marked discontinuity for the marble industry throughout the Mediterranean (see fig. 4.2).[231] Widespread civil unrest—as well as the ongoing threat posed by foreign tribes in the provinces—had made it increasingly unsafe for merchants to transport goods and commodities between markets, meaning that the export of marble from the East dropped dramatically during this period. For example, the pavonazzetto quarries of Docimium (in present-day Turkey) had witnessed a very strong expansion until the middle of the 3rd century, when the marking of blocks by imperial agents was abruptly suspended in ca. 235–236.[232] Similarly, the Vandal invasions in 280 accentuated a slowdown in production of *giallo antico* at Chemtou (Africa), where the Roman system of marking blocks had already ceased in 201, and a coin hoard dating to the end of the reign of Honorius (395–423) is latest evidence of activity found at the site.[233] The financial crisis also resulted in a dramatic decrease in imperially-financed monumental sculpture and architecture, and the quarries shifted their focus toward private, small-scale commissions,

[230] The Price Edict measures marble per foot (*pedem*). It has generally been assumed that this refers to a cubic foot (See, e.g. Barresi 2003); however, Corcoran and Delaine (1994) have argued that *pedem* instead refers to a square foot, because the cubic foot measurement results in improbably low prices for marble when compared to other materials listed in the edict.
[231] Walker 1988.
[232] Fant 1988b, 1989; Christol and Drew-Bear 1991.
[233] Sodini 2002: 132.

including sarcophagi and portraits, to make up for this deficit. J.-P. Sodini has also noted numerous abrupt changes in the type of products being exported that he attributes to the unrest during this period. For instance, the production of Attic sarcophagi dropped off around 260, perhaps because of the invasion of Herules in the Aegean provinces.[234] By the 4th century, freshly quarried marble had become scarce in Rome, and the spoliation of marble architectural elements from earlier Roman temples began. For example, the colonnade of the Basilica of St. Peter (ca. 320) was made up of a variety of colored marble columns drawn from earlier buildings or stockpiles.[235]

Figure 4.2. Shipwrecks with stone cargoes, graphed by century



Source: Russell 2013a: 346.

4.3.4 The Recovery of the Marble Industry in Late Antiquity

Evidence from shipwrecks and quarry excavations indicates that the marble trade in the West never recovered from the Crisis. However, several Imperial quarries in the East that had already been in use during the Roman period experienced a substantial increase in exploitation as stability returned and the economy regained momentum under Diocletian (r. 284-305) and the Tetrarchy.[236] In particular, Proconnesus rose to a new level of prominence during this period as the primary source of marble architectural elements for Diocletian's new capital at Nicomedia, while Galerius favored marble from the Imperial quarries at Aliki on the nearby island of Thasos for the construction of his palace at Thessalonica.[237] The Emperor Constantine's decision to relocate the administrative and political center of the Roman Empire to Constantinople in 324 further contributed to the revival of the marble trade in the East. As Jean-Pierre Sodini writes, the ultimate mission

[234] Sodini 1989.
[235] Kinney 1997: 125.
[236] Walker 1988.
[237] Sodini 2002: 131.

of the Proconnesian quarries was "to cloak the new capital in marble so that the glory of Constantinople would blaze out to all reaches of the Mediterranean."[238] This shift to the East marked the beginning of a major revival of the marble trade that would reach its crescendo during the reign of Justinian I (A.D. 527-565), whose ambitious imperial and ecclesiastical building programs resulted in a major expansion of quarrying activity at Proconnesus, Thasos, Docimium, and elsewhere. As the historian Procopius recorded in *De Aedeficiis*, Justinian went on a building spree across the Mediterranean world, constructing or restoring thousands of public buildings, military installations, roads and aqueducts, and most importantly, churches. The physical manifestation of Justinian's efforts to establish a uniformity of belief throughout his realm was this ambitious ecclesiastical building program, which articulated his vision of a "unified empire pleasing to god" in a medium accessible to all citizens, regardless of class.[239]

4.3.5 The 7th Century Decline in the Marble Industry

Despite the spike in marble production lasting from the 4th through 6th centuries, many of the quarries in the East including Proconnesus, Thasos, had begun to fall into decline by the beginning of the 7th century. Imperial expenditures had to be decreased significantly in order to make up for Justinian's costly endeavors, meaning that the demand for freshly quarried marble intended for imperially funded building programs diminished as a result. Additionally, ongoing conflicts with the Slavs, Avars, and Sassanid Persians for the first half of the century had further exhausted the Empire's resources and disrupted Byzantine trading and commerce in the Aegean, where enemy ships threatened many of the major shipping routes leading in and out of Constantinople. J.-P. Sodini suggests that these impediments to maritime traffic may have interrupted regular contacts between the island of Proconnesus and Constantinople on the mainland, depriving the capital of its primary source of marble and causing the cessation of quarry work the in first part of the 7th century.[240] Similarly, archaeological evidence indicates that the quarries of Aliki on Thasos "permanently ceased to function around 615–620, potentially as a result of an attack by the Slavs or perhaps an earthquake," while the production of marble pieces at the Phrygian quarries also dropped off during this period, before experiencing a modest recovery (albeit on a reduced scale) in the 10th and 11th centuries.[241]

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[238] Sodini 2002: 129.
[239] Mass 2005: 14
[240] Sodini 2002: 136.
[241] Id.

Table 4.2 Periods of use and ownership for important quarries (bold denotes imperial ownership)

Quarry Name	Stone Type	Periods of Exploitation	Ownership	Sources
Afyon (Docimion)	Pavonazzetto, white marble	First mentioned by Strabo; intensive excavations begin in Augustan period. Period of maximum use is 2nd century, but marking of blocks by imperial agents suspended in ca. 235–236. Use restarted and continued into Byz. Period (e.g., H. Sophia) and may have continued until end of 10th c.	Imperial property beginning with Augustus	Attanasio 2003, Monna and Pensabene 1977, Fant 1985, 1989
Altinas (Asia Minor)	Pavonazzetto, white marble	Used from at least the 1st c. AD through early Byz. Period	Inscriptions from time of Domitian and Trajan indicate imperial ownership; appears to be privately owned by Byz. Period	Attanansio 2003; Waelkens 1982, 1983
Aphrodisias (Asia Minor)	White marble	Late Hellenistic through 4th-5th c. AD	Never imperially owned	Attanasio 2003; Rockwell 1996, Ponti 1996, Monna and Pensabene 1977
Carrara/ Luna (Italy)	White marble	First used in 4th c. BC; intensive excavations begin in 1st c. BC and continue through Imperial period; exports drop in 3rd c. AD. Apparently still functioning at lower capacity in 5th c. but no more use thereafter	Private property under Augustus, annexed by Tiberius between 22 and 27 and may have remained imperial prop until Late Antiquity	Attanasio 2003; Dolci 2003
Chemtou (Africa)	giallo antico	Roman system of marking blocks ceased in 201; coin hoard dating to the end of the reign of Honorius (395–423) is latest evidence of activity	Imperial property	Sodini 2002
Chios (Aegean)	porta santa		Imperial property	
Ephesus (Asia Minor)	white/grey marble	Extraction highest in 1st-2nd c. AD	Not imperially owned	Attanasio 2003
Hymettus (Attica)	white marble	First used in Rome in 1st c. BC by Lucius Crassus	Inscriptions indicate imperial ownership, at least for a period	Attanasio 2003, 2001
Karystos (Euboiea)	cipollino			
Mons Porphyreticus and Claudianus (Egypt)	Green porphyry, red porphyry, granite	First used in c. 1stc. AD through end of 3rd c. AD; Last pottery dates to 5th c., imports to Const. cease by 6th c. at latest	Imperially owned and adminsitered since Augustus	Peacock and Maxfield 1997
Paros (Aegean)	White marble, incl. lychnites	Used extensively during classical period; large scale production appears to have ceased by 3rd c. AD	Imperial Property	Attanasio 2003
Pentelicon (Attica)	White marble	Used extensively during classical period; continued to be used into the 4th c. AD, especially for sarcophagi	Quarries never become imperial property; belong to Herodes Atticus in 2nd c. AD	Attanasio 2003; Dodge 1980
Proconnesus	White/grey marble	Known in classical period; Exploitation increases after 1st c. AD and peaks in late antiquity. Exports cease in c. 600-625 AD	Annexed by Titus in 1st c. AD	Asgari 1977, 1988; Attanasio 2003; Karagianni 2011; Sodini 2002
Teos	africano, luculleo	Last quarry marks occur in 2nd c. AD		Balance 1966
Thasos (Aegean)	White/grey marble, dolomite	Widely used in classical period; Max use in 4th-6th c; quarries of Aliki permanently ceased to function c. 615–620	Epigraphic evidence indicates imperial ownership, at least for a period	Fant 1987

4.4 The Demand for Marble in Late Antiquity

4.4.1 Public Consumption

The state was unquestionably the single largest consumer of marble in late antiquity, just as it had been in the Roman period. As discussed above, the origins of the Roman obsession with marble can be traced to Julius Caesar's use of imported marble for a number of public building projects at Rome including the Forum Iulium in the 1st century B.C. Similarly, the reorganization of the marble trade under Augustus occurred in response to his own Imperial building projects, including the Forum of Augustus and the Temple of Caesar. After a period of discontinuity in the 3rd century, Imperial demand for marble in the East resumed under Diocletian and the Tetrarchy. Imperially funded construction projects continued under Constantine (r. 306-337), who built a bevy of palaces, public forums, infrastructural developments (e.g., cisterns, aqueducts, and roads),[242] and a number of churches in Constantinople. These included the Church of the Holy Apostles, which his biographer Eusebius tells us was encased "from the foundation to the roof with marble slabs of various colors."[243] Half a century later, Theodosius I (r. 379-395) left his own unique mark on the urban fabric of Constantinople, commissioning a number of major public buildings and forums including a triumphal arch and column (both constructed of Proconnesian marble) in the forum of Tauri.

But while Constantine and Theodosius' building projects were impressive, the Imperial demand for marble reached its apex during the reign of Justinian I (A.D. 527-565), who constructed or restored thousands of public buildings, military installations, roads and aqueducts, and churches across the Mediterranean world. Of these, the most enduring symbol of Justinian's reign is unquestionably the magnificent cathedral of Hagia Sophia (Holy Wisdom) in Constantinople, which at the time of its construction "embodied the spirit of Christian renovation that Justinian wished to be characteristic of his reign."[244] No expense was spared in the lavish decoration of the church, which was constructed in just five years in the wake of the disastrous Nika riots (A.D. 532) that had almost cost the Emperor his throne. It was, according to Procopius, "…a spectacle of marvelous beauty, overwhelming to those who see it, but to those who know it by hearsay altogether incredible."[245]

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[242] On Constantine's building program, see Johnson 2015.
[243] Eusebius, *Life of Constantine/Vita Constantini* LVIII.
[244] Maas 2005: 6-7.
[245] *De Aedeficiis* 1.1.27-1.1.28.

4.4.2 Private Consumption

As discussed previously, there was also a significant degree of private demand for marble dating back to the 1st century B.C. According to Pliny, Caeasar's *praefectus fabrum*, Mamurra, was the first man in Rome "to cover with marble veneer whole walls" and "have only marble columns" in his house in the 1st century B.C.[246] For competing Roman elites like Mammura, "marble was associated with luxury, luxury was the public marker of wealth, and wealth was power."[247] In the contentious political environment of the Late Republican period, "marble made a particularly appropriate symbol of wealth and power because it was expensive, imported, and unnecessary." [248] The costs and difficulties associated with the transport of decorative stone were so great that the prestige ascribed to a given type of stone was directly correlated with how far it had to be imported from its source. For instance, Seneca tells us that elites decorated their villas with "marbles from Alexandria," "mosaics of Numidian stone" and "swimming pools lined with Thasian marble," while Lucius Crassus (consul in 95 B.C.) installed columns of Hymettian marble in his house.[249] Colored stones, such as porphyry from Egypt or granite from the Troad—described by Pliny as "our favorite marbles"— were particularly desirable markers of elite privilege as they were easily identifiable and "spoke to the public, as much as to these elites' peers, of foreign lands and distant conquests." [250] The use of exotic marbles by competing elites was apparently so ubiquitous by the 1st century A.D. that Seneca complained that "'we have become so luxurious that we will have nothing but precious stones to walk upon."[251]

This use of imported marble as decoration in elite private buildings evidently continued into the Late Antique period. Notably, the criteria necessary to obtain a permit for setting up public honorific statues was severely restricted starting in the 4th century A.D.,[252] meaning that "prosperous private dwellings became the main places for people to show themselves in luxurious surroundings in order to impress not only clients and servants, but also people of the same social standing." In addition to extensive wall murals and floor mosaics, the use of imported marble "served to express the adherence of the house-owner and his family to a highly educated and economically affluent social class." In particular,

[246] Pliny the Elder XXXVI.7: 48–50 (trans. D. E. Eichholz).
[247] Fant 1988: 149.
[248] Id.
[249] Seneca, *Epistles* LXXXVI.6 (trans. R. M. Gummere).
[250] Russell 2013b: 14.
[251] Seneca, *Epistles* LXXXVI.6 (trans. R. M. Gummere).
[252] Bauer and Witschel 2007: 4; Horster 2001.

the use of marble slabs for wall revetments in private dwellings became fashionable, resulting in a decline in painted inscriptions and figurative wall paintings from the second half of the 3rd century A.D. onwards. [253]

In the Roman West, private sponsorship of major public building projects was also a well-established tradition. Indeed, the very first buildings in Rome to be built of imported marble, the temples of Jupiter Stator and Juno Regina (c. 146 BC), were commissioned by Q. Caecilius Metellus after his triumph in Macedonia.[254] Outside of the capital, this practice was even more widespread: for example, between 72 percent (Belgica) and 97 percent (Aquitania) of building projects attested in dedicatory inscriptions were privately financed.[255] While the last attested example of a privately funded secular building project in Rome was Symmachus' restoration of the theatre of Pompey (A.D. 507-12), private patronage in the west endured well into the 6th century in the form of elite-sponsored church construction such as the financing of the Basilicas of San Vitale in Ravenna, Sant'Apollinare in Classe, and San Michele in Africisco by Iulius Argentarius. [257]

While the tradition of private sponsorship of civic buildings was a less established practice in the East than in the Roman West, there is also evidence of privately sponsored construction—particularly of churches—in the East during the Late Antique period. For example, at Gerasa (modern day Jordan) at least six out of ten churches constructed between 464 and 540 were privately financed.[258] In Constantinople, the majority of churches and public buildings were imperially-financed during the Late Antique period, with the particularly prominent exception being the construction of the church of Hagios Polyeuktos by Anicia Juliana, who—aalthough not a direct member of the ruling Imperial family at the time—was the descendant of several Western Emperors, and supposedly built the church as a direct challenge to the authority and prestige of Emperor Justin I.

4.5 The Supply of Marble in Late Antiquity

The majority of the stone used to adorn the great imperial building projects commissioned by Justinian and his predecessors came from the island of Proconnesus (Marmara), located approximately 70 kilometers to the west of Constantinople in the Sea of Marmara. The

[253] Scheibelreiter-Gail 2012: 138
[254] Wallace-Hadrill 2008: 390-1; Bernard 2010: 40-6; Russell 2013b.
[255] Frézouls 1984; Blagg 1980. Cited in Russell 2013b: 13.
[257] Agnellus XXIV.57, 59. See M. Mango 2000: 923; Cormack 2000: 906.
[258] M. Mango 2000: 923; 1984.

island's numerous quarries were renowned for their wavy, grey-white marble, described which Paul the Silentiary compared to the rippled surface of the Bosphorus:

> "The peak of Proconnesus soothingly spreading over the entire pavement/
> has gladly given its back to the life-giving ruler [Christ/the emperor],/
> the radiance of the Bosphorus softly ruffling/
> transmutes from the deepest darkness of swollen waters (*akroleainiontos*) to the soft whiteness (*argennoio*) of radiant metal (*metallou*)." [259]

Another major source of white marble during the Late Antique period was the island of Thasos, in the Northeast Aegean.[260] Thasos supplied marble to Rome, Ostia, and Ephesus from the 4th century onward, as well as to Delphi, Antioch, Cyrenaica, and Pelusium beginning in the 6th century.[261] New research by Phillipp Niewöhner also indicates that white marble from Docimium in Asia Minor continued to be widely used during this period, particularly in the form of capital pilasters and wall revetments.[262]

Although Proconnesus, Thasos, and Docimium provided most of the white marble used in Constantinople, there was also significant demand for polychromatic marbles from Greece, Egypt, and Asia Minor in late antiquity. For example, Eusebius tells us that Constantine's Church of the Holy Apostles was encased "from the foundation to the roof with marble slabs of various colors."[263] Green breccia (*verde antico*) from Thessaly was used extensively in the churches of St. John Studios, Hagia Sophia, and Sts. Sergius and Bacchus, while freshly quarried breccia was also used to construct a monumental ambo found on a 6th century shipwreck off the coast of Sicily.[264] Other colored stones that were used in large quantities at Constantinople in late antiquity include pavonazzetto from the upper Tembris valley in Phrygia* (e.g., Church of Sts. Sergius and Bacchus; Church of the Holy Apostles), cipollino rosso from Caria (e.g., Church of the Holy Apostles), serpentine from Croceia, near Sparta, red marble from Cape Taenaros, cipollino from Karystos, gray-violet granite from the Troad* (e.g., the Troad portico in the twelfth region of Constantinople), and a variety of granites from Egypt.* [265]

Although the majority of the white marble used in the monuments built in the 4th to 6th

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[259] Paul the Silentiary, *Descriptio S. Sophiae* 664-67 (Bell 2009; trans. Pentcheva 2011).
[260] Sodini 2002: 131.
[261] Sodini 2002:10; Fulford 1989. On imports of Thasos marble, but also Proconnesian and other marble to Ostia and Porto, cf. Pensabene 1994, esp. pp. 33–35.
[262] Niewöhner 2014.
[263] Eusebius, *Life of Constantine/Vita Constantini* LVIII (trans. Schaff and Wace (eds.) 1955).
[264] The sheer size of the pieces, as well as fact that many of the edges and junctures of the ambo remain untrimmed awaiting finishing at their final destination, indicates that the Marzamemi ambo was not made up of reused stone.
[265] **Denotes evidence of imperial quarry ownership in the 2nd c. AD.*

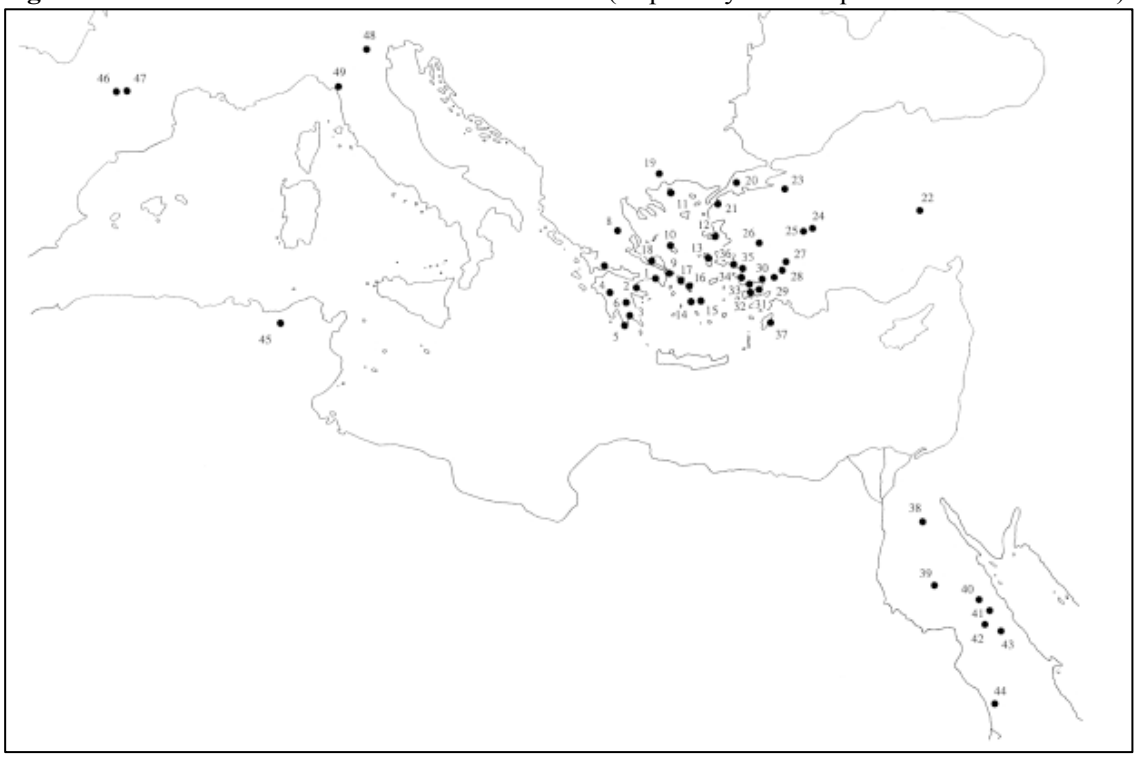
centuries appears to have been freshly quarried, there are some examples of spoliation of colored stones during this period that appear to have been primarily for symbolic purposes rather than economic necessity. For example, purple porphyry from the imperial quarries at Mons Porphyrites* and Mons Claudianus* was particularly highly prized by both the Romans and the Byzantine Emperors, and was used in Constantinople at the Hagia Sophia and the Church of the Holy Apostles as well as for the sarcophagi of the Imperial family. However, production of porphyry appears to have ceased at some point before the 6th century, making new material extremely scarce. Thus, it has been hypothesized that the porphyry columns of the Hagia Sophia, which are shorter than the other columns, may have been spoliated "to celebrate the death of the pagan gods."

4.5.1 The Imperial Quarries

At the height of the Roman Empire in the 2nd century A.D. the state owned and operated at least eleven quarries that provided the majority of the marble used for imperial building projects in Rome and later, Constantinople. These included the famed quarries at Carrara (Luna), which were the dominant suppliers of white marble to Rome during the height of the Imperial period (1st-2nd c. A.D.), as well as a number of white marble quarries in the Aegean and Asia Minor, which soon came to replace Carrara as the market leaders following the Crisis of the 3rd Century and Constantine's founding of Constantinople. By late antiquity, the most dominant amongst these were the Proconnesian marble quarries, which had been annexed by Tiberius in the 1st century A.D., followed by the quarries at Aliki on Thasos.[266] Other quarries that used a set of epigraphic conventions indicating that they were under Imperial administration, at least in the 2nd century A.D., included Chemtou in North Africa, the portasanta quarries at Latomi on Chios, the Karystos (cipollino) quarries in Euboea, the opencast and shaft marble quarries on Paros (lychnites), the africano quarries near Teos and Beyler, and all the quarries in Egypt, including Syene, Assuan, and Mons Berenicides (alabaster).[267] There is also epigraphic evidence for imperial ownership of the white marble quarries at Pentelicon in Attica and porphyry quarries at Sinnium, near Fruška Gora in modern Serbia.[268] Additionally, the marble quarries at Mt. Hymettus in Attica and on the Aegean island of Scyros may also have been under imperial ownership; however, the evidence for this remains insubstantial.[269]

[266] There is evidence indicating that Thasos was part of the Imperial system during this period, but this remains unconfirmed. Attanasio 2003: 201; Monna et al. 1993.
[267] Fant 1988: 152.
[268] Id.
[269] Id.

Figure 4.3 Sources of Marble in the Roman World (Imperially owned quarries denoted in bold)



1. Attic marble (Pentelikon, Mount Hymettos)
2. Corinth marble
3. Lakedaimon marble (from Croceai, serpentine)
4. Saraki (or Olympia) stone
5. Cape Taenaros marble (rosso antico)
6. Tegea or Doliana marble
7. Calydon marble
8. Thessaly breccia (verde antico)
9. **Karystos marble (cipollino)**
10. Skyros marble
11. **Thasos marble**
12. Lesbos marble
13. **Chios marble (porta santa)**
14. **Paros marble (including lychnites)**
15. Naxos marble
16. Tinos marble
17. Andros marble
18. Chalcis marble (fior di pesco)
19. Philippi marble
20. **Proconnesus marble**
21. Troad marble (granites)
22. **Alabaster**
23. Sangarios marble
24. **Docimeion marble**
25. Synnada marble (pavonazetto)
26. Sardis marble
27. Hierapolis marble
28. Laodikeia in Lykos marble
29. Aphrodisias marble
30. Alabanda marble
31. Mylasa marble
32. Iasos marble (cipollino rosso)
33. Herakleia ad Latmum marble
34. Priene marble
35. Ephesos marble
36. **Teos marble (africano, luculleo)**
37. Rhodes marble
38. **Ben i Suef alabaster**
39. **Hatnub alabaster**
40. **Green porphyry, red porphyry from Mons Porphyreticus**
41. **Granodiorite from Mons Claudianus (granito del foro)**
42. **Ophyte (diorite from Mons Aphites)**
43. **Basanite**
44. **Syene granite**
45. **Chemtou (giallo antico)**
46. St. Beat white marble
47. Aquitaine marble (bianco e nero antico)
48. Verona marble
49. **Luna (Carrara) marble**

Source: Sodini 2002: 131. Map legend, with modifications, after Dolci 1989.

It is unknown how many of the quarries that made up the Roman quarry system in the 2nd century were still part of the Imperial domain in late antiquity. However, there is evidence that at least some quarries, including Proconnesus, were still state-owned during the reign of Justinian in the mid-6th century. Another source of evidence for continued imperial involvement in the marble industry in the 3rd century is Diocletian's Price Edict (Table 4.1), which lists the maximum prices that could be charged for material from a number of quarries. However, it is unclear whether all of the quarries mentioned in the edict were still imperially owned at the time of its issue, and if so, whether this constitutes a complete

list.[270] Another clue as to whether the quarries were still state-controlled or not during this time period was the makeup of their workforce: imperial quarries, like mines, would likely have relied on a workforce of slaves and convicts (*damnati ad metalla*), and the Passio Quattuor Coronatorum mentions a Christian bishop condemned *ad metalla* in the porphyry quarries of Fruska-Gora as late as the 3rd century A.D.[271] Additionally, the Acta Sancti Clementis mentions several *damnati ad metalla* in the quarries of the Crimea. This limited evidence suggests that the state continued to play a central role in the organization and administration of at least some quarries in the 3rd century in much the same way as it had a century earlier; however, like all literary sources from this period, this must be interpreted with a certain degree of caution.

4.5.1.1 Administration of the Imperial Quarries

Unfortunately, no coherent, state-controlled system of quarry administration in late antiquity can be reconstructed from the textual evidence that survives.[272] Faute de mieux, this section discusses the administration of the *ratio marmorum* in the 2nd century A.D., for which there is significantly more textual and archaeological data. It remains to be seen just how much of this is transferable to the marble industry in late antiquity (4th-6th c. A.D.). But, while the Crisis of the 3rd Century and the gradual shift in political and economic power to the east was certainly a disruptive shock to the system, we must assume that there was at least some degree of continuity in how the Imperial quarries were administered between the 3rd and 4th centuries absent evidence to the contrary.

The *ratio marmorum* in the 2nd century was headed by the p*rocurator marmorum*, an official in Rome called who oversaw a number of lower *procurators* who were in charge of each quarry (or in some cases, quarry district) in the network. Much of what we know about these officials and the administration of Imperial quarries during this period comes from epigraphic evidence, which primarily consists of highly abbreviated quarry inscriptions made on quarried objects (*notae lapicidinarum*) that often refer to complex accounting systems coordinated by imperial officials.[273] While examples of these have been found at Chemtou, Docimium and the other pavonazzetto quarries of the upper Tembris Valley, the cipollino quarries on Euboea, and the marble quarries at Teos, Chios, Paros, Luna, and Proconnesus, the majority of what we know about Roman imperial quarry administration comes from the Eastern Desert of Egypt, where the Roman porphyry

[270] Sodini 2002: 133.
[271] Sodini 2002: 134.
[272] Sodini 2002.
[273] Russell 2013b: 39.

quarries of Mons Porphyites and Mons Claudianus were located. For example, analysis of *ostraka* from Mons Claudianus[274] tells us that by the 2nd century A.D., the imperial quarries in the Eastern Desert were part of an extensive *territorium metallorum* or quarrying/mining district. Each quarry appears to have been managed by an official called the *procurator metallorum*/ἐπίτροπος τῶν μετάλλων who (among other tasks) seems to have been responsible for the procurement of stone blocks.[275] This *procurator* oversaw an extensive staff of administrators tasked with "the ordering of supplies and provisions, arranging for the employment of stone-masons and other skilled workers, and guarding the quarries and their associated settlements."[276]

It would be unwise to assume that the entire quarry network was organized and administered in exactly the same manner as the Egyptian quarries, as Mons Porphyrities and Mons Claudianus were unique in that their output was destined almost exclusively for Imperial monuments in Rome and Constantinople. Additionally, there was undoubtedly a significant degree of regional and chronological variation that must be taken into account, and it remains unclear whether dedicated quarrying and mining districts (*territoria metallora)* existed outside of the Egyptian desert. However, there is a good deal of epigraphic evidence for the existence of imperial *procurators* of marble at many other sites throughout the Mediterranean (e.g., Docimium, Phrygia, Karystos, and Chemtou), meaning that we can assume this was a fairly widespread (if not universal) position.[277]

In addition to these *procurators*, we also have some patchy epigraphic evidence for a variety of other imperial officials who would have been tasked with the administration of the quarries. For example, we have references to *vilici* at Luna, a *dispensator* at Chemtou, and a *dispensator Augusti* near Krokeai in the Peloponnese, while two other officials—one Hymenaeus Thamyrianus, a *lapicidinis Carystiis*, and Thamyrus Alexandrinus, a *dispensator Augusti* and *nutricius*—are mentioned on a statue base from near Karystos as well as on an inscription from Rome.[278] One interpretation that has been proposed for this is that these officials may have initially been based in Rome before being sent out to the quarries at Karystos, meaning that officials at the quarries and at Rome were all part of the

[274]On ostraka from Mons Claudianus, see Bingen et al. 1992; 1997; Cuvigny 2000, 1996; Bülow-Jacobsen 1996, 2009.
[275] Cuvigny 2000: 37; 2002: 242-8; Cockle 1996: 23-8; Hirt 2009: 52, 107-9.
[276] Russell 2013b: 41.
[277] Russell 2013b: 33; Christol and Drew-Bear 2005: 196-200; Hirt 2010: 113-4.
[278] Russell 2013b: 44. Relevant inscriptions are *AE* 1980, 476; *AE* 1991, 1681 (Carrara); *AE* 1986, 674 (Chemtou); *CIL* III.493 (Krokeai); *CIL* VI.8486 (Rome); *CIL* III.563, 12289 (Palaeochora). Hirst (2010) has suggested that many of these individuals would either have been slaves or freedmen.

same imperial administrative structure.[279]

4.5.1.2 Private Contractors at the Imperial Quarries

In addition to direct state involvement in the marble trade through *procurators* and other imperial employees (e.g., soldiers, slaves, or freeborn salaried individuals), it has been argued that the state also employed private contractors at imperial quarries, as was a typical practice used by the Romans in imperial mining districts in Spain at roughly the same time.[280] According to Cuvigny, there were several different ways that private contracts would have been awarded: first, the administration would lease out the extraction rights to a given resource to private contractors in return for a fee or a share of the output, under what was known as a *locatio conductio rei* contract. In other cases, the administration would hire private contractors under a *locatio conductio operis* contract to undertake specific work in return for a fee.[281] Russell suggests that one possible group of individuals that may have been private contractors were the *rationarii* (account-holders), who are mentioned on inscribed blocks from Docimion, Chemtou, Teos, Chios, Paros, and various Euboean quarries.[282] It is certainly appealing to think that these blocks made up part of the quota that the *rationarii* were contractually obliged to produce under a *locatio conductio operis* contract. However, Russell argues that the limited number of references to the *rationarii* at the quarries themselves, as well as the fact that the same individuals are often mentioned in conjunction with more than one material, suggests that the *rationarii* were probably contractors tasked with acquiring particular quantities of stone, often from a range of quarries, rather than the quarrymen themselves.[283] Additionally, Russell notes that some 70 percent of the inscriptions mentioning *rationarii* come from Portus and Rome, which suggests that they were most likely based in Rome and were individuals who were closely connected to the administration.[284]

There is also epigraphic evidence for the existence of private contractual labor at the

[279] Hirt 2010: 157-9; Russell 2013b: 44.
[280] Domergue 1990: 302-5. Peter Brunt made a similar point with regard to quarrying in a letter (dated 21 June 1976) to John Ward-Perkins, stating: 'state *control* does not necessarily imply state *management*' (BSR Archive, WP.2: Box XXXV). For more on contractors in mining, see Hirt 2010: 261–90 and Russell 2013b: 46.
[281] Russell 2013b: 46. For more on these contracts, see Cuvigny 2000: 14-21; Long 1875: 710. On similar leasing systems in agriculture, see Ørsted 1994.
[282] Hirschfeld 1905: 166.
[283] For example, Russell notes that the name Her(-) is inscribed on two blocks of Parian marble at Portus datable to AD 163 and 164, the rock-face in the quarry shaft at Marathi on Paros, and also on three blocks of africano datable to 162. Bruno et al. 2002: 349.
[284] Russell 2013b: 46; Hirt 2010: 301-2; Christol and Drew-Bear 2005: 196, n. 23.

quarries themselves, the majority of which comes from Docimium in Phrygia. A number of quarry inscriptions, which range in date from A.D. 136 to 236, generally provide a consular date, coordinates of the position in the quarry where the stone had been extracted from (locus and usually b(racchium) numbers), and either one or both of two names, one preceded by *off(icina),* the other preceded by *caes(ura)*.[285] As Russell explains, *officina* is conventionally translated as a "workshop" or "studio," and appears to have been the unit responsible for handling material once it had been quarried, while a *caesura* refers to a place of cutting, presumably a quarry.[286] A similar specialization of labor, in which one group of workers is specifically tasked with the quarrying of raw material, and the other (also called *officinae*) with the working of this material into finished or semi-finished products, is also attested to at imperial mines.[287] Not much is known about either of these groups, but Christol and Drew-Bear have argued that one of the *officinae* at Docimium, who is referred to as the *officina smyrnaiorum*, would have been responsible for the production of material intended for a project at Smyrna, while other *officinae* seem to have connections with Ephesos and Nicaea.[288] Based on the dates of the inscriptions and the absence of clear status labels, for example *aug(usti)* or *Caes(aris)*, Russell and Hirt have suggested that most of the people that made up these *officinae* were probably sons of freemen, with relatively low social status.[289]

The manner by which private quarrying contracts were awarded at Docimium and elsewhere is a subject of much debate. The primary source of evidence for how this might have occurred in practice is a quarry inscription from Docimium, which indicates that *officinae* were obligated to produce a certain quantity of stone blocks each year. [290] This inscription explains that the material upon which it was inscribed was being delivered by an *officina* as a replacement for some other stone that had been used as a temporary loan made by another *caesura* to an individual named Titus. This has been interpreted by some scholars as an indication that these quarrymen were contracted by the state to produce a specific amount of blocks under a *locatio conductio operis* arrangement, and thus were keen to record exactly who had produced each block. However, an alternative explanation proposed by Russell (as well as Fant, in his original 1989 study of the quarry inscriptions)

[285] Fant 1989; Kraus 1993; Dubois 1908; Bruzza 1870; Hirt 2010; Pensabene 2010.
[286] "The term "lapicaedina" is used instead of "officinal" in one instance at Chemtou, which makes this interpretation fairly certain." Russell 2013b: 46; Dubois 1908: no. 110, 112.
[287] Ørsted 2000: 73-6.
[288] Christol and Drew-Bear 2005: 191, no. 4; 1987: 109.
[289] Russell 2013b: 47-8; Hirt 2010, *contra* Drew-Bear 1994: 806. On the status indicators of imperial freedmen, see Weaver 1972: 2.
[290] Fant 1989: no. 177.

is that these blocks may have constituted part of an annual fee paid to the administration by these contractors, in return for their right to extract stone from the quarry under a *locatio conductio rei* agreement.[291]

A final clue as to the role played by private contractors in the imperial quarry system is the fact that only a small percentage of all quarried stone from Docimium is marked in the manner described above, the majority of which is pavonazzetto from the Bacakale quarry.[292] We also know that unmarked blocks of stone were being exported during this period: for example, both inscribed as well as uninscribed blocks of pavonazzetto were part of the cargo of the Punto Scifo shipwreck, while the Dramont shipwreck contained blocks of unmarked africano.[293] This suggests that at least some of the material produced at Docimium, as well as the other imperial quarries, may have been bought and sold through "regular channels of supply" that were not subject to direct imperial intervention.[294] One plausible explanation for this offered by Russell is that the private contractors employed at the state-owned quarries could have made some money on the side by quarrying and selling stone for personal profit once they had met their imperial quota.[295]

The extent to which what is known about the role of private contractors at Docimium can be extrapolated to the rest of the imperial quarry system during this period, as well as whether such arrangements continued into late antiquity, is unclear. However, at most quarries there is explicit mention of *caesurae* or *officinae*.[296] There is also an indication of some degree of job specialization at Chemtou starting in A.D. 136, where *rationarii* are replaced by procurators whose names are preceded by *sub cura*, but mention of *caesura* holders (also referred to as procurators) does not come until later.[297] However, this does not necessarily mean that private contractors were not present at Chemtou, but rather there may not have been a record of these activities. As Russell suggests, at sites where contractors were hired with a *locatio conductio rei* contract—and thus paid for their extraction rights through a set fee, rather than by meeting an imperially mandated quota—there may have been no need for material to be explicitly labelled as imperially owned.[298]

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[291] Fant (1989) doubted whether these contractors "stood to realize a pure profit once they had met the cost of the lease."
[292] Id.; Pensabene 2007: 298-9.
[293] Pensabene 1978: 105-12; 2002: 20.
[294] Russell 2013b: 48; Ward-Perkins 1980: 39.
[295] Russell 2013b: 48-9.
[296] Hirt 2010: 309-13.
[297] Hirt 2010: 305.
[298] Russell 2013b:49.

4.6 Mechanical and logistical aspects of the marble trade

4.6.1 Extraction

Based on his surveys at a number of quarries (including Aliki on Thasos, Latomi on Chios, and Myloi on Euboea) and experimentation using ancient quarrying methods, Tony Koželj has identified several techniques by which stone blocks were extracted by quarry workers in antiquity.[299] The most common technique used in Roman and Late Antique quarries involved the digging of a three-sided channel through the rock with a depth corresponding to the desired size of the block, then the driving of wedges into this channel to pry the block free from the rock face. One technological innovation that occurred in late antiquity was the replacement of wedges with large chisels, which workers hit simultaneously. This method allowed a more rapid extraction than was previously possible. Different techniques were used to extract thin blocks for paving and veneering, while large columns were carved *in situ* before extraction.[300]

Once a block of marble had been removed from the mountainside, it was then either trimmed down to a more regular size or broken into several smaller, more manageable pieces for transportation to the storage depot, workshop for carving, or port for export by ship. These blocks were given what Manuela Wurch-Koželj calls a "protective envelope" intended to prevent damage during transportation. On unfinished blocks this entailed leaving a thicker edge to absorb any impacts during transport, while on pre-shaped column shafts it consisted of a thicker ring near their extremities.[301] Additionally, any microscopic cracks in the extracted blocks would have been consolidated at this stage using iron cramps, so as to prevent them from enlarging during transit.[302] The blocks would then be moved from the extraction area to the storage area/workshop/loading zone. The means of transport was dependent on the size of the block and the distance to be traversed: wooden rollers or sledges would be used for short distances, while for longer hauls smaller blocks could have been moved using wagons, carts and other vehicles drawn by one animal, while larger blocks would have required two or more animals in harness, or yoked teams.[303]

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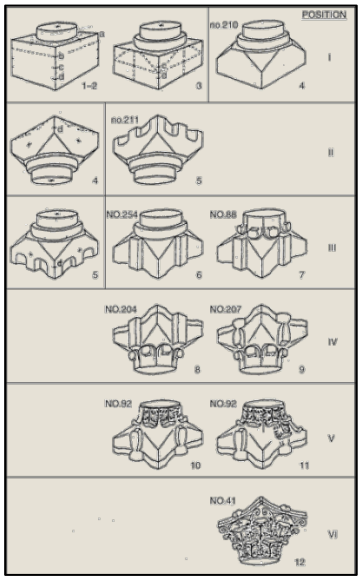
[299] These include extraction using natural cracks, extraction by heat shock, and extraction by hammering (Kožeij 1988).
[300] Koželj 1988: 32-6.
[301] "Certain buildings still have blocks with a protective envelope, which was never removed after arrival on the construction site. They usually are found near the base of a building." Wurch-Koželj 1988: 55.
[302] Id.
[303] Id.

4.6.2 Carving of Architectural Elements

Once a block of marble had been extracted from the ground, it would either be taken to the harbor to be loaded onto a ship in its raw form, or it would be taken a quarry workshop which manufactured standardized pieces including column shafts, bases, capitals, and chancel screens. These were usually left in "export form," with the intention that the last details would be added once the items reached their destination. Thanks to Nusin Asgari's extensive surveys of the quarries and workshops at Proconnesus, a good deal is known about the stages of workmanship involved in the production of these elements. For example, Corinthian capitals were first roughed out to a stage where their general shape was defined, before the details of the acanthus leaves were introduced in a series of nine distinct steps.[304] Thirty-one of the Corinthian capitals that Asgari studied at Proconnesus appear to have been roughed out in the same way using the height of the capital and the lower diameter of the column shaft as a guide. This standardization suggests that there was a degree of labor specialization at the quarries: that is, workers would have been tasked with repeating the same step(s) for each object (e.g., the roughing out) before it passed to another worker, who would then add his touches (e.g., the initial carving of the leaves), until the object had reached its export form. Similar processes have been identified for column shafts and bases; for example, column bases went through four distinct steps of carving before they were ready for transport.[305] This evidence of standardization indicates that the production of marble architectural elements was rationalized, in order to increase efficiency, and thus, maximize the productive capacity of the quarries.

Figure 4.4 Stages of production of Corinthian capitals on Proconnesus



Source: Asgari 1988: 122, fig. 1 (drawn by M. Beykan)

[304] Asgari 1988: 117-8.
[305] Id.

4.6.3 Transport and Distribution of Marble

Once a marble block or architectural element carved had reached its export form, it would usually be transported to the nearest harbor to be loaded on a ship for transport to its next or final destination. While some marble quarries (e.g., Docimium) were located inland, and thus were entirely dependent on overland transport, most (e.g., Proconnesus, Paros, Thasos, Ephesus) were located near to harbors where marble could be loaded onto ships for transport overseas. This would have been significantly cheaper and faster than overland transport, and thus quarries located near to harbor facilities would have enjoyed a competitive advantage in the market for marble. This argument is supported by recent work by Leah Long, who has used regression analysis to show a clear correlation between the prices of marble listed in the Diocletian Price Edict (Table 4.1) and the distance between the quarry and the nearest body of navigable water: the further the quarry was from water, the higher the maximum price was in the Edict.

An often-cited piece of evidence for the shipment of large quantities of marble in export form is the 6th century Marzamemi B shipwreck, which was carrying a load of 28 semi-finished Corinthian capitals, 28 column bases, and several column shafts in Proconnesian marble, several decorated marble chancel screen panels of Proconnesian or perhaps, Thasian origin, and one column and numerous pieces of an ambo made of green *verde antico* from Thessaly.[306] A similar cargo has recently been discovered at Amrit (Syria), where the wreck of ship carrying at least 20 Corinthian capitals and other marble architectural elements, most likely of Proconnesian origin, has been located.[307] Similarly, a large number of white marble capitals and column shaft inscribed with crosses have been salvaged from a wreck off the coast of Haifa, which appear to constitute a prefabricated church, similar to that found at Marzamemi.[308]

The ships used to transport marble in the Late Antique and Byzantine period varied significantly in both size and cargo capacity. At the large end of the scale were large, robustly-built ships like the Marzamemi B wreck, which was transporting a cargo of somewhere around 200–400 tons of marble when it sank off the coast of Sicily.[309] Other large marble carriers include the Punto Scifo (A and B), Porto Nuovo, and Isola delle

[306] Kapitän 1961: 290; 1980.
[307] Russell 2013a: 355.
[308] Id.
[309] Parker 1992. First published by Kapitän, 1969; 1980. On its destination, see Castagnino Berlinghieri and Paribeni 2011: 71.

Correnti wrecks, which carried individual blocks weighing up to 20-30 tons each.[310] These cargos could only have been loaded or unloaded at harbors with substantial docking and lifting facilities.On the other end of the scale, it is evident that small, ordinary merchant vessels also carried marble cargoes in the Roman and Late Antique periods. For example, the Veli Školj shipwreck in the Adriatic was only carrying five sarcophagus chests and 10 small blocks, all of Proconnesian marble, whch weighed no more than 10-20 tons. Russell notes that while most large cargoes of stone intended for building or carving projects tended to be shipped alone, some of these smaller-capacity ships sank carrying mixed cargoes of miscellaneous marble objects, amphorae, or roof tiles.[311]

Table 4.3 Prices of marble in Price Edict vs. distance from quarry to navigable body of water

Marble name	Identification	Price (denarii)	Overland (miles)
Docimeni	Pavonazzetto	200	275
Porfyritici	Porfido rosso	250	150
Claudiani	Granito del foro	100	120
Numidici	Giallo antico	200	50
Thessalici	Verde antico	150	50
Tripontici	Bithynian varieties	70	20
Carysti	Cipollino	100	5
Lacedaemonii	Serpentino	250	0
Lucullei	Africano	150	0
Pyrrhopoecili	Aswan/Syene granite	100	0
Alabastreni	Egyptian alabaster	75	0
Heracleotici	Heracleian	75	0
Scyri	Breccia di Settebassi	40	0
Lesbi	Lesbian	40	0
Thasi	Thasian	40	0
Proconnesi	Proconnesian	40	0

Long 2017: 10

4.6.4 Ordering and Purchasing Marble

In general, there were three main ways that marble could be obtained in late antiquity: it could be commissioned "to order," it could be purchased in prefabricated form, or it could be drawn from an existing stockpile. Marble destined for monumental imperial projects seems to have been commissioned directly from the quarries rather than purchased from stock, largely because of the monumental, expensive, and highly specialized nature of certain elements. One example of a marble element ordered directly from the quarry comes from a late 2nd century ostrakon from Mons Claudianus, which appears to be a draft letter addressed to Antonius Flavianus, a prefect, which reports on progress fulfilling an order:

[310] Kapitän 1961: 290; Bartoli 2008: 58-65 and 106. Whether these ships were purpose-built stone carriers, or *navis lapidaria*, remains up for debate. See Beltrame and Vittorio 2012: 144-46.
[311] Russell 2013a: 353.

> "To Antonius Flavianus, prefect, from the foremen and the stonemasons, Sir, greetings. With the help of our lord Sarapis and the Tyche of Claudianus and your Tyche we announce that we have finished one of the two 25 foot columns on the 26th day of Hathyr. If you please, Sir, and with the accord of our master the procurator, if steel and charcoal be sent to us, we shall finish the other one faster, if we can work without hindrance."[312]

Another way that marble could be obtained was by drawing from an existing stockpile or stone yard. For example, in the Imperial period there were several centralized stockpiles at Rome that were apparently replenished with blocks and architectural elements so that the imperial administration, and perhaps private consumers, could have quick and easy access to material for construction projects. The most famous of these is the stockpile of 340 marble items that have been recovered from Portus and the Tiber bank of the Emporium district in Rome, which include an assortment of blocks, slabs, column shafts, and other elements. [313] It has been argued that much of the marble used to build the 4th century basilicas in Rome was drawn from these stockpiles, although this cannot be confirmed.

Lastly, marble could be purchased in pre-fabricated form, either at the quarry or from an intermediate Emporium. Sodini has argued for the existence of a marketplace for marble at Constantinople, as well as at other major cities including Ravenna, Carthage, Antioch, Caesarea in Palestine, and Alexandria. One example of this is St. John Chrysostom's tale of an unfortunate monk from Thasos who travelled to Constantinople to acquire slabs of Proconnesian marble for his parish, but spent all his money before he made it to the marble market, while the 7th century Miracula Demetrii recounts the story of Bishop Cyprian of Carthage, who sought to purchase an ambo and ciborium.[314] His salvation came in the form of a bishop of Marseilles who had ordered porphyry columns and slabs for his church from Mons Porphyrites in Egypt, but found some equivalent stone in his own city. Cyprian was thus able to purchase the materials for his ambo and ciborium from the captain of the ship carrying the original cargo when it stopped at Carthage.These episodes serve to illustrate several different ways that marble could be obtained by consumers: first, marble elements could be commissioned "to order" directly from the quarry, as the bishop of Marseilles did; second, they could be bought in prefabricated form from a passing ship, as Cyprian did; or third, they could be purchased from specialized traders in the capital and other cities, perhaps at dedicated marketplaces modeled on the *Marmorata* in Rome.[315]

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[312] Bülow-Jacobsen 2009: no. 58.
[313] These have been studied at length by Pensabene and Fant. See e.g., Fant 1992.
[314] Gregory of Nazanzius, *Poema de ipso* 11. 875ff.= PG 37, col. 1089.
[315] Sodini 2002: 134.

Chapter 5. Geospatial Modeling and Network Analysis in Archaeology

"All models are wrong, but some are useful."

—George Box[316]

5.1 Introduction

This thesis uses a relatively new geospatial modeling tool called *ORBIS* to generate a marble distribution network in the Late Antique period. First, *ORBIS* is used to model the optimal routes by which marble object in late antiquity would have been shipped from their point of origin (the quarries/associated workshops) to consumers across the Late Roman world, as well as to estimate the transport speed, cost, and overall distance that would have been involved in this process. These routes are then aggregated to generate a complete distribution network for the type of marble architectural element in question, which is then analyzed using a variety of statistical techniques including several metrics drawn from network analysis.

In *Part 2* of this chapter, I present the rationale for using geospatial modeling in archaeology and provide an overview of how *ORBIS* is to be used in this thesis. In *Part 3*, I provide an overview of several types of network analysis and discuss some relevant applications of network analysis in archaeology and late antique history more broadly. I then focus on the ways that network-based metrics are applied in this study so as to better understand the structure of the network through which marble architectural elements were distributed in late antiquity.

5.2 The Case for Geospatial Modeling in Archaeology

There are a number of advantages associated with using geospatial modeling to investigate the roles of the state and private consumers in the ancient economy. First, models, or "*a priori* schemas which have to be subjected to the test of evidence,"[317] allow us to "fill in the gaps" of our knowledge by drawing logical deductions based on existing archaeological or textual evidence. This is extremely useful because archaeology is a field whose practitioners are often stymied by the gaps in our datasets; for example, our evidence for the time or cost of ancient travel in the ancient world is limited to textual

[316] Box and Draper 1987: 424-6.
[317] Andreau 2002: 40.

references, which are often unreliable and sometimes highly spurious in nature. More promisingly, archaeologists have used ceramic distribution patterns to attempt to reconstruct trade routes in antiquity (see, e.g., Pieri 2012, 1995; Keay and Abadie-Reynal, 1992); however, purely empirical approaches can only illuminate so much about the nature of connectivity and exchange in antiquity given the gaps that are inherent in archaeological data. Model-based approaches allow us to transcend these limitations.

Geospatial modeling in particular provides a new set of tools to analyze the complex interactions between geography, technology, politics, economics, and social connectivity in the ancient world. As Walter Scheidel, (one of the principle proponents of the archaeological application of geospatial technology) notes, conventional maps of the Roman and Late Antique world "fail to give us a proper sense of how different hard and liquid surfaces, altitudes and climes shaped people's movement across this vast space: the real cost of travel, in terms of time and money, remains unknown."[318] Moreover, movement and connectivity are dynamic concepts by their very definition. It means little, for example, to know that sailing from Constantinople to Ravenna in July took 20 days, if we do not know how long it would have taken them under different conditions, say at a different time of year, or by a different mode of transport (e.g., over land). Thus, Scheidel argues that "we cannot hope to explore the relationship between cost constraints and historical outcomes" in any meaningful sense until we can properly appreciate—if not ever fully understand—how all of these variables might have interacted in structuring space and movement in the Roman world. According to Scheidel, a good, systematic model of connectivity in the ancient world must "be able to approximate the pace of movent and economic cost of travel across different terrains, by different means of transport, at different times of the year." Such a model would need to be able to take into account a range of variables, including geomorphology, climate, technology and infrastructure."[319]

Even when greatly simplified, these types of complex, multivariable models require substantial amounts of computing power due to the large number of elements involved, which has historically made them extremely cost prohibitive for archaeological applications. However, recent technological advances have now made it possible to build and run a model that is designed to take into account most—if not all—of the factors described by Scheidel using web-based, cloud computing, rather than one's own physical servers. The result is a new geospatial model named *ORBIS*, which now offers the ability

[318] Scheidel 2013b: 2
[319] Id.

to gain the sort of systematic understanding of Roman and Late Antique connectivity that is long overdue. [320]

5.2.1 Introducing ORBIS: The Stanford Geospatial Network Model of the Roman World

ORBIS (www.orbis.stanford.edu/) is a publically available, interactive tool developed at Stanford University designed to model the distance, time, cost, and relative financial expense of travel between sites in the Roman World by simulating movement through a vast network of urban settlements, ports, roads, navigable rivers, and sea routes. The model incorporates multiple modes of transportation (e.g., fast and slow ships, oxcarts, wagons, donkeys, etc.) and also takes into account seasonal variations in environmental conditions (e.g., monthly wind patterns, strong currents, and wave height) that would have impacted travel time and transport cost between sites.

While *ORBIS* is not the first attempt to model connectivity in the Roman world, previous studies have largely focused on specific regions rather than the Empire as a whole. For example, Cèsar Carreras Monfort and Pau de Soto Cañamares have employed price-based modeling to analyze Roman trade connections in Britain and on the Iberian peninsula. However, their models are limited by comparison with *ORBIS* due to (1) scope and the lack of ability to consider travel time, (2) no means of simulating sailing routes, and (3) a relatively limited range of transportation options. Justin Leidwanger has addressed many of these shortcomings by using a Geographic Information System (GIS) to model Roman sailing speed in the northeastern Mediterranean.[321] However, Leidwanger's innovative model is focused primarily on investigating regional and local trade networks in Cyprus and the Levant, while *ORBIS* is designed to model long-distance patterns of connectivity across the Roman Empire.

Since its initial release in May 2012, *ORBIS* has generated significant excitement among academics and the general, history-loving public.[322] Yet beyond just being an "excellent new toy"[323] that is "well worth a play,"[324] several preliminary papers published by Scheidel and his colleagues at Stanford have indicated that *ORBIS* also holds a great deal of potential as a serious research tool. For example, Scheidel has compared routes

[320] *ORBIS*: The Stanford Geospatial Network Model of the Roman World. Accessible at http://www.orbis.stanford.edu.
[321] Leidwanger 2013, 2014.
[322] See, e.g., Rosen 2012; See also Gonzales 2013.
[323] Worstall 2012
[324] A.B 2012.

generated using *ORBIS* to the maximum prices for sea travel listed in Diocletian's price edict to argue that the prices are directly correlated with travel time, as Pascal Arnaud had previously hypothesized.[325] Similarly, Dan-el Padilla Peralta has applied *ORBIS* to investigate regional variations in the accuracy of the Antonine Itineraries.[326] But beyond these initial text-based applications, the ability of *ORBIS* to make sense of large archaeological datasets remains relatively untested. Thus, this thesis acts as a test of the utility of *ORBIS* as a sophisticated scientific tool with real-world applicability, rather than just a fun toy for armchair historians.

5.2.2 How ORBIS Works

ORBIS simulates travel through a network of some 632 sites, or "nodes," which represent significant cities, towns, and geographical landmarks (e.g., promontories) that have been selected from the Barrington Atlas of the Greek and Roman World.[327] To use the model, users select the time of year, a mode of transport (e.g., "Oxcart,"(12km/day) "Slow ship," "Fast ship," etc.), and a desired start and an endpoint. Optimal routes between these sites are then determined using the "Dijkstra pathfinding algorithm," which determines the shortest "path" between two nodes in a network. Movement through this network occurs through three models designed by *ORBIS*' creators to simulate the sea, road, and river routes that would have been used in Roman times.[328] For example, the road model is made up of 814 road segments from the Barrington Atlas, while major rivers including the Tiber, the Nile, the Rhone, and the Seine are included in the river model. Lastly, the sea model is the most interesting aspect of *ORBIS* for the purpose of this thesis, and is the one that truly sets *ORBIS* apart from previous attempts to model travel in the Roman period. The sea model allows movement along established ancient sea-lanes that have been documented by Pascal Arnaud,[329] which are supplemented by short-distance routes between adjacent coastal sites and several additional medium-distance routes inspired by comparative historical data. To simulate actual sea travel, rather than direct point-to-point transit, *ORBIS*' creators then overlaid the Mediterranean, Black Sea, and parts of the Atlantic with a "mesh" of lines connecting roughly 40,000 arbitrarily located nodes (Fig. 5. 1). This might be thought of as a very complicated subway system: ships in the model cannot "go off the rails," but enough rails have been built in to the model to allow for significant freedom of movement. *ORBIS* then calculates a ship's optimal path through this mesh by

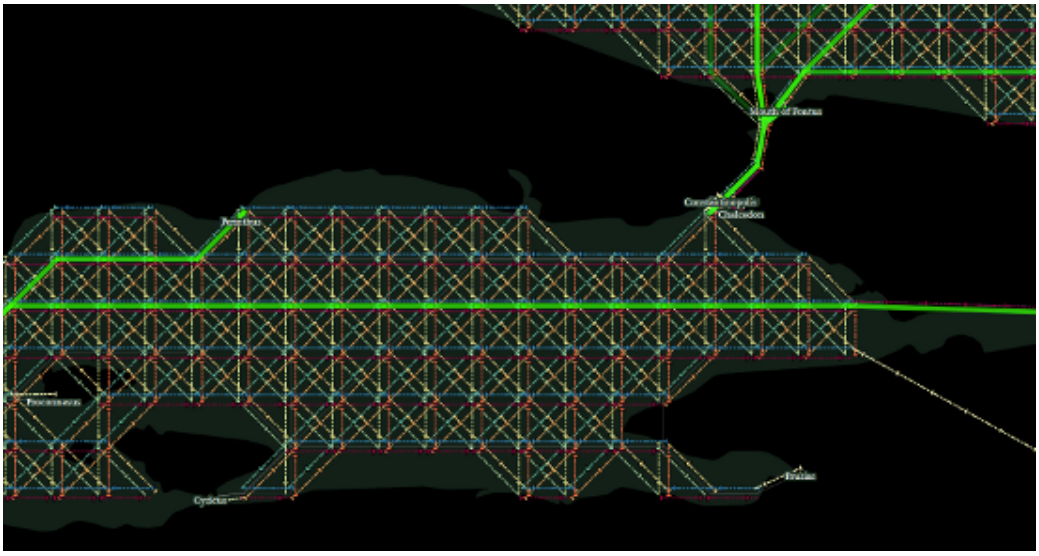
[325] Arnaud 2007.
[326] Padilla Peralta 2015.
[327] Talbert 2000.
[328] Id.
[329] Arnaud 1992, 2005.

taking into account prevailing winds, currents, and the navigational capabilities of a typical Roman sailing ship.[330]

Figure 5.1 Coastal and overseas routes used in the *ORBIS* sea model

Source: www.orbis.stanford.edu

Figure 5.2 Derived route through the "sea mesh" used in the *ORBIS* sea model



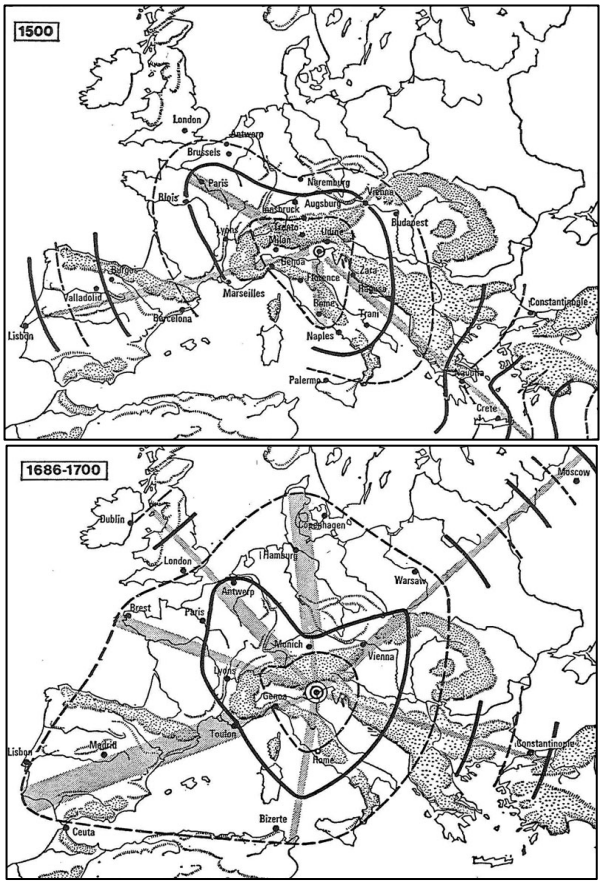
Source: www.orbis.stanford.edu

In addition to route generation and cost, distance, and travel time estimation, *ORBIS* can also be employed to generate several types of visualizations that aid in analyzing and comprehending the impact of cost, travel time, and distance on travel and connectivity in the ancient world. First, *ORBIS* can be used to generate cost contour maps, or "heat maps," in which isochronic bands are superimposed over a conventional map of the Mediterranean. This type of contour-based cartography was pioneered by the French historian Fernand Braudel, who used contour maps similar to the ones below to represent

[330] For a deeper explanation of how the sea model was built, see Arcenas 2013.

the time it took for couriered messages from different European locations to reach Venice during the early modern period.[331]

Figure 5.3 Speed of Letters Travelling Toward Venice (1500; 1686-1700)



Source: Braudel 1972.

5.2.3 Limitations of ORBIS

While *ORBIS* has great potential for changing our understanding of connectivity in the Roman world, it has a number of limitations in terms of its scope and resolution and the parameters and constraints that underly it. First, as *ORBIS*' creators caution up front, the model is designed to investigate large-scale patterns of connectivity in the Roman Empire, and thus functions on the macro-level. Accordingly, the simulations used in *ORBIS* prioritize "averages over particular outcomes, large-scale connectivity over local conditions, and the logical implications of choices, over actual preferences."[332] This means that simulations of the cost, travel time, or distance associated with a given route do not to reflect the experience of any particular traveler, but rather should be interpreted as statistically average outcomes that, when combined, shaped the system as a whole.

[331] Scheidel 2013b: 2
[332] "Understanding ORBIS." http://www.orbis.stanford.edu

Similarly, the accuracy of *ORBIS* at a local or regional scale is affected by this decision to focus on large-scale connectivity, and thus, the model is not particularly useful for analyzing routes that take less than a day or two to complete.

ORBIS is also limited by the parameters and constraints that have been built into the model. For example, the model relies on the Diocletian Price Edict of 301 for its price calculations, although questions regarding the purpose and efficacy of the Edict, its method of compilation, and how it relates to the outside world remain unresolved. Similarly, the model follows Arnaud's hypothesis that basis maritime freight charges in the Edict correspond to sailing times, and thus the model adopts his equation of 1 *denarius* with 1 day of travel for the "fast" sailing mode.[333] This conservative ratio has been chosen "to avoid exaggerating the price difference between cheap maritime travel and costlier modes of transport, but likely underestimates the cost of fast sailing travel." However, while these limitations might affect a study focusing on the *actual* cost of transporting marble in late antiquity, they arguably do not affect the utility of *ORBIS* for the purpose of this thesis, which is concerned only with *relative* cost differences between different forms of transport as well between different sites in the Empire.

Additionally, *ORBIS* is limited by the fact that sea travel was frought with unexpected delays, which it does not take into account.[334] For example, ships spring leaks, must put into port for supplies, and are confronted with unexpected calm spells or headwinds that can substantially lengthen their journey beyond the "average" time it might take to complete a voyage. Accordingly, ORBIS tends to err on the faster side for sea travel than the realities of sailing in the Mediterranean might suggest.[335]

5.3 Archaeological Applications of Network Analysis

This thesis draws on a relatively simple form of network analysis to interrogate the data generated using *ORBIS*. Although systematic network analysis can trace its origins to the "hard" sciences such as mathematics, physics, computer science, and biology,[336] it is also an established research tool in the social sciences—particularly, sociology—where social network analysis (SNA) has long been used to analyze relationships and patterns of

[333] Arnaud 2005, 2007.
[334] "Understanding ORBIS." http://www.orbis.stanford.edu.
[335] Scheidel 2013a.
[336] For an overview of the various different applications of network analysis, see Newman 2003 and the work of Tom Brughmans (2010; 2013).

interaction between members of social systems. By contrast, the use of network analysis in archaeology is a relatively recent development, and, accordingly, early adopters of archaeological network analysis have tended to draw their network methodology and terminology from a wide range of authors across various fields.[337] This heterogeneity is not necessarily problematic, as network analysis itself is a collective term that incorporates multiple ideas and quantitative tools drawn from a variety of disciplines, and its diversity contributes to its utility as a tool. However, the uncritical borrowing of tools and methods from other disciplines to analyze complex archaeological datasets must be treated with caution due to the fundamentally different nature of archaeological evidence, and there is a distinct need for a specifically archaeological network analysis that incorporates archaeological data critiques and reasoning.[338] That being said, network analysis, if "done right," possesses great potential as a tool for archaeologists to directly visualize and explore the structure of relationships between archaeological data as well as to design and test archaeological hypotheses.

In the first half of this chapter, I provide an overview of several types of network analysis and discuss some relevant applications of network analysis in archaeology and late antique history more broadly. I then focus on the ways that network-based metrics are applied in this study so as to better understand the structure of the network through which marble architectural elements were distributed in late antiquity.

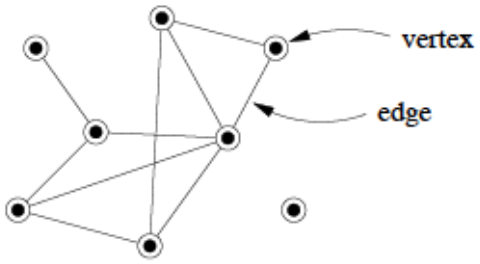
5.3.1 Types of networks and relevant applications

Network analysis is an umbrella term encompassing a wide range of subfields, including mathematics, physics, biology, sociology, history, and archaeology, each of which uses network analysis for their own specific purposes and has their own methodological nuances. Broadly speaking, a "network" is a system that consists of an assembly of nodes (also called vertices), and the linkages (edges) that connect these nodes to one another (See Fig. 5.3). To use some hypothetical examples that archaeologists might be most familiar with, each node in a network could be a household in a village, and the links between them the ties of marriage. Alternatively, each node could represent a distinct site in a particular geographic region, and their links the shared use of a particular resource—for example, a source of clay used for ceramic production[339]. Examples of other types of networks include "the Internet, social networks of acquaintance or other connections between individuals,

[337] Brughmans 2010: 2.
[338] Id. at 2, 25.
[339] Knappett 2013: 3.

organizational networks and networks of business relations between companies, neural networks, metabolic networks, food webs, networks such as blood vessels or postal delivery routes, networks of citations between papers, and many others"[340].In general, networks in the real world can be classified into four loose categories: social networks, information networks, technological networks, and biological networks.[341] However, in this chapter I will focus only on scholarship relating to two broad types of networks that appear most frequently in historical and archaeological data: (1) social or relational networks (e.g., social hierarchies, relationships between families in a particular community, etc.), and (2) spatially situated networks (e.g., settlement patterns; transportation and distribution networks). These are not necessarily mutually exclusive categories—some social networks also have a spatial component, for example, intermarriages between the inhabitants of different towns in a given region—but generally speaking, social network analysis as a field has tended to be concerned more with relational networks, while spatially situated network analysis is typically more focused on geographical considerations.

Figure 5.4 A small example network with eight vertices and ten edges



Source: Newman 2003:2

A. Social Networks

Broadly defined, a social network is a "set of people or groups of people with some pattern of contacts or interactions between them"[342]. These social interactions can take a variety of forms, including between groups of friends, business relationships between companies, intermarriages between families, and online communities of individuals who may have never even met in person. Basic social network analysis was pioneered in the 1920s and

[340] Newman 2003: 2.
[341] Id. at 5.
[342] Newman 2003: 5.

1930s by sociologists such as Jacob Moreno, who worked on friendship patterns within small social groups,[343] and Elton Mayo, who looked at the social networks of Chicagoan factory workers in the late 1930s.[344] A notable contribution to SNA was also made by Stanley Milgram, whose "small world" experiments in which letters passed from person to person were able to reach a designated target individual in a small number of (usually, six) steps, were some of the first demonstrations of the small-world effect (that is, the observation that most pairs of vertices in most networks are usually connected by the shortest possible path through the network) .[345]

A number of scholars have used social network analysis to study interaction in the ancient world and Late Antique period. For instance, Irad Malkin (2011) applied a social network-based approach to look at classical Greek settlement patterns in the ancient Mediterranean through a relational framework, while Giovanni Ruffini (2008) examined the social networks of two settlements in Byzantine Egypt using documentary evidence from 6th century papyri from Oxyrrynchus and Aphrodito.[346] Johannes Preiser-Kapeller has also experimented with using social network analysis to investigate a wide variety of types of social networks in Byzantium (e.g., networks of Byzantine aristocrats, or *dynatoi*; the hierarchy of the Byzantine church),[347] while Dumbarton Oaks recently convened a colloquium specifically aimed at social networks in Byzantium, the Medieval West, and the Islamic world.[348] But while social network analysis has undoubtedly seen a major increase in popularity among scholars of antiquity and late antiquity, it remains primarily concerned with the study of more abstract relational networks at the expense of geographical considerations. As a result, social network analysis has been more widely adopted by historians rather than archaeologists, who "find it difficult to avoid locating their network nodes first and foremost in physical space."[349]

B. Spatially Situated Networks

[343] Moreno 1934.
[344] Roethlisberger et al.1939.
[345] Milgram 1967. This famous set of experiments discussed in Milgram's 1967 *Psychology Today* article "The small world problem" also gave rise to the popular concept of "six degrees of separation," although Milgram himself never used that phrase.
[346] Malkin 2011; Ruffini 2008.
[347] See, e.g., Preiser-Kapeller 2012.
[348] Colloquium: The Social Network in Byzantium and Its Neighbors. Dumbarton Oaks, Convened by Margaret E. Mullett and Adam M. Schor. Washington D.C., March 16–17, 2012.
[349] Knappett 2013: 8.

A variety of spatially situated network analysis approaches have been applied in archaeological contexts with varying degrees of success. For example, Cyprian Broodbank[350] used proximal point analysis (PPA) to look at Early Bronze Age (EBA) settlement and connectivity patterns in the Cyclades based on the geographical distance between known archaeological sites, while Tim Evans et al. (2007)[351] have experimented with a number of different types of network models, including PPA and several types of gravitational networks, to examine patterns of interaction between Middle Bronze Age (MBA) sites in the Aegean.[352]

One particularly relevant study for the purpose of this thesis is Leif Isaksen's 2008 analysis of transport networks in Roman Baetica.[353] Using a dataset of routes and places mentioned in the Antonine Itineraries and the Ravenna Cosmography as its basis, Isaksen posited a theoretical nodal network consisting of key towns in Baetica (the nodes of the network) and the transport routes (connections/"edges") that linked them to one another. Isaksen's study was particularly interested in the exploring the relative importance of towns both as intermediary points as well as major starting/ending points in the transport network of the region, which he measured using two network metrics: closeness centrality and betweenness centrality[354]. For this purpose, Isaksen defines *closeness centrality* as "the ease with which a node can reach, or be reached by, any other node on the network" and *betweenness centrality* as "the probability that a node will be passed by traffic travelling along the shortest route between two other nodes on the network." [355] While Isaksen rightly cautions against jumping to conclusions based on a dataset that is admittedly both corrupt and incomplete, he does offer some interesting preliminary findings. First, he notes that district capitals showed a higher level of degree centrality (direct links to other sites) than other cities in the transport network, as one might expect. He also found that there were fairly similar levels of closeness across the network as a whole, which is fairly consistent with what one would expect of a strongly interlinked, symmetrical network of this type. More surprisingly, he also found a significant variation in betweenness (probability that a town will be passed by traffic travelling between two other towns)

[350] Broodbank 2000.
[351] Evans et al. 2007.
[352] Evans et al. 2009.
[353] Isaksen 2008; Cf Batty 2005; Graham 2006; Brughmans 2010.
[354] Freeman 1977.
[355] Isaksen 2008: 35.

across the network, which suggests to a high degree of probability that the regional capitals were chosen either as *de facto*, or intentional hubs within the province.[356]

Another valuable contribution to this area of scholarship is the case study of Tom Brughmans investigating tableware distributions in the Roman East, which serves as an excellent demonstration of how a variety of network analysis approaches can be applied to complex archaeological datasets. Brughmans applied a diverse array of sophisticated network analysis tools to analyze the Inventory of Crafts and Trade in the Roman East (ICRATES) database of some 25,000 individual tableware sherds datable between the 2nd century B.C. and the 7th century A.D.. In addition to building and analyzing a separate relational network of co-presence (that is, the absence or presence of pottery forms on the same sites in the same 25-year period) that did not take spatial considerations into account, Brughmans also built a distance-based network representing the relationships between sites at which pottery sherds were found based on their geographical proximity. Using a spatial clustering technique, Brughmans created distinct directed networks for each type of tableware in the ICRATES database, reflecting the absolute volume of pottery transportation over the shortest simulated path between any two sites. He then added up the values of the networks per ware to create a combined network, reflecting the complete distribution of tablewares for each 25-year period over the shortest simulated paths through the network. To analyze the resulting distribution network, Brughmans not only utilized the same closeness centrality and betweenness centrality metrics as Isaksen used to analyze transport networks in Roman Baetica, but also introduced the concept of "m-slices" as an additional quantitative tool.[357] In this particular case study, "input m-slices represent the attested volume of pottery being transported to sites" and thus can be used as "an indication of the hypothetical overall activity in table ware transport over a specific trade route." As Brughmans highlights, each of these quantitative tools "examine[s] distinct structural aspects, and produce[s] different outputs and numerical results" which must be considered critically in order to reach a meaningful interpretation of the data, and "the available archaeological data will to a large extent determine what techniques can be applied and how they need to be interpreted."[358]

5.3.2 Network analysis applications in this thesis

[356] Isaksen 2008.
[357] Brughmans 2010.
[358] Brughmans 2010.

In this project, network analysis is applied in order to better understand the structure of the network through which marble architectural elements were distributed in late antiquity. Here, the distribution network of a particular type of marble architectural element as reflected in our dataset is comprised of the routes between all the sites at which examples of that type of marble element have been found, as well as to the quarry from whence they came and all of the intermediate points through which they would have passed through on the hypothetical itineraries generated using *ORBIS*. Although a relational network of the co-presence of marble architectural elements along the same lines as that generated by Brughmans would be an excellent area for further research, it remains outside the scope of this particular study.

In the following case study, we use two network analysis metrics to analyze the structure of this simulated distribution network. First, we use the closeness centrality metric to better understand how easily marble would have been distributed throughout the Late Antique world, and can be used to identify which sites (both terminal and intermediary) in the distribution network would have been more easily reachable than others. And, second, we use the betweenness centrality metric to measure the relative degree of influence and control that individual sites in the network exercised over the transportation and distribution of marble architectural elements in late antiquity. These findings are then compared to empirical data for the distribution of marble architectural elements during this period as well as Late Antique settlement and urbanization patterns more broadly so as to confirm or disprove the validity of several research hypotheses. For example, are there more unique examples of a particular type of marble architectural element at locations in the network that exhibit higher network centrality and betweenness metrics as compared to locations with lower network centrality and betweenness values? Additionally, do regional capitals and other cities that were prominent in the Late Antique period exhibit higher closeness and betweeness centrality metrics as compared to smaller or less politically important towns in the same network, as was the case in Isaksen's study of Roman Baetica? This comparative analysis could provide valuable clues as to whether certain cities during this period became prominent *as a result of* their central position in the Late Roman trade network, or whether they achieved prominence *in spite of* occupying a more peripheral position.

One notable omission from Isaksen's study of Roman Baetica that has been introduced in this study is a measure of distance between the nodes of the network. As Isaksen notes,

introducing a distance component to the study of ancient transport networks presents some significant challenges, not least of which is what type of distance to even use: should one focus on the distance between two points "as the crow flies" (also known as the Euclidian distance), or is there a different way of conceptualizing space that is perhaps more appropriate for the purpose of the study? As discussed briefly in the introduction to the previous section on geospatial modeling, relying on conventional Euclidian distances as a measure of proximity between two locations in a given spatial landscape is an inherently abstract way of conceptualizing geography. While the advent of flight in the last century means we now actually *can* travel in a relatively straight line between two points in space "as the crow flies" without a major degree of friction,[359] this was unimaginable for the vast majority of human history. Instead, humans travelling through the world in which they lived had to contend with environmental constraints (e.g., rough terrain, mountain ranges, oceans), adverse weather conditions (e.g., too much or too little wind for ships to travel), and political obstacles (e.g., pirates/bandits; enemy armies) that imposed serious costs, both in terms of time and expense. For example, a marble trader in the 6th century would most likely not know—nor need to know—that two cities were 100 stadia apart as the crow flies, but rather would want to know the actual distance between the two cities by road or by sea, or the amount of time and expense that it would require for him to undertake a journey between them. Accordingly, this thesis does not use simple Euclidian point-to-point distance, but rather utilizes the estimates of expense and time required to travel between sites generated using *ORBIS*. Although these estimates are not without their biases, they at least are able to factor in relative difficulties involved in traversing varied terrains.

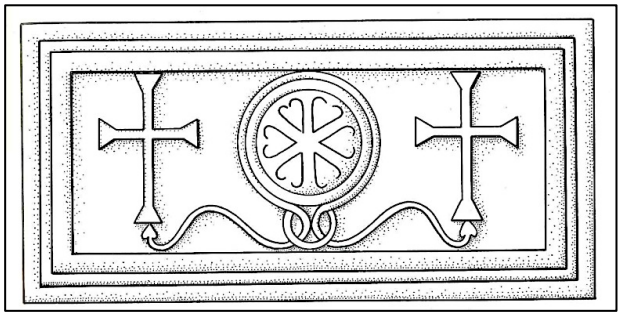
[359] It bears mentioning that even direct air travel involves a certain degree of friction—planes still have to avoid major weather systems, are restricted in their ability to fly over certain areas for political reasons, etc. The lesson here is that all forms of travel involve extraneous costs that simple Euclidian distance fails to account for.

Chapter 6. Modeling marble panel distribution with *ORBIS*

6.1 Introduction

In order to reconstruct the marble trade network in the Late Antique period, *ORBIS* was used to generate a variety of simulations and statistics that could then be used to quantitatively analyze distribution patterns of marble architectural elements based on travel time and transport cost. While a broader study taking into account other types of architectural elements would be highly informative, this case study focuses on a common type of chancel screen panel, the distribution of which was first compiled and mapped by J.-P. Sodini.[360] Chancel screen panels were utilized in churches to separate the bema from the naos and came in a variety of forms, often incorporating Christian (or in some cases, pagan) symbols. The particular type of panel that this case study focuses on is characterized by a wreathed christogram, or *chrisma,* in the center, often flanked by crosses on either side with ivy tendrils extending below (fig. 6.1). The *chrisma* is a common topos formed by the intersection of the Greek letters iota (I), for I(ησοῦς), and chi (X), for X(ριστός), while the stylized laurel wreath around the monogram is often used in Imperial and Early Christian iconography as a symbol of triumph and resurrection.[361] Some 317 screens of this variety have been identified at 96 individual sites throughout the Mediterranean and Black Sea regions, with clear clusters of sites in the Aegean, the Holy Land, and the Northwest corner of the Adriatic (fig.6.2).

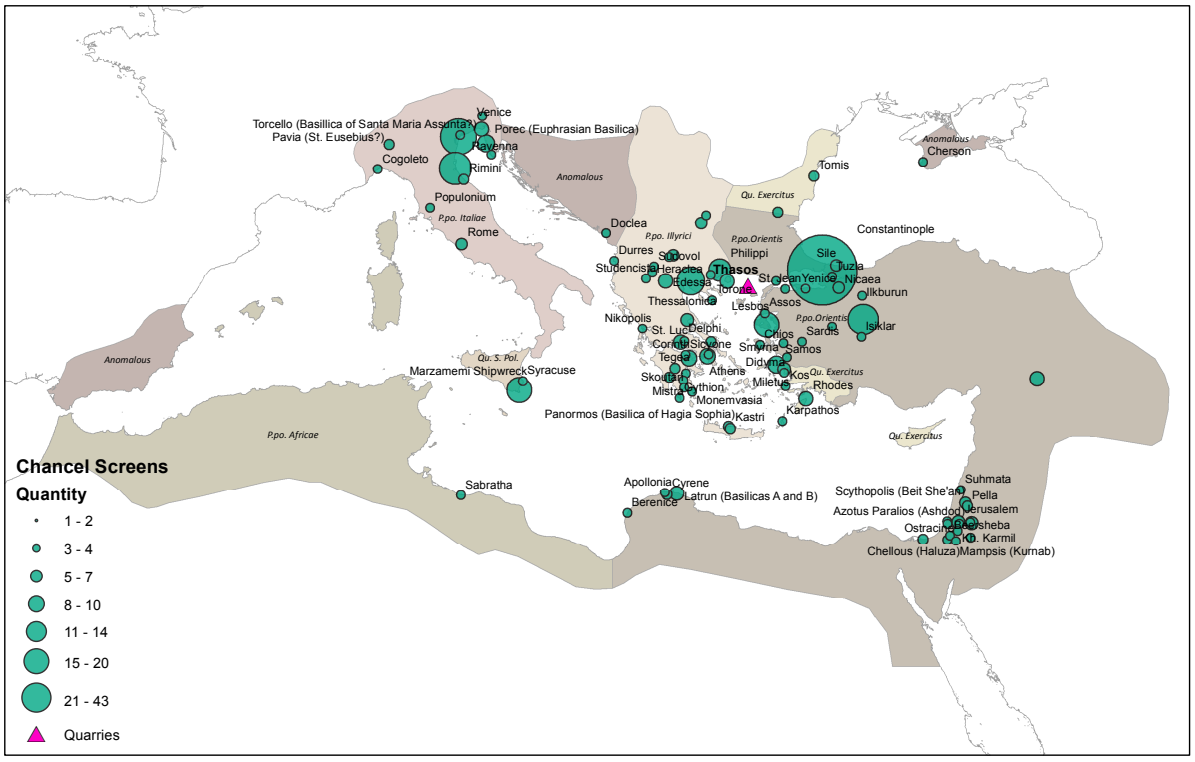
Figure 6.1 Drawing of a chancel screen with christogram and ivy motif from Marzamemi B



Source: Kapitän 1980.

[360] 1989: 184, fig. 11: Carte de repartition des placques a chrisme median et a lemnisques (dessin M. Blanc).
[361] Habas 2009: 103

Figure 6.2 Distribution of chancel screens with Christogram and ivy motif, by quantity



Source of data: Sodini 1989: 189, fig. 11.

6.1.1 Hypotheses

The extent to which the observed distribution pattern of marble architectural elements fits the cost contours generated in *ORBIS* can be read as a proxy for the prevalence of market exchange, which would arguably have been more sensitive to costs than coerced or subsidized transfers.[362] Thus, it may be hypothesized that the more the observed distribution patterns of these objects deviate from the outcomes predicted by the cost contours generated using *ORBIS*, the more likely it is that these transfers involved state intervention in the market in the form of coerced or subsidized deliveries. Conversely, the more the observed distribution patterns of marble architectural elements match the predicted cost contours, the less likely it is that these transfers involved state intervention in the market.

6.2 The Dataset

The chancel screen panel distribution map compiled by Sodini is a useful starting point for testing *ORBIS*'s utility for statistical and spatial analysis, as the quantity of screens (317) and individual sites (96) represented, as well as their wide geographic dispersal across the Empire, allows for general, large-scale patterns of connectivity to be observed. However,

[362] Scheidel 2013b: 23.

like all archaeological datasets there are a number of challenges presented when using this dataset, including the incompleteness and quality of the data, a lack of scientifically ascertained provenance data for many of the screens, and questions as to what constitutes a "site," or node in the network. Accordingly, the findings of this case study must be taken as preliminary observations regarding the nature of the marble trade in the Late Antique period as a whole, rather than a perfect model of how individual chancel screens were distributed during this period.

6.2.1 Completeness and quality of data

First, it should be noted that the distribution datset that comprises the basis of this study was drawn from a paper published by J.-P. Sodini in 1989, and is therefore somewhat dated. Somewhat problematically, Sodini also does not provide references for many of the panels included in his map. Accordingly, the author has sought to confirm the existence of the chancel screens described in Sodini's article wherever possible through researching archaeological and historical publications on each site, conducting image and map searches online, and visiting several sites in person (Marzamemi, Rhodes, and Constantinople) during the course of his dissertation research. The results of these investigations are listed in Appendix A. However, there are number of screens that, to the best of this author's knowledge, are not referenced in sources other than Sodini's article and thus their existence may be attested to only by hearsay or reliance upon Sodini's map. Given this lack of documentation, it would, of course, be preferable to visit each site for which there is no reference n both to confirm the existence of the screens referred to by Sodini, as well as to obtain samples that could be used for marble provenance studies; however, this was simply not permitted by the scope of this project. But, because this project is intended as merely preliminary study of connectivity as well as a "test run" of ORBIS, it is sufficient to assume for our purposes that at least the majority of screens in Sodini's map do exist, and thus, his distribution data may be used as the basis for this model.

The second main challenge that this dataset presents is that it is incomplete, which is a problem shared by most archaeological distribution datasets. There are two ways in which this dataset is incomplete: (1) a number of screens have likely been destroyed or have otherwise disappeared from the archaeological record; and (2) second, some screens may still exist, but have not yet been discovered or recorded by scholars. Both of these scenarios present issues regarding potential sampling bias, but are arguably not significant enough to discredit the overall model presented in this case study.

First, over the course of the millennium and a half since these panels were first made and distributed across the Empire, an unknown number have been destroyed, stolen, reused in other buildings, or otherwise disappeared from the archaeological record. Thus, the dataset of chancel screens as it exists today is unquestionably much smaller than what it would have been in late antiquity. This presents significant challenges for drawing conclusions as to the distribution of such elements: For example, if the rate of attrition was relatively constant across the Empire, we might reasonably argue that the patterns reflected in the data are significant, even in the absence of the screens that have gone missing, because the remaining distribution is still representative of the system as it existed. However, it is likely that certain political, social, or environmental events have affected the distribution of screens in some areas of the Mediterranean, but not in others: for example, modern Greece is an Orthodox Christian country, and thus many Byzantine churches survived the test of time and continued to be used as places of worship (e.g., the 6th century Church of the Ekatontapyliani in Paros), even under Ottoman Rule. Conversely, many Byzantine churches in present-day Turkey were destroyed or converted to mosques under Ottoman rule, and remain so even to this day. Given the clearly Christian symbolism of the *chrisma* and Latin crosses on the panels, it is likely that many of these objects would have been destroyed or re-carved to remove these elements over the course of time. Since these elements are flat, rectangular panels, they would be completely unrecognizable once the decorations had been removed. Additional factors that will likely have contributed to the attrition of the dataset include wars, earthquakes, looting, or natural degradation over time.

The question of spoliation must also be addressed when considering the possible corruption of the dataset: as has been widely documented, a scarcity of freshly- carved marble in the middle to late Byzantine periods resulted in significant reuse of earlier marble architectural elements throughout the Byzantine Empire. This pattern of reuse continued throughout the medieval period as well as under Arab and Ottoman rule: for example, the grand mosque at Kairouan in North Africa (built c. 670 AD) contains some 500 marble, granite and porphyry columns that were spoliated from Roman and Byzantine buildings at Sbeïtla, Carthage, Hadrumetum and Chemtou.[363] Such spoliation may have distorted the patterns observed in the dataset, which notably lacks any data from Carthage. However, with the exception of some notable examples (e.g., the use of marble elements from Constantinople to decorate St. Peter's Cathedral in Venice), the majority of such

[363] Delagrave1989: 396.

spoliation would likely have occurred on a relatively localized basis. Thus, given that this dataset is concerned more with *where* an element is, than what context it has been found in, it may be presumed that most elements that have been identified remain in the same general vicinity as where they were first used. This is, of course, an assumption, but is arguably a reasonable one given that this study is concerned more with observing general patterns rather than individual routes by which a particular object may have travelled.

Another concern regarding the completeness of the dataset is that there are undoubtedly screens in existence that have not been discovered, or at least, are not yet known to historians or archaeologists. For example, while finalizing this thesis for submission, the author came across a photograph of at least four additional chancel panels located in the museum of the Temple of Demeter at Sangri on the island of Naxos, which were removed from a sixth century basilica located in the area. These screens are clearly of the same style as the others, yet were not recorded in Sodini's dataset. Unfortunately, the functional limitations of *ORBIS* meant these screens could not be included in this thesis prior to submission, as the entire model would have had to be manually re-run. However, this discovery is evidence that the dataset will undoubtedly grow as more screens are discovered—or at least, are recorded by historians.

6.2.3 Provenance of Marble Screens

Another potential issue with using this dataset is that only a handful of provenance analyses have been conducted on marble chancel screen panels of the type used in this study. Accordingly, without an exhaustive and cost prohibitive effort to obtain and chemically analyze samples of the stone used in each object included in the dataset, the provenance (that is, the geographical origin) of the majority of these chancel screens cannot be determined to an absolute degree of certainty. However, for the purpose of this study (which is, after all, intended only as a theoretical model), some broad assumptions can be drawn from several studies that have been performed on what is arguably a representative sample of these objects from a variety of sites across the Mediterranean.

First, while these panels were historically been believed to be made of Proconnesian marble,[364] the limited provenance studies that have been conducted on such pieces indicate that many of them came instead from workshops at Aliki on Thasos, which specialized in the production of chancel screen panels that were exported not only to Macedonia and

[364] See, e.g., Sodini 1989.

central Greece, but as far away as Cyrenaica in North Africa.[365] For example, Mentzos, Barbin, and Herrmann performed cathodoluminescence and stable isotopic analysis of the marble used for several wreathed christogram chancel screen panels at the Rotunda Museum in Thessaloniki that are reported to have come from the Acheiropoietos. They determined that while many of the architectural elements in the museum were Constantinopolitan in style, most of them—including all of the chancel screen panels tested—actually originated at Aliki on Thasos.[366] The authors conclude that it is possible, if not quite likely, that "prefabricated slabs with this standardized design were exported in great numbers from the Thasian quarries."[367]

Similarly, a multivariate analysis of twenty-seven architectural marbles at two 6th century A.D. churches at Latrun (Cyrenaica) in present-day Libya including columns, capitals, bases, door moldings, and chancel screen panels (including several wreathed christogram forms), found that while the majority of marble architectural elements tested were of Proconnesian origin, seven out of the nine chancel screen panels that were analyzed originated at the quarries at Aliki on Thasos.[368] Significantly, the study found that none of the columns, capitals, column bases or other elements were of Thasian origin besides the panels, suggesting that the use of Proconnesian versus Thasian materials at Latrun was not random, but rather was directly related to the ability of certain workshops to supply specific marble fittings either as less expensive or of better quality.

On the basis of these studies, it has been assumed for the purpose of this model that the majority of chancel screens of this type originated at Thasos, and not Proconnesus. While this is the most plausible assumption that can be made based on the evidence that is currently available, it is of course highly doubtful that *all* of the panels in the dataset came from the same place. Visual observation of the various panels that have been identified indicates that while some panels are identical and likely came from the same workshop, others are clearly the product of different workshops with varying styles and quality of output that diverged from the typical form. For example, compare figure 6.3, a panel from Cividale, with figure 6.4, from Latrun in Libya. Whereas the Latrun panel relief is three-dimensional and the *chrisma* is smaller in comparison to the surrounding elements, the Cividale panel is flattened and the *chrisma* is significantly larger. These panels are clearly

[365] Cf. Mentzos et al. 2002, Hermann et al. 1999, Sodini and Kolokotsas 1984, Attanasio et al. 2008.
[366] Mentzos, Barbin, and Herrmann 2002.
[367] Id. at 321.
[368] Attanasio, Brilli, and Rocchi, 2008: 104.

the product of different workshops—however, the unanswered question is whether they are also from different quarries. Similarly, there is a high likelihood that some of the panels are local copies modeled after the Constantinopolitan style. But, this does not necessarily negate the purpose of the model, as replication indicates connectivity and knowledge transfer, perhaps through the copying of an imported original object that has since disappeared from the archaeological record.

Figure 6.3 Panel from Cividale

Source: http://www.green-man-of-cercles.org/articles/chancel_screens.pdf

Figure 6.4 Panel from Latrun, Cyrenaica

Source: Courtesy of Umberto Segnini.[369]

6.2.3What Constitutes a "Site"?

One final concern when using a distributional dataset such as this is just what constitutes a "site," or a node in the marble network. While a quarry is clearly one node, as is a city with only one church containing chancel panels, the question becomes more complicated when dealing with cities where there are multiple churches—for example, at Constantinople or Ravenna. Should these churches be treated as individual site, or should the city as a whole be treated as one cumulative site? Because this case study is focused on the structure of the network as whole, rather than looking at individual preferences or outcomes, individual churches have not been separated into separate sites. Also significant is that the model is designed to return centrality values for each site in the network, so it makes more sense to aggregate all of the objects found in each town or city into one site. However, for a more granular case study, a different approach might be taken whereby each church or site at which a panel was found would constitute its own separate node.

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[369] Accessed at: http://www.flickr.com/photos/15038841@N08/3256557046/in/photostream/

6.3 Modeling Using *ORBIS*

6.3.1 Route Simulations

For this case study, *ORBIS* was used to generate 70 simulated routes between Thasos and each location at which chancel screens were identified (fig. 6.5). Each route was first simulated prioritizing speed, and then once more prioritizing cost. All simulations were run using the same input parameters: the departure month selected was August, transfer cost was set to zero, the land transport mode was "oxcart" (12 km/day), river transport mode was "civilian," and sea transport mode was the "fast ship" option. These parameters were chosen both for standardization as well as because the summer was the preferred season for open-water sailing in antiquity due to favorable wind and sea states. The parameters could plausibly be changed (e.g., by adding a day of transfer cost to consider the time it would have taken to load marble on or off a ship), but since the parameters would change equally across all routes there would be no change in the *relative* cost or price. Additionally, these panels are relatively small (approximately 1.5 meters long by 1 meter tall on average), and thus would have been relatively easy to move on and off of ships and oxcarts without the need for specialized lifting equipment.[370] Thus, transfer costs would have been minimal in contrast to, say, large columns, which required specialized cranes and wagons to move.

Figure 6.5 All 70 simulated routes from Thasos to panel site locations, fastest setting

Source: www.orbis.stanford.edu

[370] Assuming the panels measured 1.5 m x 1 m x 0.15 m, or 0.225 m^3, using the average specific weight of stone (2.7 t per m^3)each panel would still have weighed on the order of c. 600 kg. (0.6 metric tons), which is not exactly "light"; however, this is still relatively manageable in comparison with larger objects such as column shafts and drums. For example, each of eight column drums from the Late Hellenistic Kızılburun shipwreck weighs 6-7 tons. Carlson and Aylward 2010: 114.

6.3.2 Cost Estimates

For each simulated route, *ORBIS* generated three statistics: distance (km), travel time (days), relative transport cost (denarii/kg. of grain). This data was collected and manually inputted into excel, so that it could be further analyzed both visually and quantitatively.

6.3.3 Visualizations

First, the "cartogram" function of *ORBIS* was used in combination with ArcGIS to generate heat maps in which each color band represents an increment of time or expense (e.g., fig. 6.6, using Proconnesus as the center of the network). Using the data from the route simulations, combined maps could be generated in ArcGIS showing the geographical location, quantity, and travel time/cost from Thasos for each chancel screen site (figs 6.7-6.10). These maps provide a much more useful visual representation of the connectivity costs associated with marble transport than could be provided by conventional means. Finally, *ORBIS* can also be used to generate "exploded network" diagrams (e.g., fig. 6.11) that give a sense of the real distances between sites, as well as so-called "minard diagrams" (e.g., fig. 12) in which the thickness of the line denotes the number of shared segments between routes—in other words, how well-travelled a particular route might have been–for all sites in the ORBIS network that fall within the border of the Late Roman Empire in the 6th century. Outside of this case study, this diagram is also interesting because the Marzamemi B shipwreck referred to in previous chapters is located at the tip of Sicily (labelled as "Portus Pachyni" in *ORBIS*), which is along one of the most well-travelled sea routes, suggesting the ship's possible terminus may have been Carthage or elsewhere in North Africa.

Figure 6.6 Heat map showing travel time from Proconnesus (days), fastest setting

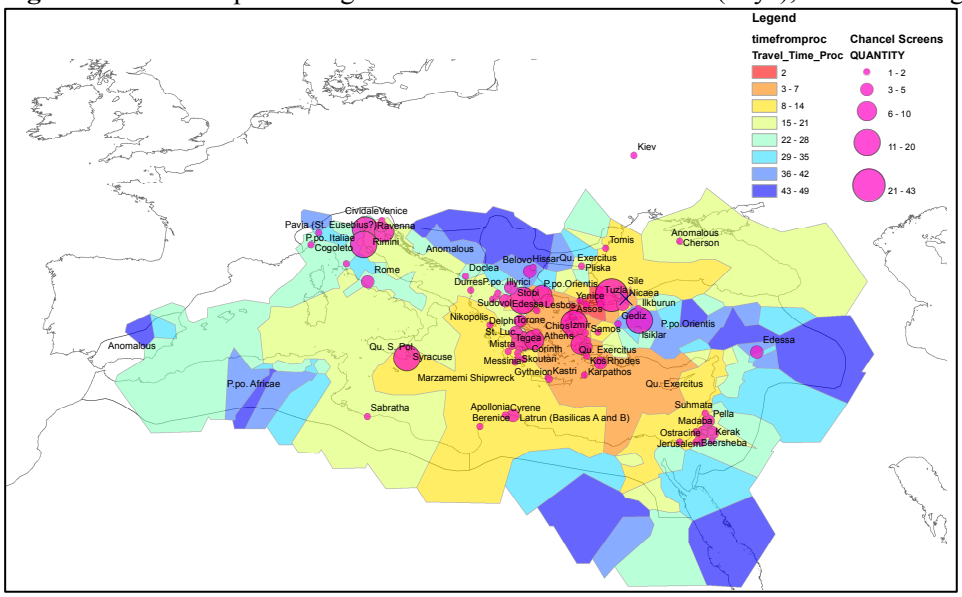


Figure 6.7 Travel time from Thasos (days), fastest setting

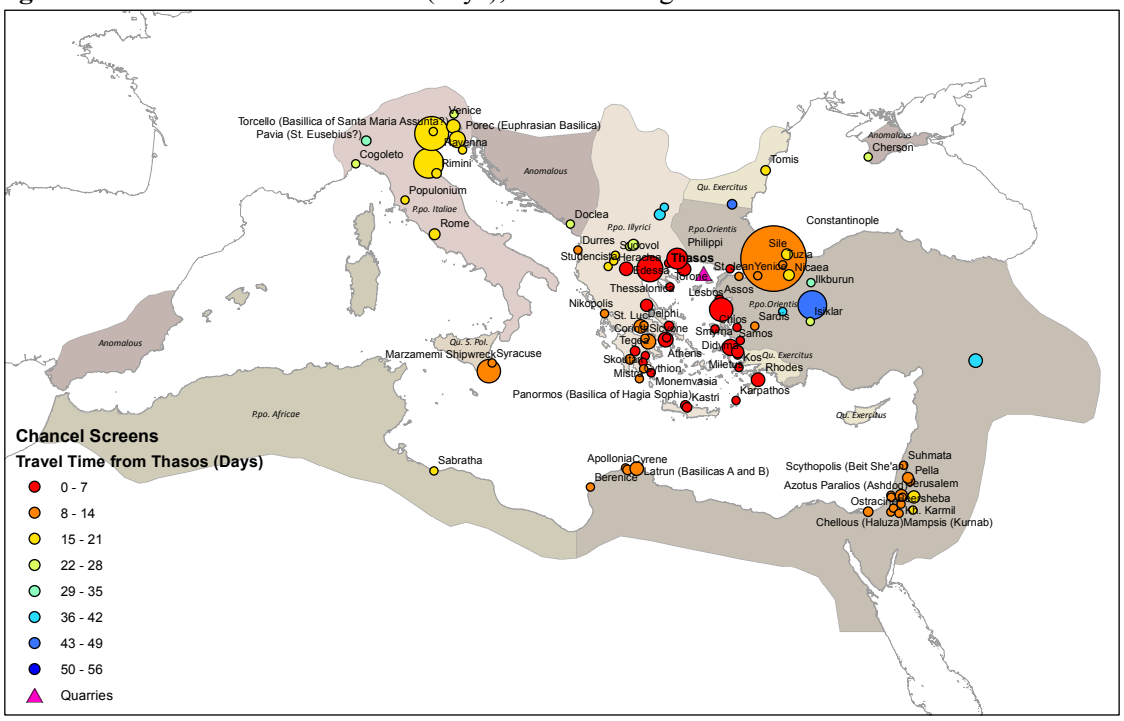


Figure 6.8 Travel time from Thasos (days), cheapest setting

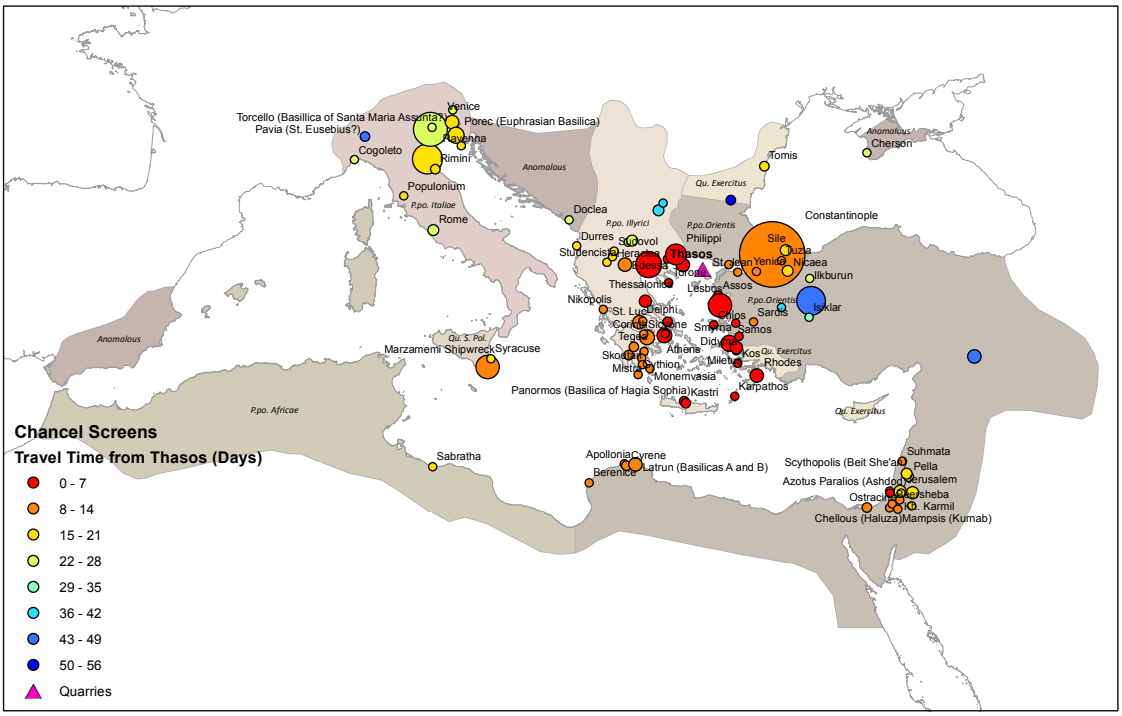


Figure 6.9 Transport cost from Thasos (Denarii), fastest setting

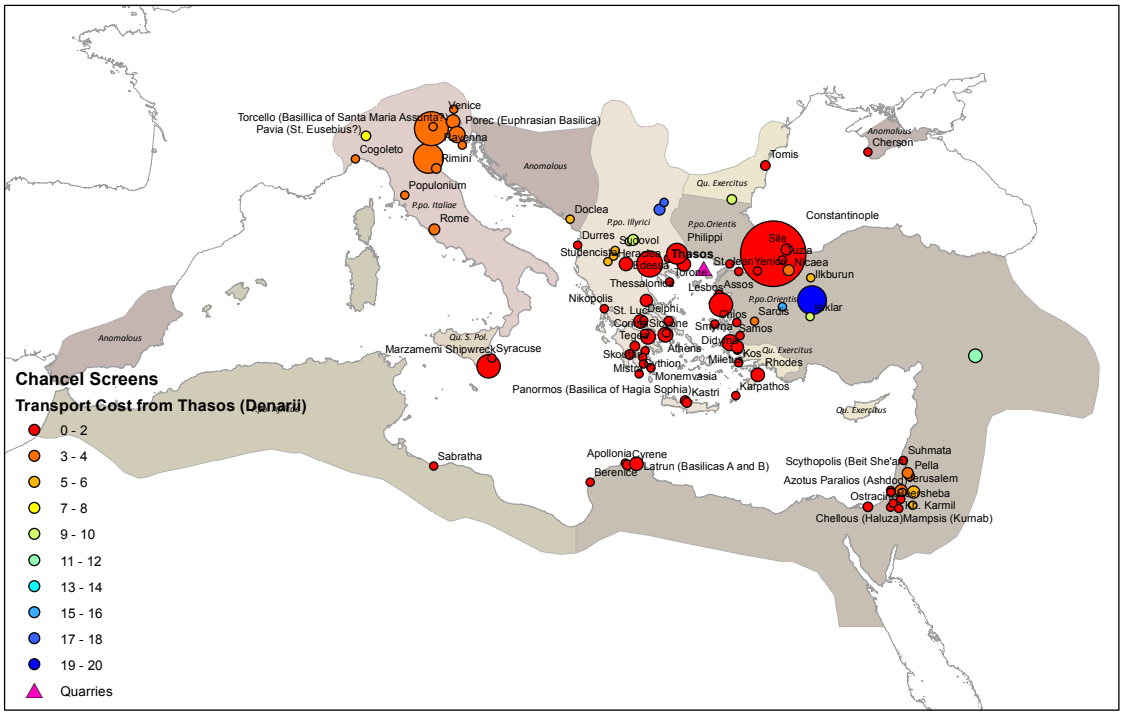


Figure 6.10 Transport cost from Thasos (Denarii), cheapest setting

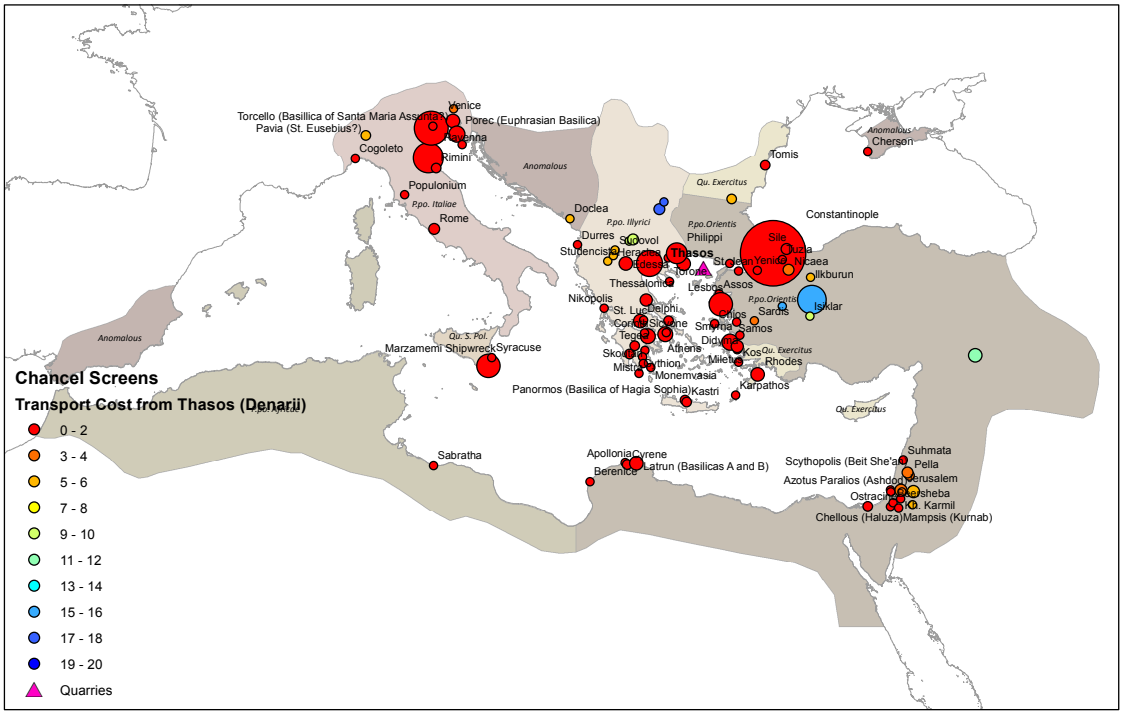


Figure 6.11 Exploded network visualization, travel time from Thasos (fastest)

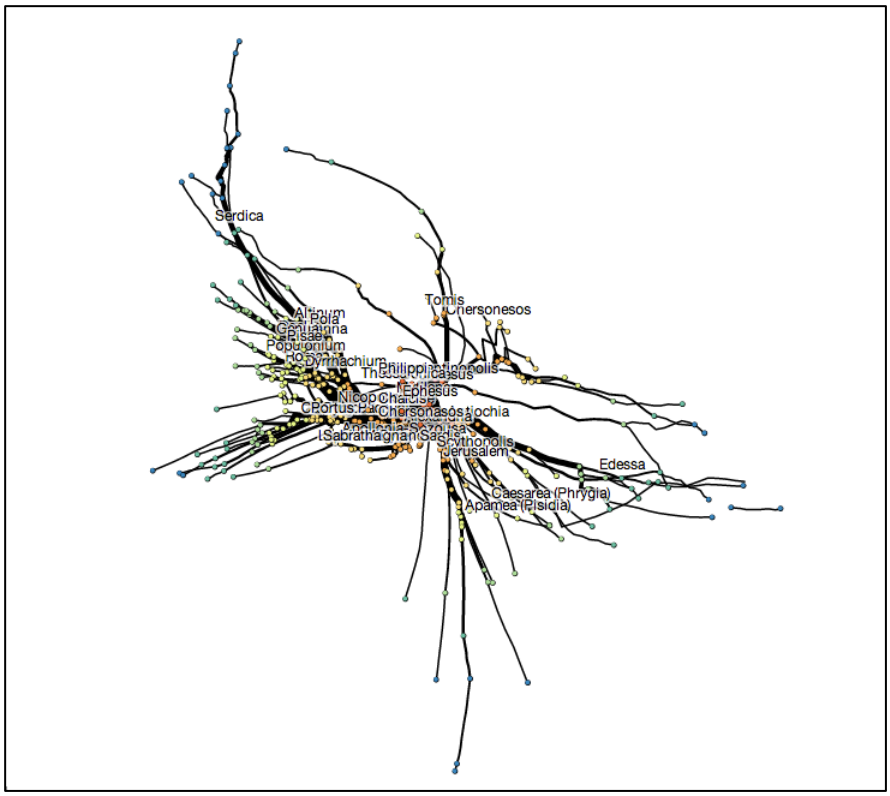
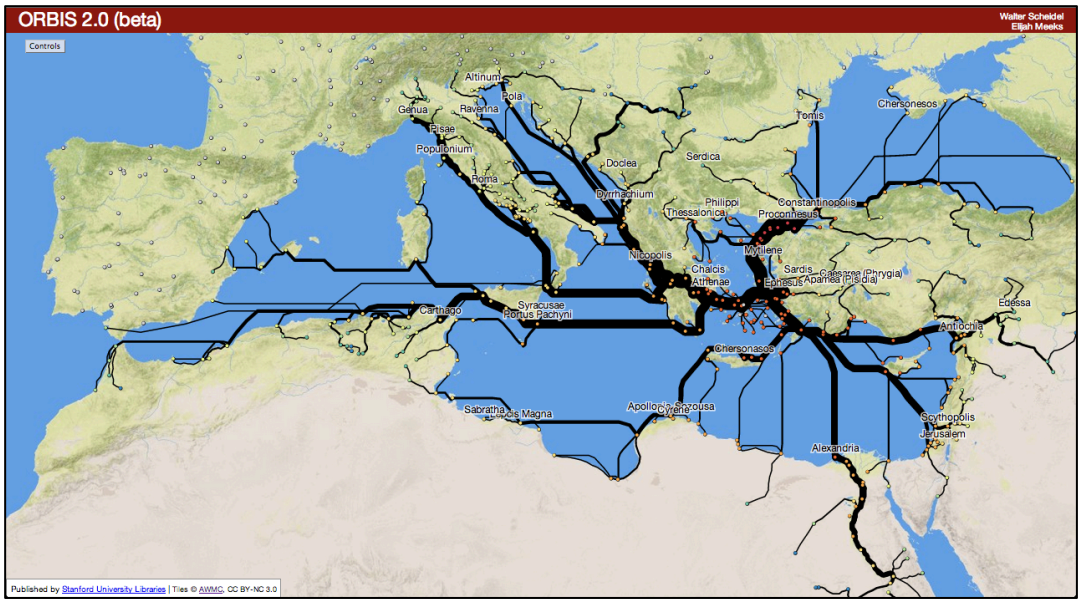


Figure 6.12 Minard diagram, travel time from Thasos (fastest)



6.4 Network Analysis

When all 70 simulated routes were aggregated, the marble trade network could be filled in by identifying the intermediate sites (for example, ports, crossroads, and geographical features such as promontories or mountain passes) through which the simulated routes pass between Thasos and their end points. The relative significance of these locations in the network was then calculated using a statistic borrowed from network theory called

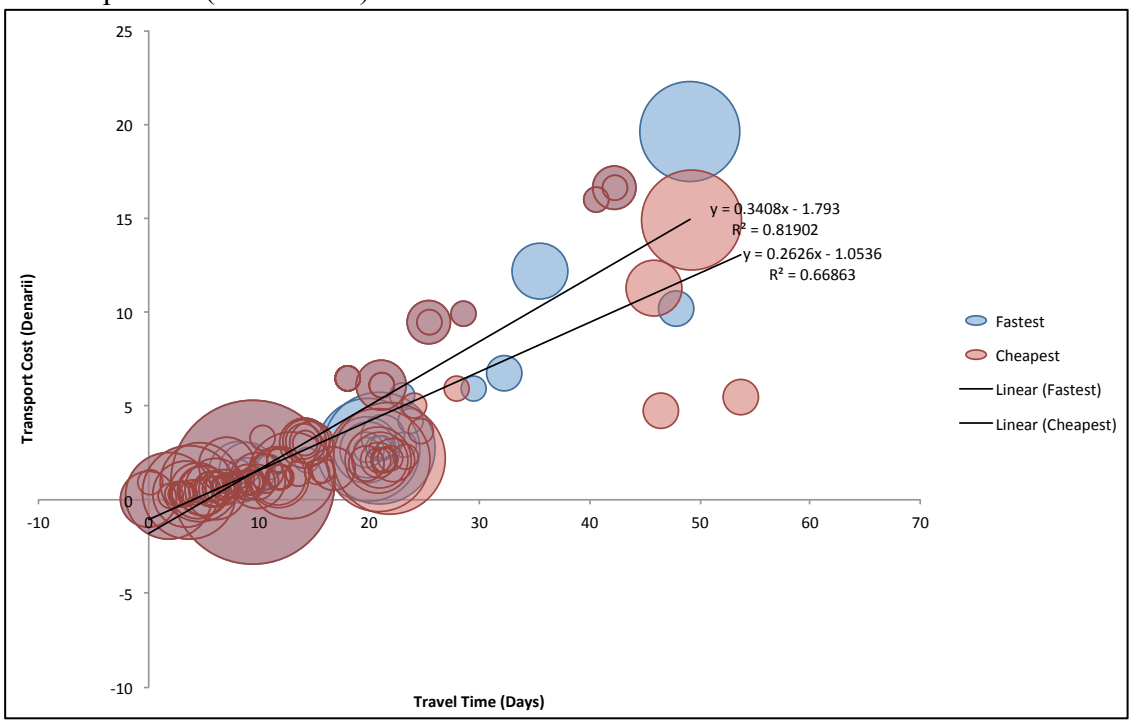
betweenness centrality. This metric measures the "extent to which a node lies on paths between other nodes in a network."[371] The higher the betweenness value of a node, the more significant it is as an intermediary point within the network. In this case study, a port with a higher betweenness value would, in theory, have seen more traffic in marble than a port with a lower betweenness value, due to its position as an intermediate point on a greater number of simulated routes.

6.5 Preliminary Observations

6.5.1 Overview

The quantitative data that was generated using the ORBIS route simulations suggests that the distribution of marble chancel screens is closely correlated with overall transport cost and trip duration from Thasos. This general trend can be observed in the figure below (fig. 6.13), which indicates that that there is a close correlation between transport cost and travel time for both "fastest" and "cheapest" models (high R-Squared values), and there is a noticeable cluster of sites at the bottom left of each graph which thins out as one moves further away in Price and Travel Time from Thasos (0,0).

Figure 6.13 Travel time (days) vs. transport cost (denarii) from Thasos vs. quantity of screens per site (bubble size)



[371] Presier-Kapeller 2013.

6.5.2 Quantity of Screen Panels per Location

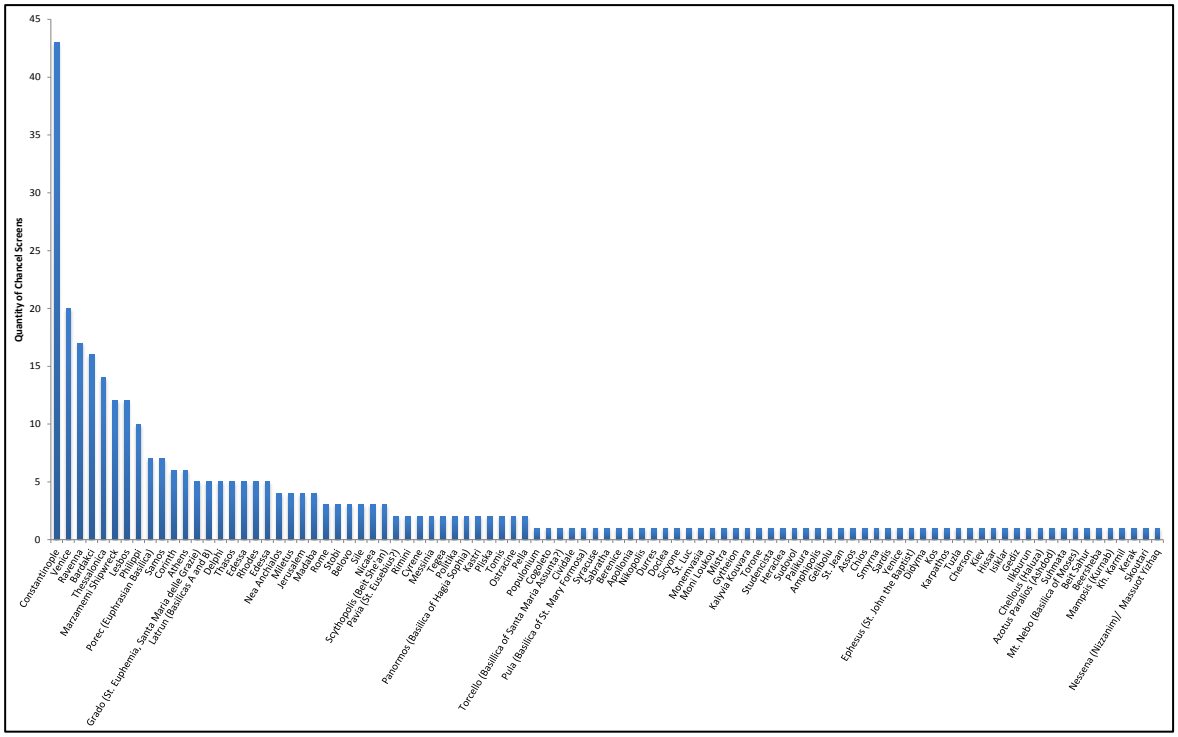
Before addressing the data generated by the simulations, it is worth first noting the relatively small quantity of chancel screens per location (fig. 6.14). On average, there were just three screens per location, while there were only one or two at some 66 out of the 96 (68.8%) locations in the dataset. Indeed, fewer than 10% of these sites had more than ten chancel screens, the most obvious (and equally unsurprising) outlier being Constantinople (43 chancel screens). In addition to Constantinople, other urban centers where large quantities of chancels were found include Ravenna (17 screens) and Thessalonica (14 screens), both of which had well-developed seaports and enjoyed elevated economic and political status as Praefectural Capitals. Additionally, a large number of screens were also found at the religious center of Philippi (10 screens) in Macedonia, where seven different churches rivalling those in Constantinople and Ravenna in both beauty and size were constructed between the mid-4th century and the end of the 6th.

The location with the second largest number of screens is Venice (20 screens), which is a somewhat problematic outlier due to the Venetians' prolific spoliation of Byzantine marble architectural elements during their conquest of Constantinople in 1204. Many of these were brought back to Venice and reused in later structures (see, e.g. the Porphyry statue of the Tetrarchs now fixed into the façade of St. Mark's Basilica). While Venice was subject to Byzantine authority in the 5th century as part of the Exarchate of Ravenna, it is therefore hard to determine just how many (or indeed, if any) of the screens in the Sodini datastet were originally shipped to Venice when they were new, or instead were removed from their original Constantinopolitan contexts and brought to Venice by the Crusaders in 1204.

Although it is unsurprising that prominent urban and religious centers like Constantinople, Ravenna, Thessalonica, and Philippi would have imported large number of chancel screens and other marble elements, one particularly anomalous site that necessitates further explanation is Bardakçı (16), which today is a small, unremarkable village in the central Turkish province of Eskişehir. However, Bardakçı (known as Santabaris in antiquity) is only 60 kilometers down the road from Dorylaion (present-day Eskişehir), an important Roman trading and military post in the Phrygian Highlands. Dorylaion is located at a strategic road junction controlling passage from Constantinople to the interior of Asia Minor and was the seat of the Bishop Eusebius in the 5th century A.D., indicating that this

region was far from the provincial backwater that it is often thought of today.[372] Another possible clue as to why so many chancel screens were found in Bardakçı comes from Cyril Mango's work on the origins of the cult of St. Michael the Archangel. While Sodini does not indicate where exactly the 16 screens from Bardakçı were found, it is highly likely that they form part of an extensive collection of Byzantine sculpture in the courtyard of a famous monastery (*tekke*) of Betkaşi dervishes located in the *kastron* above the nearby town of Seyitgazi, known as Nakoleia in antiquity. According to a scholion in the 10th century *Suda*, the aristocrat Studius—a 5th century consul, and the builder of the eponymous Early-Christian basilica dedicated to St. John in Constantinople—also built a church of St. Michael at Nakoleia, which may have occupied the same site as the present-day *tekke*.[373] This theory is supported by the large number of Byzantine stone architectural elements in the courtyard of the complex, including seven marble column bases and a high-quality Theodosian capital.[374] Studios also apparently built a third church—also dedicated to St. Michael—at Germia in Galatia, whose crypt supposedly housed the tunic of Christ. Justinian is recorded as having gone on a pilgrimage to Germia in 563, and by the 7th century it was listed as an autocephalus archbishopric, indicating that the region had become a significant pilgrimage center for the veneration of St. Michael the Archangel.[375]

Figure 6.14 Quantity of panels at each site in the dataset



[372] Hendy 1985: 123
[373] Mango 1986: 45-46.
[374]Id.
[375] Id. at 49.

6.5.3 Travel Time vs. Quantity of Screen Panels

The first major pattern that emerged when the data generated using the ORBIS simulations was plotted is that the majority of sites were clustered between 0 to 23 days of travel time from Thasos (fig. 6.15), with the only major outliers being a cluster of inland sites in the Balkans (e.g., Pliska, Belovo, and Hissar) and two sites in central Anatolia and in the upper Euphrates-Tigris basin (Bardakci and Edessa, respectively). When the total quantity of chancel screens at each time interval from Thasos were added together, an even clearer pattern emerged: In aggregate, some 80% (Cheapest) to 87% (Fastest) of chancel screens were located within a 3-week radius of Thasos.

Figure 6.15 Travel time from Thasos (days) vs. quantity of screen panels at each site

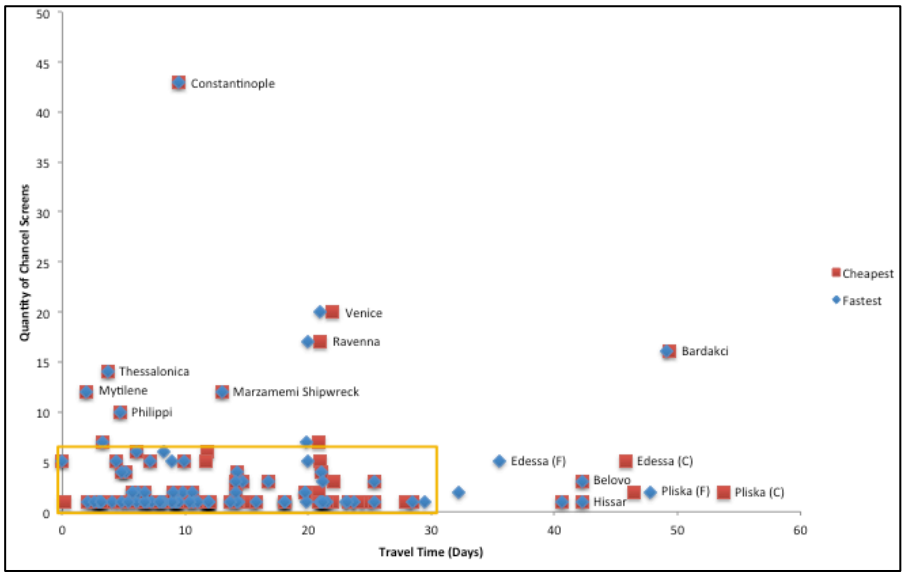
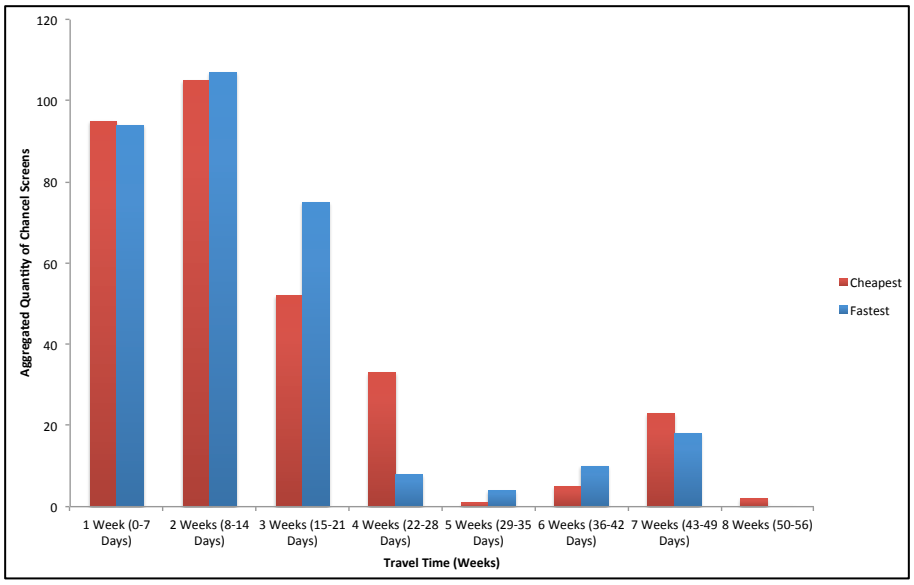


Figure 6.16 Travel time from Thasos (weeks) vs. quantity of screen panels (aggregated)



6.5.4 Transport Cost vs. Quantity of Screen Panels

The majority of sites were also clustered from 0 to 5 Denarii in relative transport cost, with the greatest concentration of chancel screens in aggregate falling into the 0-3 Denarii bracket for both the cheapest and fastest simulations (fig. 6.17). Five of the 6 of the sites that would have taken longer than 23 days to transport goods to were also the only sites that fall outside of the 10 Denarii cost threshold—Bardakci (16 Screens, 14.9/19.6 Days), Edessa (5 Screens, 11.3/12.2), Gediz (1 Screen, 16.0 Days), Hissar (1 Screen, 16.6 Days), and Belovo (3 Screens, 16.6 Days). All of these sites are located well inland, and thus could only have been reached from the nearest seaport via road or river, which was significantly slower and more expensive than sea travel. Similarly, 80.1% to 82.9% of chancel screens were located within a 3 Denarii band once aggregated (fig. 6.18).

Figure 6.17 Transport cost (denarii) vs. quantity of screen panels at each site

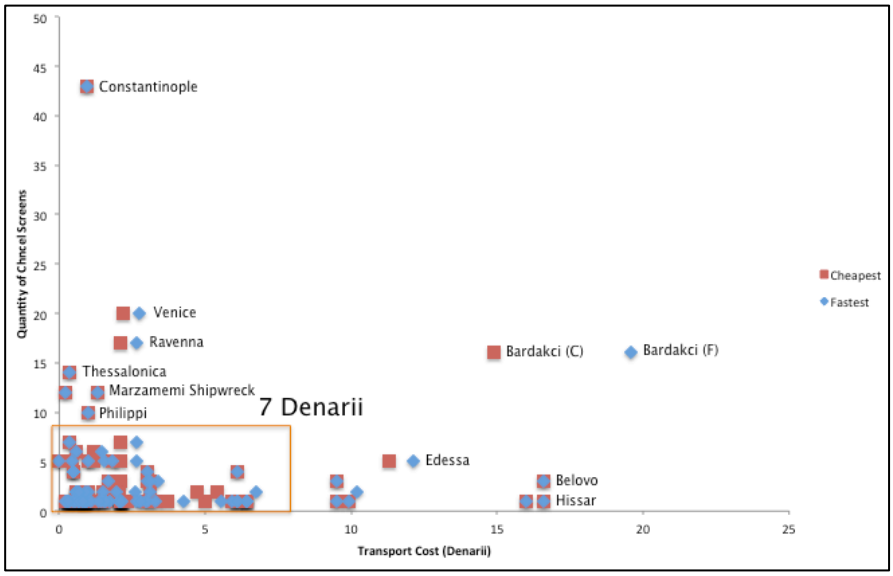
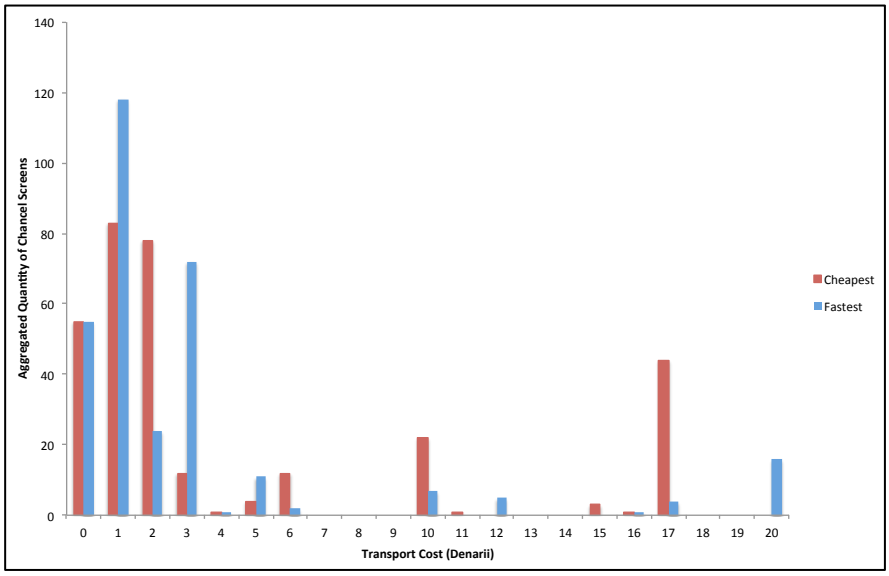


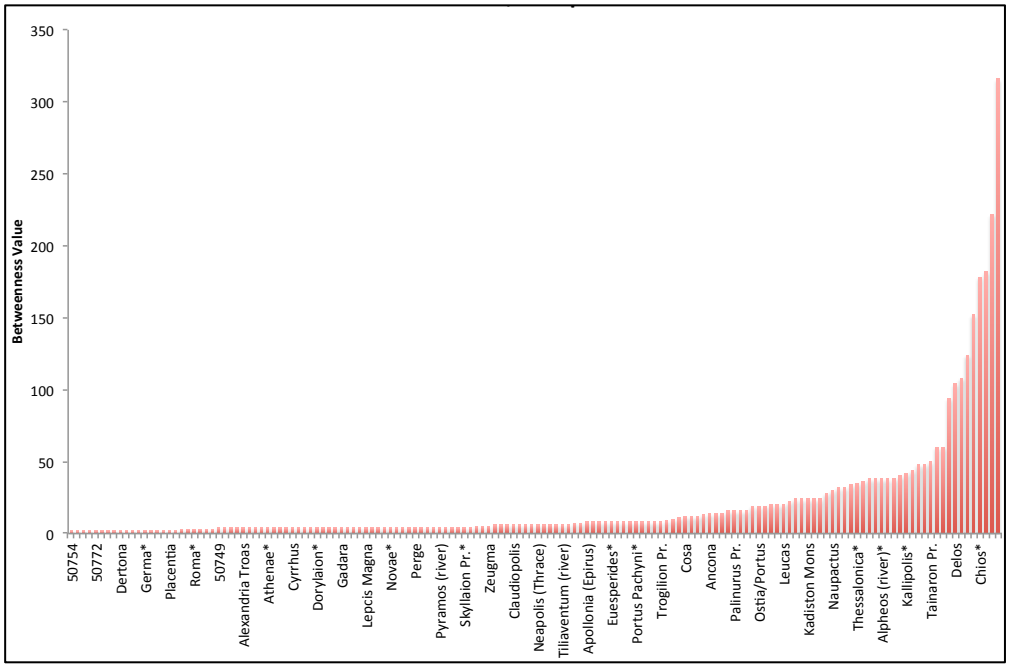
Figure 6.18 Transport cost (denarii) vs. quantity of screen panels (aggregated)



6.5.5 Betweenness Centrality

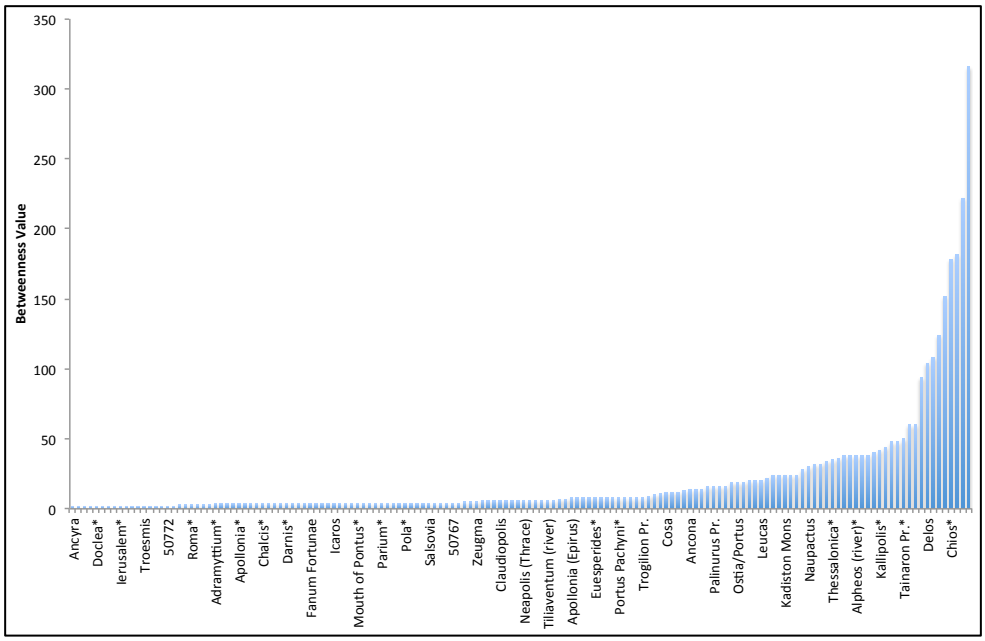
In many cases, the simulated route to a particular chancel screen site passed through several other sites at which similar screens have been found. For example, the simulated route from Thasos to Sabratha passes through Parium, Apollonia-Sozousa, Chersonasos (Crete) and Rhodos, resulting in high betweenness values for these sites. This suggests that perhaps the chancel screens found at these intermediate sites were bought by locals from itinerant traders on their way to a city further along the route, just as Bishop of Cyprian of Carthage purchased his ambo from the captain of a passing ship.[376] Additionally, when the betweenness values of each point in the network were tabulated (figs. 6.19, 6.20), it became clear that many sites that contained chancel screens were also important intermediate points along the main shipping routes to other chancel screen points (fig. 16). For example, Parium (124), Ephesus (54), Rhodos (48), Corinthus (43), Constantinople (22), Cyzicus (22), and Delphi (20) are all sites containing chancel screens that also exhibit high betweenness centrality values, indicating that they were also important intermediate points in the trade network. Another trend that should be noted is the high betweenness values for a number of islands or coastal sites in the Aegean (e.g., Chios and Delos, and the Cape Tainaron promontory at the end of the Mani Penninsula) compared to land-locked sites like Germa, which illustrates the Aegean's central position at the crossroads of the Empire as well as the dominance of sea travel as the primary means of marble transport.

Figure 6.19 Betweenness centrality values (cheapest setting)



[376] Gregory of Nazanzius, *Poema de ipso* 11. 875ff.= PG 37, col. 1089.

Figure 6.20 Betweenness centrality values (fastest setting)



6.6 Conclusions

First, the results of this case study, although highly preliminary, suggest that the export of at least some types of standardized marble architectural elements was correlated with overall transport cost and time, with the majority of exports falling within clearly defined cost/time thresholds. Beyond these time and cost thresholds, the number of panels drops off dramatically, although there are a few prominent outliers clustered in the Phrygian highlands in central Anatolia (e.g., Bardakçı/Nakoleia and Gediz/Dorylaion) and the Balkans (e.g., Stobi, Pliska). While it is possible that Thasian marble was imported to these sites despite the monumental costs associated with transporting it there, the more plausible explanation is that the assumption that all of the elements in the dataset came from Thasos is overly simplistic. Instead, it is likely that the chancel screen panels found in these regions were produced by workshops using marble from 'local' quarries such as Docimium, which was capable of producing elements nearly identical to those from Thasos and Proconnesus in both style and quality but is only about 60 kilometers from Bardakçı/ Nakoleia.[377] Similarly, Niewöhner argues that a recently identified quarry at Sivec in Macedonia, which was also capable of producing the same Constantinopolitan repertoire and quality of goods, would have supplied marble goods to Stobi and other

[377]Philip Niewöhner has shown this to be the case for a number of other white marble objects found in west-central Anatolia, which were previously believed to be of Proconnesian origin, For example, recent archaeometric analysis of a marble capital from the church of St. Michael at Germa has been confirmed to be from Docimium, and Niewöhner argues that the same may be inferred for the objects at Nakoleia as well as other works of white marble from west-central Anatolia where workmanship meets Constantinopolitan standards. Niewöhner 2013 :227.

Balkan highland towns such as Pliska and Hissar.[378] If correct, this would lend even more support to the overall hypothesis that buyers of marble in Late Antiquity were cost-sensitive consumers, because it indicates that buyers made a concerted choice not to buy 'foreign' marble once its import price exceeded the price of making such elements locally, but to rely on local sources of raw materials instead.

These conclusions must be tempered by the relatively small sample size used in this case study, as well as the concerns regarding the quality and completeness of the dataset described previously. However, when taken together these findings lend support to Angeliki Laiou and Jean-Michel Carrié's argument that private enterprise and the laws of supply and demand played a more central role in the Late Antique economy than has been suggested. Although there are known examples of imperially sponsored, no-expense-spared consumption of marble during this time period (for example, the Hagia Sophia in Constantinople), the general picture that emerges from this case study is one of a thriving non-imperial market operating alongside—and often overlapping with—the imperial system, in which many cost-conscious private (or ecclesiastical) consumers were purchasing and importing small quantities of pre-fabricated marble objects from the quarries and workshops at Proconnesus and Thasos to sites across the Mediterranean basin. Against this backdrop of relatively low-level, market-based exchange, the type of conspicuous, state-level activity described above ought to be regarded as anomalous, both in terms of scale and expense. These findings, if replicated across a range of further studies using other datasets, have the potential to challenge a number of existing assumptions regarding the relative degree of state involvement in the marble trade as well as in the Late Antique economy generally. Most importantly, if it turns out that the state played a less pivotal role in the marble industry than has previously been suggested, this could indicate that the role of the state in the economy more broadly has been similarly overestimated.

Second, this case study has served to show that *ORBIS* is a promising tool for analyzing archaeological distribution datasets, and identifies some key areas that could be improved on in *ORBIS* to enhance its functionality. As discussed in Chapter 5, geospatial models have largely been constrained either by their scope or by their inability to model sailing speed, which was the primary form of long-distance transport in late antiquity. This case study proves that *ORBIS*, while not perfect, has addressed this problem in a way that allows us to finally begin to analyze the economic effects of distance and travel costs

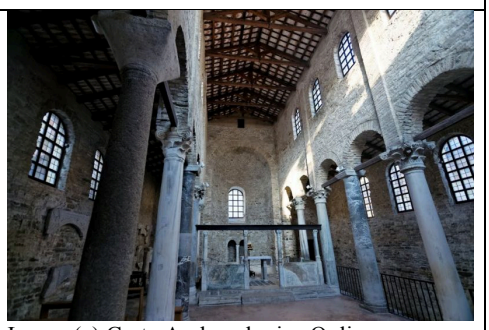
[378] Id.; Niewöhner and Prochaska 2011.

across the entire Roman Empire while also taking sailing speed into account. However, this experiment has also identified several areas that the publicly- available *ORBIS* website could be improved to meet the needs of researchers. First, this project has highlighted the need to be able to save models in *ORBIS* to return to and adjust as necessary, as well as the need to be able to export geospatial data from *ORBIS* directly into Geographic Information Systems like ArcGIS. Thankfully, because the code used to build *ORBIS* is open source, other research groups have begun to explore ways to expand the functionality of the basic model for research purposes: for example, the Generative Historiography of Religion Project (GEHIR) at Masaryk University, Brno, recently introduced *LINUM*, which is a computational environment for agent-based modeling that is based on the geospatial transport model developed for *ORBIS*.[379] Unlike *ORBIS*, *LINUM* has been designed so that researchers interested in modeling dynamic processes in the context of ancient Mediterranean can build and modify reusable models and transfer data between different research projects. Such a program is arguably the logical extension of *ORBIS*, and holds great potential for those seeking to analyze archaeological datasets in the future.

While this case study was limited in its scope to one type of marble chancel screen, it is hoped that the methodology and approaches developed here can be applied in future studies to analyze the distribution of other types marble elements, such as the maps and datasets of multiple forms of Corinthian capitals that were included in J.-P. Sodini's 1989 article. Increasing the complexity of the model through the inclusion of various types of architectural elements from multiple different quarries and from a variety of time periods, would most certainly yield a far deeper and more nuanced understanding of the trade in marble in Roman and Late Antique Mediterranean world than can possibly be obtained through this highly simplified case study. Such a future study of marble elements would ideally combine the geospatial modelling approach developed in this thesis with archaeometric analysis to determine the provenance of each of the elements used in the dataset, which would allow for greater certainty when drawing conclusions from the model as well as to differentiate between imported and locally-produced elements. Lastly, it is hoped that the methods developed herein could also be applied to analyze the distribution of many other types of archaeological materials for which there are existing datasets, such as ceramics, metal objects, shipwrecks, and foodstuffs, which could greatly advance our understanding of trade and exchange in the ancient world more broadly.

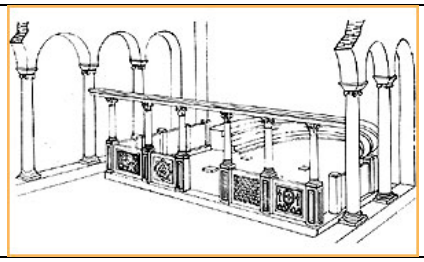
[379] Fousek et al. 2016.

Appendix A. Chancel Screen Dataset Sources and Images

Location	Quantity	References	Image(s)
Marzamemi Shipwreck	12	Kapitän 1980	 Image courtesy of Justin Leidwanger/ Marzamemi Maritime Heritage project
Rome	3		
Populonium	1		
Cogoleto	1		
Pavia (St. Eusebius?)	2		
Ravenna	17		
Venice	20		
Torcello (Basillica of Santa Maria Assunta)	1		 Source: Google Street View, Accessed March 2017. https://www.google.com/maps/
Rimini	2		
Grado (St. Euphemia, Santa Maria delle Grazie)	5	Marano 2016: 4; Terry 1988: 31-3, 35-7, 39, Figs. 58-9, 62, 67, 71-2, 81	 Image (c) Carta Archaeologica Online http://www.archeocartafvg.it/portfolio/grado-go-basilica-di-santa-maria-delle-grazie/
Cividale	1		 Source: http://www.green-man-of-cercles.org/articles/chancel_screens.pdf

Porec (Euphrasian Basilica)	7	Marano 2016: 4; Terry 1988: 31-3, 35-7, 39, Figs. 58-9, 62, 67, 71-2, 81	 Image (c) and courtesy of Trip Advisor, https://www.tripadvisor.com/Attraction_Review-g303829-d319594-Reviews-Euphrasius_Basilica-Porec_Istria.html
Pula (Basilica of St. Mary Formosa)	1	Marano 2016: 4; Vicelja 1998, 1039-1040	
Syracuse	1		
Sabratha	1		
Berenice	1		
Apollonia	1		
Cyrene	2		
Latrun (Basilicas A and B)	5		 Yse courtesy of Umberto Segnini, http://www.flickr.com/photos/15038841@N08/3256553376/in/photostream/
Nikopolis	1	Chalkia 2006	
Durres	1		
Doclea	1		
Corinth	6	Terry 1988: 31-3, 35-7, 39, Figs. 58-9, 62, 67, 71-2, 81	
Sicyone	1		
Delphi	5	Deroche et al. 1989	
St. Luc	1		
Messinia	2		
Monemvasia	1		
Moni Loukou	1		
Mistra	1		
Tegea	2		
Gytheion	1		
Athens	6		
Kalyvia Kouvara	1		
Politika	2		
Nea Anchialos	4		
Thessalonica	14	Mentzos, Barbin, and Herrmann	

		2002	
Torone	1		
Thasos	5	Sodini and Kolokotsas: 1984	
Studencista (Ohrid)	1		 Image (c) Evan Freeman, http://ism.yale.edu/sites/default/files/styles/adaptive/public/sophia_interior_evan.jpg?itok=1sVCr5a9
Heraclea	1		 http://static.panoramio.com/photos/large/76968256.jpg
Sudovol	1		
Edessa	5		
Palikura	1		
Stobi	3		
Amphipolis	1		
Philippi	10	Herrmann et al. 1999	 http://via.lib.harvard.edu/via/deliver/chunkDisplay?
Gelibolu	1		
Constantinople (St. Sphia, St. Irene)	43	Mark and Cakmak 1992: Fig. 6; Mathews 1976: 120, Fig. 11:27	
St. Jean	1		
Assos	1		

Lesbos	12	Orlandos 1954: 527, fig. 427	
Chios	1		
Smyrna	1		
Samos	7		
Sardis	1		
Yenice	1		
Ephesus (St. John the Baptist)	1		
Didyma	1		
Miletus	4		
Kos	1		
Rhodes	5		
Karpathos	1		
Panormos (Basilica of Hagia Sophia)	2	Frend and Johnston 1962: 186-238; Sweetman 2010	
Kastri	2		
Belovo	3		
Pliska	2		
Tomis	2		
Pisae	1		
Sile	3		
Nicaea	3		
Cherson	1		
Hissar	1		
Edessa	5		
Bardakçı (=Seyitgazi?)	16	C. Mango 1986a: 45-46; Kramer 1973: 241-250.	 Source: Zeynel Cebeci, https://commons.wikimedia.org/wiki/Category:Seyit_Battal_Gazi_K%C3%BCllliyesi
Isiklar	1		
Gediz	1		
Ilkburun	1		
Ostracine	2	Habas 1994: Vol. I: 67-8, Vol. III: 56-9, Figs. 82-5, Nos. 82-5.	
Jerusalem	4		
Chellous (Haluza)	1		
Azotus Paralios (Ashdod)	1		
Pella	2	Smith and Day 1989: 120-22, Figs. 33, Pl. 27:C; Habas 1994: Vol. I:33-4, Vol. III: 7-8, Fig. 15b, No.	

		15b.	
Suhmata	1		
Scythopolis (Beit She'an)	3	Fitzgerald 1939: 3, Pl. III, Fig. 5; Habas 1994: Vol. I: 60, Vol. III:39-40, Fig. 57, No. 57.	
Mt. Nebo (Basilica of Moses)	1		 http://www.wonderstourism.com/wp-content/uploads/2012/03/inside-nebo-mount.jpg
Beit Sahur	1		
Beersheba	1	Aviam 1990: 364, Fig. 20; Habas 1994: Vol. I: 68-9, Vol. III: 59-60,Fig. 87, No. 87	
Mampsis (Kurnab)	1	Negev 1988: 107, Fig. 9; Habas 1994: Vol. I: 62, Vol. III: 42-3, Fig.62, No. 62	
Kh. Karmil	1		
Kerak	1		
Madaba	4		
Skoutari	1		
Nessena (Nizzanim)/ Massuot Yizhaq	1	Colt 1962: 50, Pl. XIX:5; Habas 1994: Vol. I: 62, Vol. III: 41-2, Fig.60, No. 60	 Israel Museum, Jerusalem http://www.imj.org.il/imagine/collections/item.asp?itemNum=222825

Appendix B. ORBIS Data Generation Protocol

Dataset Preparation

1. Compare ArcGIS file of object findspots to ORBIS model, and locate closest ORBIS ID for each spot used. This will be used to approximate travel time, cost, etc. Put this into Excel File.

Route Generation

1. Select sites (restrict to only those sites included within borders of Roman Empire during 6th c. AD)
2. Set trip parameters from drop-down menu on the left. For all models generated, these are:
    a. Month of Departure: August
    b. Priority: Fastest (1st model), Cheapest (2nd model)
    c. Network modes: All
    d. Aquatic modes: Civilian, Fast
    e. Road Options: Oxcart (12 km/day)
    f. Transfer Cost: 0 days
3. Route Simulation
    a. Select start point (Quarry) and end point (closest ORBIS point to each artifact findspot)
    b. Click "Calculate Route"
    c. Repeat for all sites in dataset
4. Export Data into Excel as .csv
    a. Cost (Denarii)
    b. Duration (Days)
    c. Betweenness values for all sites in the trade network (i.e. findspots, midpoints, and origin).

Appendix C. Data from *ORBIS* Route Simulations

1. Raw Data

(Cost units= Denarii; Time units= Days; Length units = kilometers)

Sodini Label	Closest ORBIS ID	#	Time, (Fastest)	Cost (Fastest)	Trip Length (Fastest)	Time (Cheapest)	Cost (Cheapest)	Trip Length (Cheapest)
Cividale	Ad Tricesimum	1	23.7	4.24	2426	24.7	3.69	2761
Assos	Adramyttium	1	2.9	0.29	384	2.9	0.29	384
Suhmata	Ake-Ptolemais	1	9.2	0.92	1668	9.2	0.92	1668
Messinia	Alpheos (river)	2	9.8	0.98	1425	9.8	0.98	1425
Torcello	Altinum	1	20.9	2.74	2508	21.9	2.19	2844
Venice	Altinum	20	20.9	2.74	2508	21.9	2.19	2844
Amphipolis	Amphipolis	1	3.1	0.31	426	3.1	0.31	426
Apollonia	Apollonia-Sozousa	1	9.3	0.93	1556	9.3	0.93	1556
Grado	Aquileia	5	19.9	2.63	2380	20.9	2.08	2715
Rimini	Ariminum	2	19.7	2.62	2390	20.8	2.07	2726
Athens	Athenae	6	6	0.6	918	6	0.6	918
Kalyvia Kouvara	Athenae	1	6	0.6	918	6	0.6	918
Torone	Athos Mons	1	2	0.2	282	2	0.2	282
Azotus Paralios	Azotus Paralios	1	9.2	0.92	1702	9.2	0.92	1702
Nessena	Azotus Paralios	1	9.2	0.92	1702	0.2	0.92	1702
Isiklar	Caesarea (Phrygia)	1	28.5	9.9	1369	28.5	9.9	1369
Politika	Chalcis	2	6.1	0.61	931	6.1	0.61	931
Kastri	Chersonasos	2	5.7	0.57	998	5.7	0.57	998
Panormos	Chersonasos	2	5.7	0.57	998	5.7	0.57	998
Cherson	Chersonesus	1	21.5	2.15	1271	21.5	2.15	1271
Chios	Chios	1	2.6	0.26	416	2.6	0.26	416
Constantinople	Constantinopolis	43	9.4	0.94	548	9.4	0.94	548
Tuzla	Constantinopolis	1	9.4	0.94	548	9.4	0.94	548
Corinth	Corinthus	6	8.2	1.47	983	11.8	1.18	1719
Sicyone	Corinthus	1	8.2	1.47	983	11.8	1.18	1719
Cyrene	Cyrene	2	10.6	1.49	1572	10.6	1.49	1572
Yenice	Cyzicus	1	9	0.9	523	9	0.9	523
Latrun	Darnis	5	9.9	0.99	1660	9.9	0.99	1660
Delphi	Delphi	5	8.9	1.54	1059	11.7	1.17	1698
St. Luc	Delphi	1	8.9	1.54	1059	11.7	1.17	1698
Nea Anchialos	Demetrias	4	5.1	0.51	730	5.1	0.51	730
Doclea	Doclea	1	23	5.54	1855	24	4.99	2190

Sodini Label	Closest ORBIS ID	#	Time, (Fastest)	Cost (Fastest)	Trip Length (Fastest)	Time (Cheapest)	Cost (Cheapest)	Trip Length (Cheapest)
Gediz	Dorylaion	1	40.6	16.01	991	40.6	16.01	991
Durres	Dyrrhachium	1	14.3	2.07	1681	15.3	1.52	2017
Edessa	Edessa	5	35.5	12.15	1873	45.8	11.31	1983
Beersheba	Eleutheropolis	1	11.9	2.1	1705	11.9	2.1	1705
Chellous	Eleutheropolis	1	11.9	2.1	1705	11.9	2.1	1705
Kh. Kharmil	Eleutheropolis	1	11.9	2.1	1705	11.9	2.1	1705
Mampsis	Eleutheropolis	1	11.9	2.1	1705	11.9	2.1	1705
Ephesus	Ephesus	1	3.2	0.32	550	3.2	0.32	550
Berenice	Eusperides	1	10.7	1.07	1769	10.7	1.07	1769
Ilkburun	Flaviopolis	1	29.4	5.92	903	27.9	5.92	903
Cogoleto	Genua	1	23.2	2.97	2907	23.3	2.33	3119
Bardakci	Germa	16	49.1	19.6	1093	49.3	14.87	1159
Skoutari	Gythion	1	8.1	0.81	1245	8.1	0.81	1245
Heraclea	Heraklea	1	18.1	6.44	663	18.1	6.44	663
Studencista	Heraklea	1	18.1	6.44	663	18.1	6.44	663
Studovol	Heraklea	1	18.1	6.44	663	18.1	6.44	663
Beit Sahur	Ierusalem	1	14.2	3.02	1730	14.2	3.02	14.2
Jerusalem	Ierusalem	4	14.2	3.02	1730	14.2	3.02	14.2
Gelibolu	Kallipolis	1	6.9	0.69	267	6.9	0.69	267
Kos	Kos	1	4	0.4	661	4	0.4	661
Monemvasia	Malea Pr.	1	7.3	0.73	1162	7.3	0.73	1162
Didyma	Miletus	1	4.8	0.48	753	4.8	0.48	753
Miletus	Miletus	4	4.8	0.48	753	4.8	0.48	753
Sile	Mouth of Pontus	3	16.7	1.67	581	16.7	1.67	581
Lesbos	Mytilene	12	1.9	0.19	307	1.9	0.19	307
Nicaea	Nicaea	3	14.7	3.04	703	14.7	3.04	703
Nikopolis	Nicopolis	1	11	1.75	1319	12	1.2	1654
Pliska	Novae	2	47.8	10.22	1335	53.7	5.43	1545
St. Jean	Parium	1	7.9	0.79	370	7.9	0.79	370
Edessa	Pella	5	7.1	1.82	531	7.1	1.82	531
Ostracine	Pelusium	2	9	0.9	1670	9	0.9	1670
Kerak	Philadelphia	1	21.1	6.08	1752	21.1	6.08	1752
Madaba	Philadelphia	4	21.1	6.08	1752	21.1	6.08	1752
Mt. Nebo	Philadelphia	1	21.1	6.08	1752	21.1	6.08	1752
Philippi	Philippi	10	4.7	0.98	473	4.7	0.98	473

Sodini Label	Closest ORBIS ID	#	Time, (Fastest)	Cost (Fastest)	Trip Length (Fastest)	Time (Cheapest)	Cost (Cheapest)	Trip Length (Cheapest)
Porec	Pola	7	19.8	2.63	2421	20.8	2.08	2757
Pula	Pola	1	19.8	2.63	2421	20.8	2.08	2757
Populonium	Populonium	1	21.2	2.77	2635	21.3	2.13	2847
Marzamemi Shipwreck	Portus Pachyni	12	13	1.3	1906	13	1.3	1906
Karpathos	Potidaion	1	5.4	0.54	923	5.4	0.54	923
Ravenna	Ravenna	17	19.9	2.64	2419	20.9	2.09	2755
Rhodes	Rhodos	5	4.4	0.44	762	4.4	0.44	762
Rome	Roma	3	21.2	3.4	2423	22.1	2.12	2640
Sabratha	Sabratha	1	15.8	1.58	2579	15.8	1.58	2579
Samos	Samos	7	3.3	0.33	551	3.3	0.33	551
Sardis	Sardis	1	10.3	3.31	628	10.3	3.31	628
Pella	Scythopolis	2	14.1	3.11	1667	14.1	3.11	1667
Scythopolis	Scythopolis	3	14.1	3.11	1667	14.1	3.11	1667
Belovo	Serdica	3	42.3	16.59	953	42.3	16.59	953
Hissar	Serdica	1	42.3	16.59	953	42.3	16.59	953
Mistra	Skyllaion Pr.	1	6.7	0.67	1088	6.7	0.67	1088
Moni Loukou	Skyllaion Pr.	1	6.7	0.67	1088	6.7	0.67	1088
Tegea	Skyllaion Pr.	2	6.7	0.67	1088	6.7	0.67	1088
Smyrna	Smyrna	1	3.2	0.32	542	3.2	0.32	542
Palikura	Stobi	1	25.4	9.5	751	25.4	9.5	751
Stobi	Stobi	3	25.4	9.5	751	25.4	9.5	751
Syracuse	Syracusae	1	13.6	1.36	1965	13.6	1.36	1965
Gytheion	Tainaron Pr.	1	7.9	0.79	1232	7.9	0.79	1232
Thasos	Thasos	5	0	0	0	0	0	0
Thessalonica	Thessalonica	14	3.7	0.37	490	3.7	0.37	490
Pavia	Ticinum	2	32.2	6.75	3015	46.5	4.7	3138
Tomis	Tomis	2	19.7	1.97	1009	19.7	1.97	1009

2. Screens Aggregated by Travel Time from Thasos

Travel Time from Thasos (Weeks)	Quantity of Sites (Fastest)	Quantity of Sites (Cheapest)	Quantity of Screens, Aggregated (Fastest)	Quantity of Screens, (Aggregated (Cheapest)
1 Week (0-7 Days)	28	29	94	95
2 Weeks (8-14 Days)	32	30	107	105
3 Weeks (15-21 Days)	19	17	75	52
4 Weeks (22-28 Days)	6	10	8	33
5 Weeks (29-35 Days)	3	1	4	1
6 Weeks (36-42 Days)	4	3	10	5
7 Weeks (43-49 Days)	2	3	18	23
8 Weeks (50-56)	0	1	0	2

3. Screens Aggregated By Transport Cost from Thasos

Transport Cost via Wagon, Nearest Denarii (Cheapest)	Quantity of Sites	Quantity of Screens (Aggregated)
0	14	55
1	35	83
2	20	78
3	6	12
4	1	1
5	3	4
6	7	12
7	0	0
8	0	0
9	0	0
10	3	22
11	1	1
12	0	0
13	0	0
14	0	0
15	1	3
16	1	1
17	2	44
Total:	*94*	*316*

Transport Cost via Wagon, Nearest Denarius (Fastest)	Quantity of Sites	Quantity of Screens (Aggregated)
0	14	55
1	32	118
2	13	24
3	16	72
4	1	1
6	8	11
7	1	2
10	4	7
12	1	5
16	1	1
17	2	4
20	1	16
Total:	*94*	*316*

4. Percentage Calculations

Travel Time	Cheapest	Fastest	% of Total (C)	% of Total (F)
1 Week	95	94	30.1%	29.7%
2 Weeks	105	107	33.2%	33.9%
3 Weeks	52	75	16.5%	23.7%
4 Weeks	33	8	10.4%	2.5%
5 Weeks	1	4	0.3%	1.3%
6 Weeks	5	10	1.6%	3.2%
7 Weeks	23	18	7.3%	5.7%
8 Weeks	2	0	0.6%	0.0%
Total:	*316*	*316*		

Transport Cost	Cheapest	Fastest	% of Total (C)	% of Total (F)
0 Denarii	55	55	17.4%	17.4%
1 Denarius	83	118	26.3%	37.3%
2 Denarii	78	24	24.7%	7.6%
3 Denarii	12	72	3.8%	22.8%
4 Denarii	1	1	0.3%	0.3%
5 Denarii	4	0	1.3%	0.0%
6 Denarii	12	11	3.8%	0.6%
7 Denarii	0	2	0.0%	0.6%
8 Denarii	0	0	0.0%	0.0%
9 Denarii	0	0	0.0%	0.0%
10 Denarii	22	7	7.0%	2.2%
11 Denarii	1	0	0.3%	0.0%
12 Denarii	0	5	0.0%	1.6%
13 Denarii	0	0	0.0%	0.0%
14 Denarii	0	0	0.0%	0.0%
15 Denarii	3	0	0.9%	0.0%
16 Denarii	1	1	0.3%	0.3%
17 Denarii	44	4	13.9%	1.3%
18 Denarii	0	0	0.0%	0.0%
19 Denarii	0	0	0.0%	0.0%
20 Denarii	0	16	0.0%	5.1%
Total:	*316*	*316*		

5. Betweenness Centrality Data

ORBIS ID	BC	ORBIS ID	BC	ORBIS ID	BC	ORBIS ID	BC	ORBIS ID	BC
Acroceraunia Pr.	16	Chersonasos*	12	Genua*	5	Neapolis (Thrace)	3	Roma*	2
Ad Tricesimum*	1	Chersonesos*	2	Germa*	1	Nicaea*	1	Sabratha*	2
Adramyttium*	2	Chios*	80	Gythion*	2	Nicomedia	3	Samos*	8
Ake-Ptolemais*	2	Claudiopolis	2	Hephaistia	100	Nicopolis*	18	Sardis*	5
Akitas Pr.	2	Constantinopolis*	16	Heraclea Pontica	5	Novae*	2	Scodra	2
Alexandria Troas	2	Corcyra	16	Heraklea*	5	Oea	2	Scythopolis*	3
Alpheos (river)*	2	Corinthus*	46	Histria	5	Ostia/Portus	12	Seleukeia Pieria	3
Altinum*	2	Cosa	6	Ichthys Pr.	10	Palinurus Pr.	10	Serdica*	1
Amastris	2	Cyrene*	1	Ierusalem*	1	Paphos	14	Sestus	48
Amphipolis*	2	Cyrrhus	2	Ioppe	3	Parium*	2	Sigeion	26
Ancona	6	Cyzicus*	2	Isthmia	62	Patara	16	Skyllaion Pr.*	2
Antiochia	2	Darnis*	2	Kadiston Mons	12	Patrae	10	Smyrna*	11
Apollonia	2	Delos	58	Kallipolis*	20	Pella*	7	Stobi*	3
Apollonia (Epirus)	4	Delphi*	20	Kimaros Pr.	10	Pelusium*	2	Syracusae*	2
Apollonia-Sozousa*	11	Demetrias*	2	Kos*	2	Perge	2	Tainaron Pr.*	10
Aquileia*	7	Dertona	2	Lampsacus	2	Perinthus	18	Thasos**	148
Ariminum*	2	Doclea*	1	Lepcis Magna	2	Phaselis	2	Thera	12
Ascalon	5	Dorylaion*	3	Lissus	3	Philadelpheia*	1	Thessalonica	16
Athenae*	2	Durostorum	3	Luna	4	Philippi*	1	Ticinum*	1
Athos Mons*	16	Dyrrhachium*	4	Lydda	2	Pisae	4	Tiliaventum (river)	2
Attalea	3	Edessa*	1	Malea Pr.*	14	Pola*	2	Tomis*	2
Azotus Paralios*	2	Eleutheropolis*	1	Messana	10	Populonium*	2	Trogilion Pr.	4
Bargylia	2	Emmaus	2	Miletus*	2	Portus Pachyni*	6	x	2
Barium	6	Ephesus*	62	Mouth of Pontus*	2	Potidaion*	2	x	2
Brundisium	6	Euesperides*	4	Myndos	2	Pyramos (river)	2	x	2
Caesarea (Phrygia)*	1	Fanum Fortunae	2	Myra	2	Ravenna*	2	x	2
Caesarea Maritima	10	Flaviopolis*	1	Mytilene*	82	Regium	10	x	2
Chalcis*	2	Gadara	2	Naupactus	18	Rhodos*	24	Zeugma	2

Bibliography

A.B. 2012. Business Travel for the Romans: London to Rome, on Horseback. *The Economist*, May 24, 2012. Accessed at http://www.economist.com/blogs/gulliver/2012/05/business-travel-romans?fsrc=scn/tw_ec/london_to_rome_on_horseback.

Alpaslan, S. 2001. Architectural Sculpture in Constantinople and the Influence of the Capital in Anatolia. In N. Necipoğlu (ed.), *Byzantine Constantinople: Monuments, Topography and Everyday Life*. Brill, Leiden.

Alpi, F. 1992. Les Inscriptions de L'eglise d'Ain Fattir. *Revue Biblique* 99(2): 435-439.

Andreau, J. 2002. Twenty Years after Moses I. Finley's 'The Ancient Economy. In W. Scheidel and S. von Reden, (eds.), *The Ancient Economy*. Edinburgh Univ. Press Ltd, Edinburgh: 34.

Antonelli, F. and Lazzarini, L. 2000. Le "Marbre Campan": histoire, diffusion et archéométrie. *Revue d'Archéométrie* 24: 111–28.

Antonelli, F. 2002. I marmi della Gallia e dell'Iberia importati a Roma. In M. De Nuccio and L. Ungaro (eds.), *I marmi colorati della Roma imperiale*. Padua: 267–76.

Antonelli, F. and Lazzarini, L. 2004a. La caratterizzazione minero-petrografica e geochimica delle rocce. In L. Lazzarini (ed.), *Pietre e marmi antichi. Natura, caratterizzazione, origine, storia d'uso, diffusione, collezionismo*. Padua: 33–45.

Antonelli, F. and Lazzarini, L. 2004b. Les marbres de couleur des monuments d'*Arausio* (Orange, Provence). In P. Chardron-Picault, J. Lorenz, P. Rat, and G. Sauron (eds.), *Les roches décoratives dans l'architecture antique et du Haut Moyen Âge* (Archéologie et d'histoire de l'art 16). Paris: 9–24.

Arnaud, P. 1992. Les relations maritimes dans lePont-Euxin d'après les données numériques des géographesanciens (pseudo-Scylax, Strabon, Pomponius Mela, Pline, Arrien, Anonyme de 500, Marcien d'Héraclée), REA 94: 57-77.

Arnaud, P. 2005. *Les routes de la navigation antique: Itinéraires en Méditerranée.* Éditions Errance.

Arnaud, P. 2007. Diocletian's prices edict: the prices of seaborne transport and the average duration of maritime travel. *Journal of Roman Archaeology* 20, 334.

Asemakopoulou-Atzaka, P. 1993. Το επάγγελμα του ψήφοθετή κατα την όψιμη αρχαιότητα 3ος-7ος αιώνας. Athens.

Asgari, N. 1977. Die halbfabrikate kleinasiatischer Girlandensarkophage und ihre Herkunft. *Archäologischer Anzeiger* 329-82.

Asgari, N. 1988. The Stages of Workmanship of the Corinthian Capital in Proconnesus and its Export Form. In N. Herz and M. Waelkens (eds.), *Classical Marble: Geochemistry, Technology, Trade*. Kluwer Academic Publishers, Dordrecht, Boston, London:115–125.

Attanasio, D. 2003. Ancient White Marbles. Analysis and Identification by Paramagnetic Resonance Spectroscopy. *Studia Archaeologica* 122. Rome.

Attanasio, D., Brilli, M., and Ogle, N. 2006. The Isotopic Signature of Classical Marbles. *Studia Archaeologica* 145. Rome.

Attanasio, D., Brilli, M. and Rocchi, P. 2008. The Marbles of two Early Christian Churches at Latrun (Cyrenaica, Libya). *Journal of Archaeological Science* 35(4): 1040–1048.

Aupert, P. 1996. *Guide d'Amathonte*. École française d'Athènes, Athens.

Aviam, M. 1990. Horvath Hesheq – A Unique Church inUpper Galilee: Preliminary Report. In Bottini, G.C.Alliata, E. and L. Di Segni (eds.), *Christian Archaeology in the Holy Land. New Discoveries* (Essays in Honour of V.C. Corbo, OFM). SBF, Collectio Maior 36, Jerusalem: 351-78.

Avramea, A. 2002. Land and Sea Communications, Fourth-Fifteenth Centuries. In A.E. Laiou (ed.), *The Economic History of Byzantium.* Dumbarton Oaks, Washington, D.C.

Bagnall, R. S. 1985. Agricultural Productivity and Taxation in Later Roman Egypt. *Transactions of the American Philological Association* 115: 289–308.

Bagnall, R.S. 1993. *Egypt in Late Antiquity.* Princeton Univ. Press, Princeton, N.J.

Balty, J-C. 1989. Apamee au Vie siècle: Te moignages archeologiques de la richesse d'une ville. In V. Kravari, J. Lefort, and C. Morrisson (eds.), *Hommes et Richesses dans L'empire Byzantin*, Vol 2. P. Lethielleux, Paris: 81–96.

Bang, P. 2009. The Ancient Economy and New Institutional Economics. *Journal of Roman Studies* 99: 194-206.

Bar, D. 2004. Population, Settlement and Economy in Late Roman and Byzantine Palestine (70-641 AD). *Bulletin of the School of Oriental and African Studies, Univ. of London*, 67(3): 307–320.

Barbin, V., Ramseyer, K., Decrouez, D., Burns, S. V., Chamay, J. and Maier, J. L. 1992. Cathodoluminescence of white marble: An overview. *Archaeometry* 34: 175–83.

Bardill, J. 1995. A Catalogue of Stamped Bricks. *Anatolian Archaeology* 1: 28–29.

Bardill, J. 2008. Building Materials and Techniques. In R. Cormack, J. F. Haldon, and E. Jeffreys (eds.), *The Oxford Handbook of Byzantine Studies.* Oxford Univ. Press, Oxford, New York: 335–352

Barnes, T. E. D. 1981. *Constantine and Eusebius*. Harvard Univ. Press, Cambridge MA.

Barnish, S.J.B. 1986. The Wealth of Julianus Argentarius: Late Antique Banking and the Mediterranean Economy, *Byzantion* 55 (1985).

Barresi, P. 2003. *Province dell'Asia Minore: Costo dei maermi, architettura public e committenza*. L'Erma di Bretschneider, Rome.

Bell, P.N. (Ed.). 2009. *Three Political Voices from the Age of Justinian: Agapetus, Advice to the Dialogue on Political Science; Paul the Silentiary, Description of Hagia Sophia* (Vol. 52). Liverpool Univ. Press, Liverpool.

Bernard, S. G. 2010. Pentelic Marble in ARchitecture at Rome and the Republican Marble Trade. *Journal of Roman Archaeology* 23: 35–54.

Bingen, J., Bülow-Jacobsen, A., Cockle, W. E. H., Cuvigny, H., Rubinstein, L., and Van Rengen, W. 1992. *Mons Claudianus: Ostraca Graeca et Latina I (O. Claud. 1 à 190)* (Documents de Fouilles de l'Institut Français d'Archéologie Orientale 29). Cairo.

Bingen, J., Bülow-Jacobsen, A., Cockle, W.E., Cuvigny, H., Rubinstein, L. and Van Rengen, W. 1997. Mons Claudianus. *Ostraca graeca et latina II (O. Claud. 191-414)*. Institut français d'archéologie orientale.

Blagg, T.F.C. 1980. Roman civil and military architecture in the province of Britain: aspects of patronage, influence and craft organization. *World Archaeology* 12.1: 27–42.

Blakely, J.A. 2013. Ceramics and Commerce: Amphorae from Caesarea Maritima. *Bulletin of the American Schools of Oriental Research*, 271: 31–50.

Bonifay, M. and Pieri, D. 1995. Amphores du Ve au VIIe s. à Marseille: nouvelles données sur la typologie et le contenu. *Journal of Roman Archaeology* 8 94–120.

Braudel, F. 1972. *The Mediterranean and the Mediterranean World in the Age of Philip II,*, Volume 1. Harper and Rowe, New York: 326-61.

Broodbank, C. 2000. *An Island Archaeology of the Early Cyclades.* Cambridge Univ. Press, Cambridge.

Brooks, E.W. (Trans.). 1924. *Zacharias of Mytilene, Historia Ecclesiastica Zachariae rhetori vulgo adscripta*. Paris.

Brown, P. 1967. Review of the Later Roman Empire. *The Economic History Review,* New Series, Vol. 20, No. 2: 327-343.

Brughmans, T. 2010. Connecting the Dots: Network Analysis in Archaeology. *Oxford Journal of Archaeology* 29.3: 277-303.

Brughmans, T. 2013. Thinking Through Networks: A Review of Formal Network Methods in Archaeology. *Journal of Archaeological Method and Theory* 20: 623–662

Brun, J.P. 1993a. La discrimination entre les installations oleicoles et vinicoles. In M.C Amouretti (ed.), *La production du vin et de l'huile en Méditerranée* (Vol. 26). Ecole française d'Athènes, Athens.

Brun, J.P. 1993b. L'oléiculture et la Viticulture Antiques en Gaule: Instruments et Instalations de Production. In M.C. Amouretti (ed.), *La Production du vin et de L'huile en Méditerranée* (Vol. 26). Ecole française d'Athènes, Athens.

Bruneau, P. P. and Fraisse, P. 1984. Pressoirs Déliens. *Bulletin de Correspondance Hellénique* 108: 717.

Bruno, M., Cancelliere, S., Gorgoni, C., Lazzarini, L., Pallante, P. and Pensabene, P. 2002. Provenance and Distribution of White Marbles in Temples and Public Buildings of Imperial Rome. In *Asmosia* 5: 289-300.

Bruno, M., Elçi, H., Yavuz, A.B. and Attanasio, D. 2012. Unknown ancient marble quarries of western Asia Minor. In A. Gutiérrez, P. Lapuente, P. and I. Rodà (eds.), *Interdisciplinary studies on ancient stone, proceedings of the 9th ASMOSIA Conference.* Institut Catala d'SArqueologia Classica, Tarragona: 562-572.

Bruzza, L.1870. Iscrizioni dei marmi grezzi. *Annali dell'Instituto di Corrispondenza Archeologica* 42: 106–205.

Bülow-Jacobsen, A. 1996. *Mons Claudianus. Organisation, administration og teknik i et romersk stenbrud fra kejsertiden*. Copenhagen.

Bülow-Jacobsen, A. 2009. Writing materials in the Ancient World. In R. Bagnall (ed.), *The Oxford Handbook of Papyrology*. Oxford Univ. Press, Oxford.

Bury, J.B. 1920. The Notitia Dignitatum. *Journal of Roman Studies*, 10:131-154.

Bury, J.B. 1923. *History of the Later Roman Empire from the Death of Theodosius I to the Death of Justinian:(AD 395 to AD 565*), Vol. 2. Macmillan and Company, London.

Cameron, A. 1993. *The Mediterranean World in Late Antiquity A.D. 395-600.* Routledge, London, New York.

Cameron, A. 1996. *Procopius and the Sixth Century*. Routledge, London, New York.

Carlson, D. N., and W. Aylward. 2010. The Kızılburun Shipwreck and the Temple of Apollo at Claros. *American Journal of Archaeology* 114(1): 145-159.

Carrié, J.M. 2004. *Tissus et vêtements dans l'antiquité tardive*. Association pour l'antiquité tardive Vol. 12. Brepols, Paris.

Carrié, J.M. 2012. Were Late Roman and Byzantine Economies Market Economies? A Comparative look at Historiography. In C. Morrisson (ed.), *Trade and Markets in Byzantium.* Dumbarton Oaks Research Library and Collection, Washington, D.C.:13-26.

Carrié, J.M. and Rousselle, A. 1999. *L'Empire Romain Mutation: des Sévères à Constantin, 192-337* (Vol. 221). Ed. du Seuil.

Castagnino Berlinghieri, E.F. and Paribeni, A. 2011. Byzantine Merchant Ships and Marble Trade: New data from Central Mediterranean. *Proceedings of "In Poseidons Realm XV: Byzantium at Sea. Innovation and Tradition"* (Wien 2010), in SKYLLIS, 11 Jahrgang 2011, Heft 1: 64-75.

Chalkia, E. 2006. La Scultura Paleocristiana di Nicopoli. Alcune Considerazioni. In R. Harreither, Ph. Pergola, P. Pillinger & A. Pulz (eds.), *Acta Congressus Internationalis XIV Archaeologiae Christianae*: 281-287. Pontifico Instituto di Archaeologia Christianae, Citta del Vaticano.

Chastagnol, A. 1994. La carrier senatoriale nel Basso Impreo (dopo Diocleziano). In S. Roda (ed.), *La parte migliore del genere umano. Aristocrazie, portere e ideologia nell' occidente tardoantico*. Torino: 23-57.

Christol, M. and Drew-Bear, T. 1987. Un Castellum Romain Près D'apamée de Phrygie (No. 12). *Austrian Academy of Sciences.*

Christol M.and Drew-Bear, T. 1991. Les carrieres de Dokimion a` l'epoque severienne. *Epigraphica* 53: 113–74.

Christol, M., Drew-Bear, T. 2005. De Lepcis Magna à Aizanoi: Hesperus Procurateur de Phrygie et l'Administration des Carrières de Marbre. In J. Desmulliez, Chr. Hoët-van Cauwenberghe (eds.)*, Le monde romain à travers l'épigraphie: méthodes et pratiques (Lille, 8–10 novembre 2001),* Lille, pp.189-216.

Christol, M., Drew-Bear, T. and Taçlialan, M. 2005. Appius Alexander, Serviteur de L'état Romain et Philosophe. *Anatolia Antiqua 13*(1): 271-284.

Coase, R.H. 1988. *The Firm, the Market, and the Law*. Univ. of Chicago Press, Chicago.

Coase, R.H. 1992. The Institutional Structure of Production. *The American Economic Review* 82: 713-19.

Coase, R.H. 1994. *Essays on Economics and Economists*. Univ. of Chicago Press, Chicago.

Cockle, W.E.H. 1996. An inscribed architectural fragment from Middle Egypt concerning the imperial quarries. *Journal of Roman Archaeology-Supplementary Series* 19:.23-28.

Coleman, M. and Walker, S. 1979. Stable Isotope Identification of Greek and Turkish Marbles. *Archaeometry* 21: 107–12.

Colt, H.D. 1962. *Architectural Details*. In H.D. Colt (ed.), Excavations at Nessana, Vol. 1. London: 48-50.

Corcoran, S. 2000. *The Empire of the Tetrarchs: Imperial Pronouncements and Government AD 284-324*. Revised edn. Oxford Univ. Press, Oxford.

Corcoran, S. and DeLaine, J. 1994. The unit measurement of marble in Diocletian's Prices Edict. *Journal of Roman Archaeology* 7: 263-273.

Craig, H. and Craig, V. 1972. Greek Marbles: Determination of Provenance by Isotopic Analysis. *Science* 176: 401–3.

Croke, B. 2005a. Justinian's Constantinople, in Maas, M. (ed.), *The Cambridge Companion to the Age of Justinian.* Cambridge Univ. Press, Cambridge: 60-86.

Croke, B. 2005b. Procopius' secret history: Rethinking the date. *Greek, Roman, and Byzantine Studies* 45(4): 405-431.

Croke B. and Crow, J. 1983. Procopius and Dara. *Journal of Roman Studies* 73: 143–59

Cuvigny, H. 1996. The amount of wages paid to the quarry-workers at Mons Claudianus. *Journal of Roman Studies* 86:139-145.

Cuvigny, H. 2000. Procurator Montis. *Papyri in Honorem Johannis Bingen Octogenarii (P. Bingen)*: 415-18.

Dagron, G. 1974. *Naissance d'une capitale: Constantinople et ses Institutions de 330 à 451* (Vol. 7). Presses Universitaires de France, Paris.

Dagron, G. 1979. Entre village et cite: La bourgade rurale des IVe–VIIe siecles en Orient. *Koinonia* 3: 29–52.

Dagron, G. 1985. Un Tarif des Sportules a Payer aux Curiosi du port de Séleucie de Piérie (VIe Siècle). *Travaux et Mémoires* 9: 435-51.

Dagron, G. 1996. *Empereur et Prêtre: Étude sur le" Césaropapisme" Byzantin*. Gallimard, Paris.

Dagron, G. 2002. Urban Economy. In A. E. Laiou (ed.), *The Economic History of Byzantium: From the Seventh Through the Fifteenth Century.* Dumbarton Oaks Research Library and Collection, Washington, D.C.: 129–146.

Dagron, G. and Marcillet-Jaubert, J. 1978. Inscriptions de Cilicie et d'Isaurie, *Belleten* 42: 373–420.

Dar, S. 1986. *Landscape and Pattern: An Archaeological Survey of Samaria, 800 B.C.E.–636 C.*E. Oxfurd Univ. Press, Oxford.

Deichmann, F.W. 1982. Westliche Bautechnik im romischen und rhomaischen Osten. In *Rom, Ravenna, Konstantinopel, Naher Osten: Gesammelte Studien zur spatantiken Architektur, Kunst und Geschichte*. Wiesbaden: 473–527.

Delagrave, C. (ed.). 1989. *Revue de géographie*, vol. 8, Paris: 396.

DeLaine, J. 1997. The Baths of Caracalla. *A study in the design, cosntruction and economics of large-scale building projects in imperial Rome.* JRA suppl. 25.

Deroche, V., Maniatis, Y., Mandi, V., and Nikolaou, A. 1989. Identification de marbres antiques a Delphes. *Bulletin de correspondance hellenique* 113: 407- 9, 414.

Dewing, H.B. (Ed. Trans.). 1940. Procopius, Vol. VII: *De Aedeficiis* (Loeb Classical Library No. 343). Harvard Univ. Press, Cambridge, MA.

Dodd, S.D., Drakopoulos, S., Scheidel, W. and Von Reden, S. 2003. *The Ancient Economy*. Edinburgh Univ. Press Ltd, Edinburgh.

Dodge, H. and Ward-Perkins, B. (Eds.). 1992. *Marble in Antiquity: Collected Papers of JB Ward-Perkins,* Archaeological Monographs of the British School at Rome 6, British School at Rome, London.

Domergue, C. 1983. *La mine antique d'Aljustrel (Portugal) et les tables bronzes de Vipasca* (Publication du Centre Pierre Paris (E.R.A. 522), 9/Collection de la Maison des Pays Iberiques 12). Paris.

Domergue, C. 199). *Les mines de la péninsule Ibérique dans l'Antiquité romaine*

Domergue, C., 1990. *Les Mines de la Péninsule Ibérique dans L'antiquité Romaine* Vol. 127, No. 1). Persée-Portail des Revues Scientifiques en SHS.

Drake, H.A. 2006.*Violence in Late Antiquity: Perceptions and Practices*. Ashgate, Fanham.

Dubois, M. 1908. *Etude sur L'administration et L'exploration des Carrières Marbres, Porphyre, Granit etc dans le Monde Romain*. Paris.

Duncan-Jones, R. 1990. *Structure and Scale in the Roman Economy*. Cambridge Univ. Press, Cambridge.

Eichholz, D. E. (Ed. Trans.). 1962a. Pliny, *Naturalis Historia*. Loeb Classical Library, Harvard Univ. Press, Cambridge, Mass.

Eichholz, D. E. (Ed. Trans.). 1962b. *Pliny the Elder XXXVI*. Loeb Classical Library, Harvard Univ. Press, Cambridge, Mass.

Errington, R.M. 2006. *Roman Imperial Policy from Julian to Theodosius*. Univ. of North Carolina Press, Chapel Hill.

Evans, T., Knappett, C.and Rivers, R. 2009. Using statistical physics to understand relational space: A case study from Mediterranean prehistory. In D. Lane, D. Pumain, S. van der Leeuw, and G. West. (eds.), *Complexity Perspectives on Innovation and Social Change*, Methodos Series, Vol. 7, chapter 17, Springer, pp. 451–479.

Fant, J.C. 1992. The Roman imperial marble yard at Portus. In M. Waelkens, N. Herz and L. Moens (eds.), *Ancient Stones: Quarrying, Trade, and Provenance. Interdisciplary Studies on Stones and Stone Technology in Europe and Near East from the Prehistoric to the Early Christian Period*. Leuven Univ. Press Leuven:115-120.

Fant, J. C. 1989. *Cavum antrum Phrygiae: The Organization and Operations of the Roman Imperial Marble Quarries in Phrygia*. Oxford Univ. Press, Oxford.

Fant, J. C. 1985. Four Unfinished Sarcophagus Lids at Docimium and the Roman Imperial Quarry System in Phrygia. *American Journal of Archaeology*, pp.655-662.

Fant, J. C. 1988a. IRT 794b and the Building History of the Hadrianic Baths at Lepcis Magna. *Zeitschrift für Papyrologie und Epigraphik*, pp.291-294.

Fant, J. C. 1988b. New Sculptural and Architectural Finds From Docimium. Department of Anthropology and Classical Studies Paper 117.

Fant, J. C. 1988c. The Roman Emperors in the Marble Business: Capitalists, Middlemen, or Philanthropists? In N. Herz and M. Waelkens (eds.), *Classical Marble: Geochemistry, Technology, Trade.* Kluwer, Dordrecht, Boston, London: 147–158.

Fant, J. C. 1989. Poikiloi Lithoi: The Anomalous Economics of the Roman Imperial Marble Quarry at Teos. *Bulletin of the Institute of Classical Studies* 36(S55): 206-218.

Fant, J. C. 1993. Ideology, gift and trade: A Distribution Model for the Roman Imperial Marbles, in W. V. Harris (ed.), *The inscribed economy: Production and distribution in the Roman Empire in the light of instrumentum domesticum. Journal of Roman Archaeology* Suppl. 6: 145–70.

Fant, J. C. 2001. Rome's marble yards. *Journal of Roman Archaeology* 14: 167,98.

Feissel, D., Dobias-Lalou, C., Bingen, J., Panayotou, A., Brixhe, C., Hatzopoulos, M.B., Cabanes, P., Bousquet, J., Dubois, L., Masson, O. and Sève, M. 1992. Bulletin épigraphique. *Revue des Études Grecques* 105(502): 644.

Feissel,D. 1988. L'architecte Viktorinos et les Fortifications de Justinien dans les Provinces Balkaniques. *Bulletin de la Société nationale des antiquaires de France*: 136–46.

Fejfer J. 1995. *Ancient Akamas, vol. 1, Settlement and Environment*. Waxmann, Aarhus.

Festugiere, A-J. (Ed. Trans.). 1970. *Vie de Theodore de Sykeon* (Subsidia Hagographica 48, 2 vols). Societe des Bollandistes, Brussels.

Fitzgerald, G.M. 1939. *A Sixth Century Monastery at Beth Shan (Scythopolis)*. Philadelphia.

Foss, C. 1994. The Lycian Coast in the Byzantine Age. *Dumbarton Oaks Papers* 408: 1-52.

Fourdrin, J.P. and Feissel, D. 1994. Une Porte Urbaine Construite a Chalcis de Syrie par Isidore de Milet Le Jeune (550–551). *Travaux et Mémoires 12*: 299-307.

Fousek, J., Výtvarová, E., Mertel, A., Chalupa, A., and Hladká, E. 2016. Agent-Based Modeling And Simulation For The Geospatial Network Model Of The Roman World. *Proceedings of Science*. International Symposium on Grids and Clouds (ISGC) 2016, 13-18 March 2016, Taipei, Taiwan.

Fox, R.L. 1986. Hellenistic Culture and Literature. In J. Boardman, J. Griffin and O. Murray (eds.), *Oxford History of Greece and the Hellenistic World (Oxford, 2001)*, pp.390-420.

Frankel, R. 1987. Oil Presses in Western Galilee and the Judaea—A Comparison. In D. Eitam and M. Heltzer (eds.), *Olive Oil in Antiquity, Israel and Neighbouring Countries from Neolith to Early Arab Period.* Haifa, pp.63-80.

Frankel, R. 1988. An Oil Press at Tel Safsafot. *Tel Aviv 15*(1): 77-91.

French, D.H. 1993. A Road Problem: Roman or Byzantine? *Istanbuler Mitteilungen* 43: 445-454.

Frend, W.H. 1972. The Monks and the Survival of the East Roman Empire in the Fifth Century. *Past and Present* 54: 3-24.

Frend, W. C. and D. E. Johnston. 1962. The Byzantine Basilica Church at Knossos. *British School at Athens* 57: 186-238.

Frézouls, E. 1984. Evergétisme et Construction Urbaine dans le Trois Gaules et les Germanies. In *Mélanges offerts à E. Will* (Revue du Nord 66). Lille: 27–54.

Fulford, M.G. 1989: To East and West: the Mediterranean Trade of Cyrenaica and Tripolitania in Antiquity. *Libyan Studies* 20: 169-191.

Garnsey, P. 1983. Grain for Rome. In W. Scheidel and S. von Reden, (eds.) *The Ancient Economy*. Edinburgh Univ. Press Ltd, Edinburgh: 118-30.

Garnsey, P., Hopkins, K. and Whittaker, C.R., 1983. T*rade in the Ancient Economy*. Univ. of California Press, Berkeley.

Gibbon, E. 1804. *The History of the Decline and Fall of the Roman Empire,* Chapter. 32 (Vol. 5). W.Y. Birch and A. Small, London.

Gonzales, R. 2013. This interactive travel map of the Roman Empire is like Oregon Trail meets Civilization. *io9*, January 117, 2013. http://io9.com/5975032/this-interactive-travel-map-of-the-roman-world-is-like-oregon-trail-meets-civilization-and-it-is-awesome.

Graham, S. 2006. Networks, agent-based models and the Antonine itineraries: implications for Roman archaeology. *Journal of Mediterranean Archaeology* 19(1): 45–64.

Greatrex, G. 2008. Political-Historical Survey, c. 250-518. In Cormack, R., Haldon, J., and Jeffries, E. (eds.), *The Oxford Handbook of Byzantine Studies*, Ch. II.3.2A. Oxford Univ. Press, Oxford.

Greene, K. 1986. *Archaeology of the Roman Economy*. Univ. of California Press, Berkeley.

Greenhalgh, M. 2009. *Marble Past, Monumental Present: Building With Antiquities in the Medieaeval Mediterranean*. Brill, Leiden and Boston.

Gregory, T.E. 1982. Fortification and Urban Design in Early Byzantine Greece. In R.L. Hohlfelder (ed.) *City, Town, and Countryside in the Early Byzantine Era*. East European Monographs, New York.

Greif, A. 1994. Cultural Beliefs and the Organization of Society: A Historical and Theoretical Reflection on Collectivist and Individualist Societies. *Journal of Political Economy*, *102*(5): 912-950.

Greif, A. 2006. *Institutions and the Path to the Modern Economy: Lessons From Medieval Trade*. Cambridge Univ. Press, Cambridge.

Gummere, R. M. (Ed. Trans.). 1917. Seneca, *Epistles* LXXXVI.6. Loeb Classical Library 75, Harvard Univ. Press, Cambridge, MA.

Gutiérrez, A., Lapuente, P. and Rodà, I. (eds). 2012. *Interdisciplinary Studies on Ancient Stone. ASMOSIA IX* (Documenta 23). Institut Catala d'Arqueologia Classica, Tarragona.

Habas, L. 1994. *The Relief Art of Chancel Screens inChurches and Synagogues in Palestine in the Byzantine Period: A Stylistic and Iconographic Study*. Unpublished MA dissertation, Hebrew Univ. of Jerusalem, Vol. I: Text, Vol. II: Catalogue of the Chancel Posts, Vol. III: Catalogue of the Chancel Screens. Jerusalem.

Habas, L. 2009. The Art of Imported Marble Chancel Screens and its Influence on Local Production in the Churches of the Provinces of Palaestina and Arabia: A Case Study. In H. Oniz (ed.), *SOMA 2008: Proceedings of the XII Symposium on Mediterranean Archaeology*. Eastern Mediterranean Univ., Famagusta, North Cyprus, 5-8 March 2008.

Haldon, J. 2005. *Byzantium: A History*. The History Press, Stroud.

Haldon, J. 2008. The State: Structures and Administration. In R. Cormack, J. Haldon, E. Jeffreys (eds.), *The Oxford Handbook of Byzantine Studies*, Ch. III.10.1. Oxford Univ. Press, Oxford, New York.

Hanfmann G.M.A. and Waldbaum, J.C. 1975. *A Survey of Sardis and the Major Monuments outside the City Walls.* Cambridge, Mass.

Harrison, R.M. 1986. *Excavations at Sarachane,* vol. 1. Princeton Univ. Press, Princeton, N.J.–Washington, D.C.

Harvey, A. 1989. Economic Expansion in the Byzantine Empire 900-1200. Cambridge Univ. Press, Cambridge.

Harvey, A. 2008. The Economy. In R. Cormack, J.F. Haldon and E. Jeffreys (eds.), *The Oxford Handbook of Byzantine Studies.* Oxford Univ. Press, Oxford, New York: 631–641.

Hayes, J.W. 1992. *Excavations at Saraçhane in Istanbul.* Dumbarton Oaks, Princeton, N.J.–Washington D.C.

Heather, P. 2006. *The fall of the Roman Empire: A New History*. Pan Macmillan, London.

Hendy, M.F. 1985. *Studies in the Byzantine Monetary Economy, c. 300-1450*. Cambridge Univ. Press, London and New York.

Hendy, M.F. 1989. *The Economy, Fiscal Administration and Coinage of Byzantium*. Collected studies series CS305, Variorum Reprints, Northampton, UK.

Herrmann, J., Barbin, V., and Mentzos, A. 1999. The exportation of marble from Thasos in Late Antiquity: the quarries of Aliki and Cape Fanari. In C. Koukouli-Chrysanthaki and A. Muller (eds.), *Thasos: Matieres Premieres et Technologie de La Prehistoire a nos Jours*: 75-90. Ecole Francaise d'Athenes, Athens.

Herz, N. 1988a. Classical Marble Quarries of Thasos. In G. A. Wagner and G. Weisgerber (eds.), *Antike Edel- und Buntmetallgewinnung auf Thasos* (Der Anschnitt, Zeitshrift für Kunst und Kultur im Bergbau 6). Bochum: 232–40.

Herz, N. 1988b. The Oxygen and Carbon Isotopic Database for Classical Marble. In N. Herz and M. Wealkens (eds.), *Classical Marble: Geochemistry, Technology, Trade*, NATO ASI Series E: Applied Sciences. Kluwer Academic, Boston: 305–14.

Herz, N. 1990. Greek and Roman Marble: Provenance Determination and Artifact Reconstruction. In P. G. Marinos and G. C. Koukis (eds.), *The Engineering Geology of Ancient Works, Monuments and Historical Sites: Preservation and Protection*. 4 vols. Rotterdam: 1987–94.

Herz, N. 2000. The Classical Marble Quarries of Paros: Paros-1, Paros-2 and Paros-3. In D. U. Schilardi and D. Katsonopoulou (eds.), *Paria Lithos: Parian Quarries, Marble and Workshops of Sculpture*. Athens: 27–34.

Herz, N. and Waelkens, M. (eds.). 1988. *Classical Marble: Geochemistry, Technology and Trade*. NATO ASI series E: Applied Sciences 153. Dordrecht.

Hild, F.H. and G. Hellenkemper Salies. 1984. Kommagene-Kilikien-Isaurien. *Reallexikon zur Byzantinischen Kunst* 4:182–356.

Hirschfeld Y. and Birger, R. 1991. Early Roman and Byzantine Estates near Caesarea. *Israel Exploration Journal* 41: 81–111.

Hirschfeld, O. 1905. *Die kaiserlichen Verwaltungsbeamten bis auf Diocletian*. Weidmann, Frankfurt.

Hirt, A.M. 2010. *Imperial Mines and Quarries in the Roman World*. Oxford Univ. Press, Oxford.

Hitchner, R.B. 1993. Olive Production and the Roman Economy: The Case for Intensive Growth in the Roman Empire. In M.-C. Amouretti and J.-P. Brun (eds.), *La production du vin et de L'huile en Mediterranee*. BCH suppl. 26: 499–508.

Hopkins, K. 1978a. *Conquerors and Slaves. Sociological Studies in Roman History, Volume I*. Cambridge Univ. Press, Cambridge-London-New York: 39-43.

Hopkins, K. 1978b. Economic Growth in Towns in Classical Antiquity. In P. Abrams and E.A. Wrigley (eds.), *Towns in Societies: Essays in Economic History and Historical Sociology*. Cambridge Univ. Press, Cambridge-London-New York.

Hopkins, K. 1980. Taxes and Trade in the Roman Empire (200 B.C.-A.D. 400). *The Journal of Roman Studies* 70: 101–125.

Hopkins, K. 1983. Models, Ships and Staples. In P. Garnsey and C. R. Whittaker (eds.), *Trade and Famine in Classical Antiquity.* Cambridge Philological Society, Cambridge.

Horster, M. 2001. *Bauinschriften römischer Kaiser. Untersuchungen zu Inschriftenpraxis und Bautätigkeit in Städten des westlichen Imperium Romanum in der Zeit des Prinzipats* (Historia Einzelschriften 157). Stuttgart.

Jacoby, D. and Lemerle, P. 1975. *Société et démographie à Byzance et en Romanie latine*. Variorum Reprints, London.

Jameson, M.H., Runnels C.N. and Van Andel, T.H. 1994. *A Greek Countryside: The Southern Argolid from Prehistory to the Present Day*. Stanford Univ. Press, Stanford.

Johnson, M.J. 2015. The Architecture of Empire. In Lenski, N. (ed.), *The Cambridge Companion to the Age of Constantine*. Cambridge Univ. Press, Cambridge-London-New York: 278-297.

Jones, A.H.M. 1964. *The Later Roman Empire (284–602)*. Oxford Univ. Press, Oxford.

Jones, A.H.M. 1986. *The Later Roman Empire, 284-602: Social Economic and Administrative Survey* (Vol. 2). Taylor and Francis, New York.

Jones, E. 1981. *The European Miracle: Environments, Economies and Geopolitics in the History of Europe and Asia.* Cambridge Univ. Press, Cambridge.

Kagan, D. 1978. *The End of the Roman Empire. Decline or Transformation?* Heath, Lexington, Mass.

Kapitän, G. 1969. The Church Wreck off Marzamemi. *Archaeology* 22(2):122-133.

Kapitän, G. 1980. *Elementi Architettonici per una Basilica dal Relitto Navale del VI Secolo di Marzamemi (Siracusa)* (1).

Kaplan, M. 1992. *Les hommes et la terre à Byzance du VIe au XIe siècle*. Gallimard, Paris.

Karagianni A. 2011/12. The harbour of Proconnesus in Greco-Roman and early Byzantine times: the marble trade, a source of financial and cultural development. *European Journal of Archaeology* 36:17–22.

Karnapp, W. 1976. *Die Stadtmauer von Resafa in Syrien*. De Gruyter, Berlin.

Keay, S.J. 2015. Rome, Portus and the Mediterranean. *Archaeological Monographs of the British School at Rome* 21.

Keay, S.J. and Abadie-Reynal, C. 1986. A propos des Actes du Colloque de Sienne, Amphores romaines et histoire economique, Rome 1989. *Journal of Roman Archaeology* 5: 353–66.

Keay, S.J., Millett, M., Paroli, Land Strutt, K. 2005. *Portus: An Archaeological Survey of the Port Of Imperial Rome* (No. 15). British School at Rome, Rome.

Khanoussi, M. 1991. Nouveaux Documents sur la Présence Militaire dans la Colonie Julienne Augustéenne de Simitthus (Chemtou, Tunisie).*Comptes rendus des séances de l'Académie des Inscriptions et Belles-Lettres* 135: 825-839.

Khanoussi, M. 1996. Nouveaux Vestiges Épigraphiques de la Cité Latine de Capsa (Gafsa), en Tunisie. *L'Africa Romana 11:*1341-1353.

Kingsley, S. and Decker, M. 2001. *Economy and Exchange in the East Mediterranean during Late Antiquity: Proceedings of a Conference at Somerville College, Oxford, 29th May, 1999*. Oxbow, Oxford.

Kinney, D. 1997. *Spolia Damnatio and Renovatio Memoriae*. Memoirs of the American Academy in Rome, Vol. 42: 117-148.

Kislinger, E. 2010. La Città bizantina in Sicilia come centro amministrativo. In Congiu, Modeo and Arnone (eds*.), La Sicilia bizantina: storia, città e territorio: Atti del VI convegno di studi*. Caltanissetta, Sciascia Editore: 147-67.

Kocabaş, U. 2015. The Yenikapı Byzantine-Era Shipwrecks, Istanbul, Turkey: a preliminary report and inventory of the 27 wrecks studied by Istanbul Univ. . *The International Journal of Nautical Archaeology* (2015) 44.1: 5–38, 19.

Koželj, T. 1988. 'Les carrières des époques grecque, romaine et byzantine', in J. C. Fant (ed.), *Ancient Marble Quarrying and Trade* (BAR International Series 453). Oxford: 3–79.

Kraemer, C (ed.). 1958. *Non-Literary Papyri, Excavations at Nessana* 3. Princeton, N.J.: 92, 230, 272.

Kramer, J. 1973. Architekturteile des Seyitgazi-Tekke (Vilayet Eskişehir) und die Michaelkirche von Nakoleia. *JOB* 22: -250.

Kretikekou, K. 1990. Μνείες οικοδομικών επάγγελματων στις επιγραφές της ρωμαϊκής-παλιοχρστιανικης Παλαιστινης και Αραβιας. *Μελετήματα 10 Ποικιλα*, Athens: 373–94.

Ladstätter, S., Pirson, F., and Schmidts, T. 2015. *Harbors and Harbor Cities in the Eastern Mediterranean* (Byzas 19). Ege Yayinlari, Istanbul.

Laiou-Thomadakis, A. 1980. The Byzantine Economy in the Mediterranean Trade System: Thirteenth-Fifteenth Centuries. *Dumbarton Oaks Papers* 34/35: 177-222.

Laiou, A. 1995. Handler und Kaufleute, and Byzantium and the Commercial Revolution. In G. Arnaldi and G. Cavallo (eds.), *Europa Medievale e Mondo Bizantino contatti effettivi e possibilità di studi,* Tavola rotonda del 18. Congresso del CISH, Montréal, 29 agosto 1995.

Laiou, A. 2002. Economic and noneconomic exchange. In A. Laiou (ed.), *The Economic History of Byzantium: from the Seventh Through the Fifteenth Century.* Dumbarton Oaks, Washington, D.C.: 681-96.

Lapuente, P., Turi, B. and Blanc, P. 2009. Marbles and coloured stones from the theatre of *Caesaraugusta* (*Hispania*): preliminary study. In Y. Maniatis (ed.), *ASMOSIA VII* (BCH Supplement 51). Athens: 509–22.

Lassus, J. 1935. *Inventaire archeologique de la region au nord-est de Hama.* Damascus.

Lauffray, J. 1983. Halabiyya-Zenobia, Place Forte du Limos Oriental et la Haute-Mesopotamie au VIe siecle, vol. 1 and 2. Paris.

Lazzarini, L (ed.). 2002a. *Interdisciplinary Studies on Ancient Stone: ASMOSIA VI, Proceedings of the Sixth International Conference of the Association for the Study of Marble and Other Stones in Antiquity, Venice, June 15-18, 2000.* Bottega d'Erasmo Aldo Ausilio Editore, Padua.

Lazzarini, L. 2002b. A new Grey Marble from Gortyna (Crete) Used in Greek and Roman Antiquity. In L. Lazzarini (ed.), *Interdisciplinary Studies on Ancient Stone: ASMOSIA VI, Proceedings of the Sixth International Conference of the Association for the Study of Marble and Other Stones in Antiquity, Venice, June 15-18, 2000.* Bottega d'Erasmo Aldo Ausilio Editore, Padua*:* 227–32.

Lazzarini, L. 2002c. La determinazione della provenienza delle pietre decorative usate dai romani. In M. De Nuccio and L. Ungaro (eds), *I marmi colorati della Roma imperiale*. Padua, 223–75.

Leidwanger, J. 2013. Modeling Distance with Time in Ancient Mediterranean Seafaring: A GIS Application for the Interpretation of Maritime Connectivity. *Journal of Archaeological Science* 40: 3302-3308.

Leidwanger, J. 2014. Maritime Networks and Economic Regionalism in the Roman Eastern Mediterranean. *Les Nouvelles de l'archéologie* no 135 – Mars 2014: 32-38.

Leppin, H. 2003. The Church Historians (I): Socrates, Sozomenus and Theodoretus. In G. Marasco (ed.), *Greek and Roman Historiography in Late Antiquity, Fourth to Sixth Century A.D*. Brill Press, Leiden: 220-23.

Liebeschuetz, J. H.W.G. 1972. *Antioch: City and Imperial Administration in the Later Roman Empire,* Oxford Univ. Press, Oxford.

Long. L. 2017. Extracting Economics from Roman Marble Quarries. *The Economic History Review* 70(1): 52-78.

Lopez, R.S. 1959. The Role of Trade in the Economic Readjustment of Byzantium in the Seventh Century. *Dumbarton Oaks Papers* 13: 67-85.

Maas, M. 2005. Roman Questions, Byzantine Answers: Contours of the Age of Justinian. In M. Maas (ed.), *The Cambridge Companion to the Age of Justinian*, Cambridge Univ. Press, Cambridge.

Maioli, M.G. 1983. Classe, podere Chiavichetta, zona portuale. In G. B. Montanari (ed.), *Ravenna e il porto di Classe: Venti anni di ricerche archeologiche tra Ravenna e Classe*. Saterno, Imola: 65–78.

Malkin, I. 2011. *A Small Greek World: Networks in the Ancient Mediterranean. Greeks Overseas*. Oxford Univ. Press, Oxford; New York.

Mango, C. 1985. *Le development urbain de Constantinople, IVe-VIIe Siècle, Travaux et Mémoires du Centre de Recherche d'Histoire et de Civilization de Byzance, Monographies 2.* De Bocard, Paris.

Mango C. 1986a. St. Michael and Attis. *Δελτίον της Χριστιανικής Αρχαιολογικής Εταιρείας* 12: 39-62.

Mango, C. 1986b. The Development of Constantinople as an Urban Centre. In *The 17th International Byzantine Congress: Main Papers*. Dumbarton Oaks, Washington, D.C.: 117-36.

Mango, M. M. 1990. The Uses of Liturgical Silver, 4th–7th Century, in R. Morris (ed.), *Church and People in Byzantium*. Birmingham: 245–61.

Mango, M. M. 2000. Building and Architecture, AD 425-ca. 600, in A. Cameron, B. Ward-Perkins, and L.M. Whitby (eds.), *The Cambridge Ancient History, Volume XIV*. Cambridge Univ. Press, Cambridge: 918-971.

Mango, M. M. (Ed.). 2009. *Byzantine Trade, 4th-12th Centuries. The Archaeology of Local, Regional and International Exchange*. Papers of the Thirty-eighth Spring Symposium of Byzantine Studies, St John's College, Univ. of Oxford, March 2004. Society for the Promotion of Byzantine Studies 14. Ashgate, Farnham and Burlington.

Maniatis, Y. (Ed.). 2009. *ASMOSIA VII: Proceedings of the 7th International Conference of the Association for the Study of Marble and Other Stones in Antiquity, Thassos 15-20 September, 2003.* Bulletin de Correspondance Hellénique Suppl. 51. École Francaise d' Athénes, Athens.

Maniatis, Y., Herz, N., and Basiakos, Y. (Eds). 1995. *The Study of Marble and Other Stones Used in Antiquity. ASMOSIA III*. London.

Maniatis, Y., Mandi, V., and Nikolaou, A. 1988. Provenance Investigation of Marbles From Delphi With ESR Spectroscopy. In N. Herz and M. Wealkens (eds.), *Classical Marble: Geochemistry, Technology, Trade*, 443–52, NATO ASI Series, E: Applied Sciences, Kluwer Academic, Boston.

Manning, S., Bolger, D.L., Swinton, A., and Pointing, M.J. 1994. Maroni Valley Archaeological Survey Project: Preliminary Report on the 1992–1993 Seasons. R*eport of the Department of Antiquities, Cyprus*: 345–67.

Marano, Y.A. 2016. The circulation of marble in the Adriatic Sea at the time of Justinian, in J. Herrin and J. Nelson, eds., *Ravenna its role in earlier medieval change and exchange*, Institute of Historical Research, Univ. of London, School of Advanced Studies, London 2016, p. 111-132.

Maraval, P. 1998. La Réception de Chalcédoine dans L'empire d'Orient. *Histoire du christianisme* 3: 432-610.

Maraval, P. 2002. The earliest phase of Christian pilgrimage in the Near East (before the 7th century). *Dumbarton Oaks Papers* 56*:* 63-74.

Mark, R. and Cakmak, A.S. 1992. *Hagia Sophia from the Age of Justinian to the Present*. Cambridge Univ. Press, Cambridge.

Mathews, T.F. 1976. *The Byzantine Churches of Istanbul, A Photographic Survey*. The Pennsylvania State Univ. Press, Philadelphia.

Mattingly, D.J. 1988. Oil for Export? A Comparison of Libyan, Spanish and Tunisian Olive Oil Production in the Roman Empire. *Journal Roman Archaeology* 1: 33–57.

McCormick, M. 1998. Bateaux de vie, bateaux de mort. Maladie, commerce, transports annonaires et le passage économique du bas-empire au moyen âge. *Settimane di studio-Centro Italiano di studi alto medioevo* 45: 35-118.

McCormick, M. 2001. Origins *of the European Economy: Communications and Commerce AD 300-900*. Cambridge Univ. Press, Cambridge.

McCormick, M. 2012. Movements and Markets in the First Millennium: Information, Containers and Shipwrecks. In C. Morrisson (ed.), *Trade and Markets in Byzantium, Dumbarton Oaks Research Library and Collection*: 51-98.

Mentzos, A., Barbin, V. and Herrmann J. 2002. Cathodoluminescence and Isotopic Analysis of Roman and Early Byzantine Architectural Decoration in the Rotunda Museum, Thessaloniki. In J. Hermann, H. Herz and R. Newman (eds.), *ASMOSIA 5: Interdisciplinary Studies on Ancient Stone. Proceedings of the Fifth International Conference of the Association for the Study of Marble and Other Stones in Antiquity, Museum of Fine Arts, Boston*: 316-327.

Meyendorff, J. 1989. *Imperial Unity and Christian Divisions: The Church, 450-680 AD* (Vol. 2). St Vladimir's Seminary Press, New York.

Migne, J-P. (Ed.). 1857-1866. St. Gregory Nazianzen. *Patrologia Graeca* 37. Paris.

Millar, F. 1977. *The Emperor in the Roman World: 31 BC-AD 337*. Gerald Duckworth & Co., London.

Millar, F. 1992. The Jews of the Graeco-Roman Diaspora between Paganism and Christianity, AD 312-438. In J. Lieu, J. North, and T. Rajak (eds.), *The Jews among Pagans and Christians in the Roman Empire.* Routledge, London and New York: 97-123.

Monna, D. 1988. J. B. Ward-Perkins and the Marble Committee. In N. Herz and M. Waelkens (eds.), *Classical Marble: Geochemistry, Technology and Trade* (NATO ASI Series E: Applied Sciences 153). Dordrecht, 3–6.

Montesquieu, C. d. S. 1734. *Considerations sur les Causes de la Grandeur des Romains et de Leur Decadence.* Paris.

Moreno, J. L. 1934. *Who Shall Survive?* Beacon House, Beacon, NY.

Morrisson, C. 1976. *La dévaluation de la monnaie byzantine au XIe siècle: Essai d'interprétation*. De Boccard, Paris.

Morrisson, C. 1994. *Monnaie et finances à Byzance: analyses, techniques* (Vol. 461). Variorum Publishing, Farnham.

Morrisson, C. 2002. Byzantine Money: Its Production and Circulation. In A.E. Laiou (ed.), *The Economic History of Byzantium: from the Seventh Through the Fifteenth Century,* Dumbarton Oaks, Washington, D.C.

Morrisson, C. 2012a. *Trade and Markets in Byzantium*. Dumbarton Oaks Byzantine Symposia and Colloquia: Dumbarton Oaks Research Library and Collection, Washington, D.C.

Morrisson, C. 2012b. Weighing, Measuring, and Paying: Exchanges in the Market and the Marketplace. In C. Morrisson (ed.), *Trade and Markets in Byzantium.* Dumbarton Oaks Research Library and Collection, Washington, D.C.: 373-92.

Morrisson, C. and Sodini, J.-P. 2002. The sixth-century economy. In A. E. Laiou (ed.), *The Economic History of Byzantium*, *1*: 206-12.

Mullett, M. and Schor, A (Conveners). 2012. Colloquium: The Social Network in Byzantium and Its Neighbors. Dumbarton Oaks, Washington D.C., March 16–17, 2012.

Negev, A. 1988. *The Architecture of Mampsis, Final Report*. Vol. II: The Late Roman and Byzantine Periods. Qedem 27, Jerusalem.

Newman, M. E. J. 2003. The structure and function of complex networks. Phd. Thesis, Dept. of Physics, Univ. of Michigan, Ann Arbor, MI.

Niewöhner, P. 2013. Phrygian Marble and Stonemasonry as Markers of Regional Distinctiveness in Late Antiquity. In P. Thonemann (ed.), *Roman Phrygia: Culture and Society*. Cambridge Univ. Press, Cambridge: 215-248.

Niewöhner, P. 2014. Production and Distribution of Docimian Marble in the Theodosian Age. In I Jacobs (ed.), *Production and Prosperity in the Theodosian Period*. Interdisciplinary Studies in Ancient Culture and Religion 14.

Niewöhner, P. and Prochaska, W. 2011. Konstantinopolitanisches Formenrepertoire in Mazedonien. ZurBischof-skirche von Stobi und den Marmorbruchen von Prilep. *IstMitt* 61: 433–9.

North, D.C. and Thomas, R.P. 1973. *The Rise of the Western World: A New Economic History*. Cambridge Univ. Press, Cambridge.

North, D.C. 1981. *Structure and Change in Economic History,* Norton, London and New York.

North, D.C. 1990. *Institutions, Institutional Change and Economic Performance*. Cambridge Univ. Press, Cambridge.

North, D.C. 2006. *Understanding the Process of Economic Change*. Academic Foundation, New Delhi.

North, D.C., Wallis, J.J. and Weingast, B.R. 2009. *Violence and Social Orders: A Conceptual Framework for Interpreting Recorded Human History*. Cambridge Univ. Press, Cambridge.

Oikonomides, N. 1986. Silk Trade and Production in Byzantium from the Sixth to the Ninth Century: The Seals of Kommerkiarioi. Dumbarton Oaks Papers 40: 33–53.

ORBIS: The Stanford Geospatial Network Model of the Roman World. Accessible at http://www.orbis.stanford.edu.

Orlandos, A. 1954. *He xylostegos basilike tes Mesogeiakes Lekanes, Vol. II*. The Archaeological Society at Athens, Athens.

Ørsted, P. 1994. From Henchir Mettich to the Albertini Tablets: A Study in the Economic and Social Significance of the Roman Lease System (Locatio-conductio). In J. Carlsen, J. E. Skydsgaard, and P. Ørsted (eds.), *Land Use in the Roman Empire.* L'Erma di Bretschneider, Rome: 115-125.

Ørsted, P., Carlsen, J., Ladjmi Sebaï, L. and Ben Hassen, H. 2000. Africa Proconsularis. *Regional Studies in the Segermes valley of northern Tunisia III: Historical Conclusions (Copenhagen 2000)*.

Panella, C. 1986. Le merci: Produzione, Itinerati e Destini. In S. A. Giardina (ed.), *Ocieta Romana e Impero Tardoantico Vol. 3*: *Rome*. Rome.

Parker, A.J. 1992. *Ancient Shipwrecks of the Mediterranean and the Roman Provinces* (BAR International Series 580). Oxford Univ. Press, Oxford.

Patlagean, É. 1993. Byzance et les marchés du grand commerce vers 830–vers 1030: Entre Pirenne et Polanyi. In *Mercati e mercanti nell'alto medioevo: L'area Euroasiatica e l'area Mediterranea*. Settimane di studi del Centro italiano di studi sull'alto medioevo 40, Spoleto: 587–632.

Patlagean, É. 2004. Écrire l'histoire économique de Byzance: À propos d'un ouvrage recent. *Le Moyen Age* 110: 659–69.

Pensabene, P. 1978. A cargo of marble shipwrecked at Punta Scifo near Crotone (Italy). *International Journal of Nautical Archaeology*, *7*(2): 105-118.

Pensabene, P. 1992. The Method Used for Dressing the Columns of the Colosseum Portico. In M.Waelkens, N. Herz, and L. Moens (eds.), *Ancient Stones: Quarrying, Trade and Provenance, Acta Archaeologica Lovaniensia, Monographiae*, 4: 81-89.

Pensabene, P. 1994. *Le vie del marmo: i blocchi di cava di Roma e di Ostia, il fenomeno del marmo nella Roma antica*. Ministero per i beni culturali e ambientali, Soprintendenza archeologica di Ostia, Rome.

Pensabene, P. 1998a. *Marmi Antichi ii, Cave E Tecnica di Lavorazione Provenienza e Distribuzione*. L'Erma di Bretschneider, Rome: 333-390.

Pensabene, P.1998b. Nota Sugli Archi in Facciata Della Cappelle Funerarie Della Necropoli di el Bagawat nell'Oasi di Kharga. In N. Bonacasa, M. Casini, and A Utman (eds.), *The Culture of the Oasis from the Antiquity to the Modern Age*: El Kharga, 22-27 Oct. 1998. Istituto Italiano di Cultura del Cairo, Cairo: 85-104.

Pensabene, P. 2002a. Le principali cave di marmo bianco. In L. Ungaro and M. De Nuccio (eds.), *I marmi colorati della Roma imperiale* (catalogo mostra). Rome: 203-205.

Pensabene, P. 2002b. Inscribed Architectural Elements form the Prokonnesos in Durazzo, Tartous, Cilician Aphrodisias, and Caesarea. In J.J. Hermann, N. Herz, R. Newman (eds.), *ASMOSIA V, Interdisciplinary Studies on Ancient Stones: Proceedings of the Fifth International Conference of the Association for the Study of Marble and Other Stones in Antiquity*. Ashgate, London: 328-334.

Pensabene, P. and Lazzarini, L. 2007. *Ostiensium Marmorum Decus et Décor: Studi architettonici, decorativi e archeometrici*. L'Erma di Bretschneider 33*,* Rome.

Pentcheva, B.V. 2011. Hagia Sophia and multisensory aesthetics. *Gesta*, 50(2): 93-111.

Picon, M. 2008. Production Artisanale et Manufacturière à L'époque Romaine: À propos de L'Histoire Brisée d'Aldo Schiavon. In Y. Roman and J. Dalaison (eds.), *L'économie antique: Une économie de marché?* De Boccard, Paris*:* 191-214.

Pieri, D. 2012. Regional and Interregional Exchanges in the Eastern Mediterranean during the Byzantine Period: The Evidence of Amphorae. In C. Morrisson (ed.), *Trade and Markets in Byzantium*. Dumbarton Oaks Symposia and Colloquia 4. Harvard Univ. Press, Cambridge, MA: 27-50.

Pike, S., Herrmann Jnr, J. J.,and Herz, N. 2002. A Provenance Study of Calcitic Marble from the Archaeological Museum of Thessaloniki. In J. J. Herrmann, N. Herz, and R. Newman (eds.), *ASMOSIA V, Interdisciplinary Studies on Ancient Stone*. Ashgate, London: 263–73.

Pirenne, H. 1939. *Mohammed and Charlemagne* (Trans. Bernard Miall). Barnes and Noble, New York.

Pirenne, H., 2014. *Medieval cities: Their origins and the revival of trade*. Princeton Univ. Press, Princeton.

Polanyi, K. 1944. *The Great Transformation: The Political and Economic Origins of Our Time*. Farrar and Rinehart, New York.

Polanyi, K. 1977. *Livelihood of Man*. Academic Press, New York.

Polikreti, K. and Maniatis, Y. 2002. A new methodology for the provenance of marble based on EPR spectroscopy. *Archaeometry* 44: 1-21.

Preiser-Kapeller, J. 2012. *Luhmann in Byzantium: A Systems Theory Approach for Historical Network Analysis*. Conference Paper, The Connected Past, Southampton 2012 / 1.

Preiser-Kapeller, J. 2013. *Mapping maritime networks of Byzantium: Aims and prospects of the project "Ports and landing places at the Balkan coasts of the Byzantine Empire"*. Conference paper, "Olkas. From Aegean to the Black Sea. Medieval Ports in the Maritime Routes of the East", Thessaloniki, December 2013 (cf. http://www.olkas.net/com/9_Conference).

Pulak, C., Ingram, R. and Jones, M. 2014. The Shipwrecks at Yenikapı: Recent Research in Byzantine Shipbuilding. In D. N. Carlson, S. M. Kampbell, and J. Leidwanger (eds.), *Tradition and Transition: Maritime Studies in the Wake of the Byzantine Shipwreck at Yassıada, Turkey*. Proceedings of a Symposium Held at Texas AandM Univ. , November 2-4, 2007, College Station: Texas AandM Univ. Press.

Pulak, C., Ingram, R. and Jones, M. 2015. Eight Shipwrecks from the Theodosian Harbour Excavations at Yenikapı in Istanbul, Turkey: An Introduction. *International Journal of Nautical Archaeology* 44.1: 39-73.

Quilico, G. 1994. Contrepoids de Pressoirs a vis Retrouve Carthage. *CEDAC Carthage Bulletin* 14: 47–48.

Rautmann, M. 1996. Survey at Roman Akamas (western Cyprus). *Journal of Roman Archaeology* 9: 466.

Rautman, M.L. and McClellan, M.C. 1992. Excavations at Late Roman Kopetra (Cyprus). *Journal of Roman Archaeology* 5: 265-271.

Reynolds, P. 1995. *Trade in the Western Mediterranean, AD 400-700: The ceramic evidence.* BAR International Series 604. Archaeopress, London.

Robert, J and Robert, L. 1979. Bulletin epigraphique. *Revue des Etudes Grecques* 92: 548.

Roethlisberger, F. J. and Dickson, W. J. 1939. *Management and the Worker*. Harvard Univ. Press, Cambridge, MA.

Roll, I. and Ayalon, E. 1981. Two Large Wine Presses in the Red Soils Regions of Israel. *Palestine Exploration Quarterly London* 113(3-4):111-125.

Rollins, A.M. 1983. *The Fall of Rome: a Reference Guide*. McFarland, Jefferson, N.C..

Rosen, R. 2012. Plan a Trip Through History With ORBIS, a Google Maps for Ancient Rome. *The Atlantic,* May 23, 2012. Accessed at: http://www.theatlantic.com/technology/archive/2012/05/plan-a-trip-through-history-with-orbis-a-google-maps-for-ancient-rome/25755.

Rostovtzeff, M.I. 1926. *The Social and Economic History of the Roman Empire Vol. 1.* Biblo and Tannen, New York.

Roueché, C., Reynolds, J.M. and Erim, K.T. 1989. *Aphrodisias in late Antiquity*. Society for the promotion of Roman Studies, London.

Rougé, J. 1961. Quelques Aspects de la Navigation en Mediterranee au vers et dans la Premiere moitie du VIe s. *Cahiers Histoire* 6: 129–54.

Ruffini, G. 2008. *Social Networks in Byzantine Egypt*. Cambridge Univ. Press, Cambridge.

Runciman, S. 1933. *Byzantine Civilisation*. Arnold, London.

Russell, B. 2009: Lapis Transmarinus: Stone-Carrying Ships and the Maritime Distribution of Stone in the Roman Empire. In D.J. Robinson and A.I. Wilson (eds.), *Maritime Archaeology and Ancient Trade in the Mediterranean*. Proceedings of the 2008 OCMA Conference, Madrid. Oxford Centre for Maritime Archaeology Monographs, Oxford.

Russell, B. 2013a. Roman and Late-Antique Shipwrecks with Stone Cargoes: A new Inventory. *Journal of Roman Archaeology* 26: 331-361.

Russell, B. 2013b. *The Economics of the Roman Stone Trade*. Oxford Univ. Press, Oxford.

Russell, J. 1986. *Transformations in Early Byzantine Urban Life: The Contribution and Limitations of Archaeological Evidence*, The 17th International Byzantine Congress, Major Papers. New Rochelle, N.Y.

Sarantis, A. 2008. A.H.M Martin Jones (1904-1970). In D.M. Gwynn (ed.), *A.H.M. Jones and the Later Roman Empire*. Brill, Leiden.

Schaff, P. and Wace, H. (Ed. Trans). 1955. Eusebius, *Life of Constantine/Vita Constantini* LVIII*, Volume I, Nicene and Post-Nicene Fathers*, 2nd Series. Edinburgh: repr. Grand Rapids MI: Wm. B. Eerdmans. Downloaded from *The Internet Medieval Sourcebook*. http://legacy.fordham.edu/halsall/basis/vita-constantine.asp

Scheibelreiter-Gail, V. 2012. Inscriptions in the Late Antique Private House: Some Thoughts about their Function and Distribution. In S. Birk and B. Poulsen (eds.), *Patrons and Viewers in Late Antiquity.* Aarhus Univ. Press, Aarhus: 135 – 166.

Scheidel, W. 2013a. Explaining the Maritime Freight Charges in Diocletian's Price Edict. *Journal of Roman Archaeology* 26.

Scheidel, W. 2013b. *The shape of the Roman world.* Princeton-Stanford Working Paper 60.

Scheidel, W., Morris, I. and Saller, R.P. 2007. *The Cambridge Economic History of the Greco-Roman World.* Cambridge Univ. Press, Cambridge.

Schvoerer, M. 1999. *Archéomatériaux: marbres et autres roches. ASMOSIA IV*. Bordeaux.

Silver, M. 2003. Review of The Ancient Economy, edited by W. Scheidel and S. von Reden. *Economic History Services*, 3.

Sirks, A.J.B. 1991a. *Food for Rome: The Legal Structure of the Transportation and Processing of Supplies for The Imperial Distributions in Rome and Constantinople* (Vol. 31).

Sirks, A.J.B. 1991b. The Size of the Grain Distribution in Imperial Rome and Constantinople. *Athenaeum* 79: 215–37.

Smith, R.H. and L.R. Day. 1989. *Pella of the Decapolis* Vol. II: Final Report on the College of Wooster Excavations in Area IX, The Civic Complex, 1979-1985. Wooster, Ohio.

Sodini, J-P. 1979. L'artisanat Urbain a L´epoque Paleochretienne (IVe–VIIe s.), *Ktema* 4: 97-100.

Sodini, J.-P. 1989. Le Commerce des Marbres a l'Epoque Protobyzantine, in *Hommes et Richesses dans l'Empire Byzantin, I. IVe-VIIe Siècle*. P. Lethielleux, Paris: 163–186.

Sodini, J-P. 1993. La Contribution de L'archeologie a la Connaissance du Monde Byzantin (IVe–VIIe s.). *Dumbarton Oaks Papers* 47: 147 nn. 46–47.

Sodini J-P. 2002. Marble and Stoneworking in Byzantium, Seventh-Fifteenth Centuries, in A. Laiou (ed.), *The Economic History of Byzantium: From the Seventh through the Fifteenth Century.* Dumbarton Oaks Research Library and Collection, Washington, D.C.: 129-146.

Sodini, J-P. and Kolokotsas, K. 1984. Aliki II: La Basilique Double. École française d'Athènes.

Sodini, J-P., Lambraki, A. and Kozelj, T. 1980. *Les Carriers de Marbre a L'epoque Paleochretienne.* Paris.

Stein, E. 1949. *Histoire du Bas-Empire*. Desclée de Brouwer, Paris.

Strauss, J. 2013. *Shipwrecks Database*. Version 1.0. Accessible at: http://www.oxrep.classics.ox.ac.uk/databases/shipwrecks_database/

Sweetman, R. 2010. *The Knossos Medical Faculty Basilica in its Cretan context*, Proceedings of the 10th International Cretelogical Congress. Athens.

Tainter, A. 1988. *The Collapse of Complex Societies*. Cambridge Univ. Press, Cambridge.

Talbert, R.A. 2000. *Barrington Atlas of the Roman World.* Princeton Univ. Press, Princeton, N.J.

Tate, G. 1992. *Les campagnes de la Syrie du Nord, du IIe au VIIe siecle: Un exemple d'expansion de mographique et economique dans les campagnes a la fin de l'Antiquite,* Paris.

Temin, P. 2012. Byzantine Trade, Summary and Prospect. In C. Morrisson (ed.), *Trade and Markets in Byzantium.* Dumbarton Oaks Research Library and Collection, Washington, D.C.*:* 429-36.

Terry, A. 1988. *The Sculpture at the Cathedral of Eufrasius in Poreč*. Dumbarton Oaks Papers 42, 13-64.

Tsafrir Y. and Foerster, G. 1994. From Scythopolis to Baysan: Changing Concepts of Urbanism. In G.R.D. King and A. Cameron (eds.), *The Byzantine and Early Islamic Near East, vol. 2*, *Land Use and Settlement Patterns*. Princeton Univ. Press, Princeton, N.J.

Tsafrir, Y. 1996. Some Notes on the Settlement and Demography of Palestine in the Byzantine Period: The Archaeological Evidence. In J.D. Seger (ed.), *Retrieving the Past: Essays on Archaeological Research and Methodology in Honor of Gus W. Van Beck*. Winona Lake, USA.

Ulbert, T. 1989. Villes et fortifications de l'Euphrate a l'epoque Paleochretienne. In J.-M. Dentzer and W. Orthmann (eds.), *Archeologie et Histoire de la Syrie*. Saarbrucken, 2: 283–96.

Van Doornick, F. 2002. Byzantine Shipwrecks. In A. E. Laiou (ed.), *The Economic History of Byzantium: From the Seventh through the Fifteenth Century*. Dumbarton Oaks Research Library and Collection, Washington, D.C.

Veyne, P. 1976. *Le Pain et le Cirque: Sociologie Historique d'un Pluralisme Politique,* Seuil, Paris.

Voltaire. 1769. *Le Pyrrhonisme de L'histoire, par un Bachelier en Theologie*, Ch. 5.

Waelkens, M. 1982. Carrières de marbre en Phrygia. *Bulletin des Musées royaux de l'art et d'histoire:*33-35.

Waelkens, M. 1985. From a Phrygian quarry: the provenance of the statues of the Dacian prisoners in Trajan's Forum at Rome. *American Journal of Archaeology*: 641-653.

Waelkens, M., 1993. Sagalassos. History and archaeology. *Acta Archaeologica Lovaniensia Monographiae* 5:37-82.

Waelkens, M., De Paepe, P. and Moens, L. 1988. Quarries and the Marble Trade in Antiquity, in N. Herz and M. Waelkens (eds.), *Classical Marble: Geochemistry, Technology, Trade*. Kluwer Academic Publishers, Dordrecht, Boston, London:11–28.

Waelkens, M., Herz, N., and Moens, J.-L. (eds.). 1992. *Ancient Stones: Quarrying, Trade and Provenance*. Acta Archaeologica Lovaniensia, Monographiae 4, Leuven.

Walker, S. 1988. From West to East: Evidence for a Shift in the Balance of Trade in White Marbles. In N. Herz and M. Waelkens (eds.), *Classical Marble: Geochemistry, Technology, Trade.* Kluwer Academic Publishers, Dordrecht, Boston, London: 187–195.

Wallace-Hadrill, A. 2008, *Rome's Cultural Revolution*. Cambridge Univ. Press, Cambridge.

Ward, P. 1970. *Sabratha. A Guide for Visitors*. Oleander Press, Harrow.

Ward-Perkins, B. and Dodge, H. (Eds.). 1992. *Marble in Antiquity: Collected Papers of J.B. Ward-Perkins*. Archaeological Monographs of the British School at Rome 6. British School at Rome, London.

Ward-Perkins, J.B. 1951. Tripolitania and the Marble Trade. *Journal of Roman Studies* 41: 89-104.

Ward-Perkins, J. B. 1971a. Quarries and Stoneworking in the Early Middle Ages: The Heritage of the Ancient World. *Settimane di Studio del Centro Italino di Studi sull' Alto Medievo XVIII Spoleto 2–8 Aprile 1970*. Spoleto: Centro Italiano di Studi sull' Alto Medievo, 525–44.

Ward-Perkins, J.B. 1971b. Quarrying in Antiquity: Technology, Tradition and Social change. *Proceedings of the British Academy* 57: 137–58.

Ward-Perkins, J.B. 1980. Nicomedia and the marble trade. *Papers of the British School at Rome 48*: 23-69.

Ward-Perkins, J.B. 1992. The Trade in Sarcophagi (Third Shuffrey Lecture). In B. Ward-Perkins and H. Dodge (eds.), *Marble in Antiquity: Collected Papers of J.B. Ward-Perkins*. Archaeological Monographs of the British School at Rome 6. British school at Rome, London.

Whitby, L.M. 1986. Procopius's Description of Dara (Buildings 2.1–3). In P. Freeman and D. Kennedy (eds.), *The Defence of the Roman and Byzantine East*. Oxford Univ. Press, Oxford: 737–83.

Whittaker, C.R. 1983. Late Roman Trade and Traders. In P. Garnsey, K. Hopkins, and C.R. Whittaker (eds.), *Trade in the Ancient Economy*. Univ. of California Press, Berkeley: 163–168.

Wickham, C. 2010. *The Inheritance of Rome: Illuminating the Dark Ages 400-1000.* Penguin Books, London.

Worstall, T. 2012. Roman Travel Speeds: An Excellent New Toy. *Forbes*, May 17, 2012. Accessed at http://www.forbes.com/sites/timworstall/2012/05/17/roman-travel-speeds-an-excellent-new-toy/.

Wozniak, F.E. 1988. The Justinianic Fortification in the Interior Illyricum. In R.L. Hohlfelder (ed.), *City, Town, and Countryside in the Early Byzantine Era*. East European Monographs, New York.

Wurch- Koželj, M. 1988. Methods of Transporing Blocks in Antiquity. In N. Herz and M. Waelkens (eds.), *Classical Marble: Geochemistry, Technology, Trade.* Kluwer Academic Publishers, Dordrecht, Boston, London: 55–64.

Zanini, E. 1990. La Cinta Muraria di Dara: Materiali per un'analisi stratigrafica. *Milion* 2: 229–64.

Zuckerman, C. and Gascou, J. 2004. *Du village à l'empire: autour du registre fiscal d'Aphroditô (525/526)*. Association des amis du Centre d'histoire et civilisation de Byzance, Paris.