Building Big and Greek Classical and Hellenistic Houses? Estimating Total Costs of Private Housing in Attica

Jari Pakkanen

Introduction

This paper uses different types of source materials to estimate the construction costs of private housing in late Classical and early Hellenistic Attica. The reconstructed city blocks and houses of the Piraeus are the basis of the first case study and data from the new fieldwork project on the island of Salamis supplements previously published data of the second one[1] (fig. 1). The ancient urban remains at Athens and the rest of Attica are mostly covered by dense modern blocks, so the archaeological data from Salamis is important. The insulae in the Piraeus follow a strict rectangular plan, so the limited extent of the excavated remains is sufficient for a reliable reconstruction of a typical block and the city grid, and probably also the employed design unit.[2] Archaeological data, building accounts, other ancient textual sources and modern ethnographical data are the most important categories of evidence for estimating the volumes of different materials and how much energy was required to build private houses in ancient Greece.[3] The cost of constructing an individual house was small but the total private expenditure can be shown to have been substantial. A model of how to estimate the total cost of building materials and construction process of private ancient houses at Athens and Attica is presented in the chapter.

Econometric analyses of *monumental* Greek architecture have one major advantage over most other building types and construction projects outside the sphere of the Hellenic world: most of the public construction programmes have left some trace in the archaeological record; also, due to the employed materials and conservative designs by Greek architects, very limited number of preserved architectural fragments can result in sufficiently reliable reconstructions to estimate used building resources.[4] The picture we have of private residences could be viewed as quite the opposite. With the exception of stone foundations, the houses were very often built of materials which have now entirely disappeared: the mudbrick walls and flat clay roofs quickly dissolved and wooden beams rotted after they were no longer maintained, and even before that everything recyclable had already been removed. The pitched roofs were covered by large durable terracotta rooftiles, but since they were valuable, only broken fragments were often left at the sites after abandonment. However, the excavated stone foundations and tile fragments give the most important variables in the analysis of total costs of private residences: the size of the rooms and the house and the material used for the roof. Also, an estimation of the built-up and habited area of the town inside the city walls is a significant factor in calculating the total costs of residential building in ancient cities.[5] The cost estimates in this paper are expressed in terms of ten-hour man-days.[6] The prices known from

Published in: Jari Pakkanen – Ann Brysbaert (Eds.), Building BIG – Constructing Economies: from Design to Long-Term Impact of Large-Scale Building Projects, Panel 3.6, Archaeology and Economy in the Ancient World 10 (Heidelberg, Propylaeum 2021) 59–75.
DOI: *https://doi.org/10.11588/propylaeum.850.c10936*

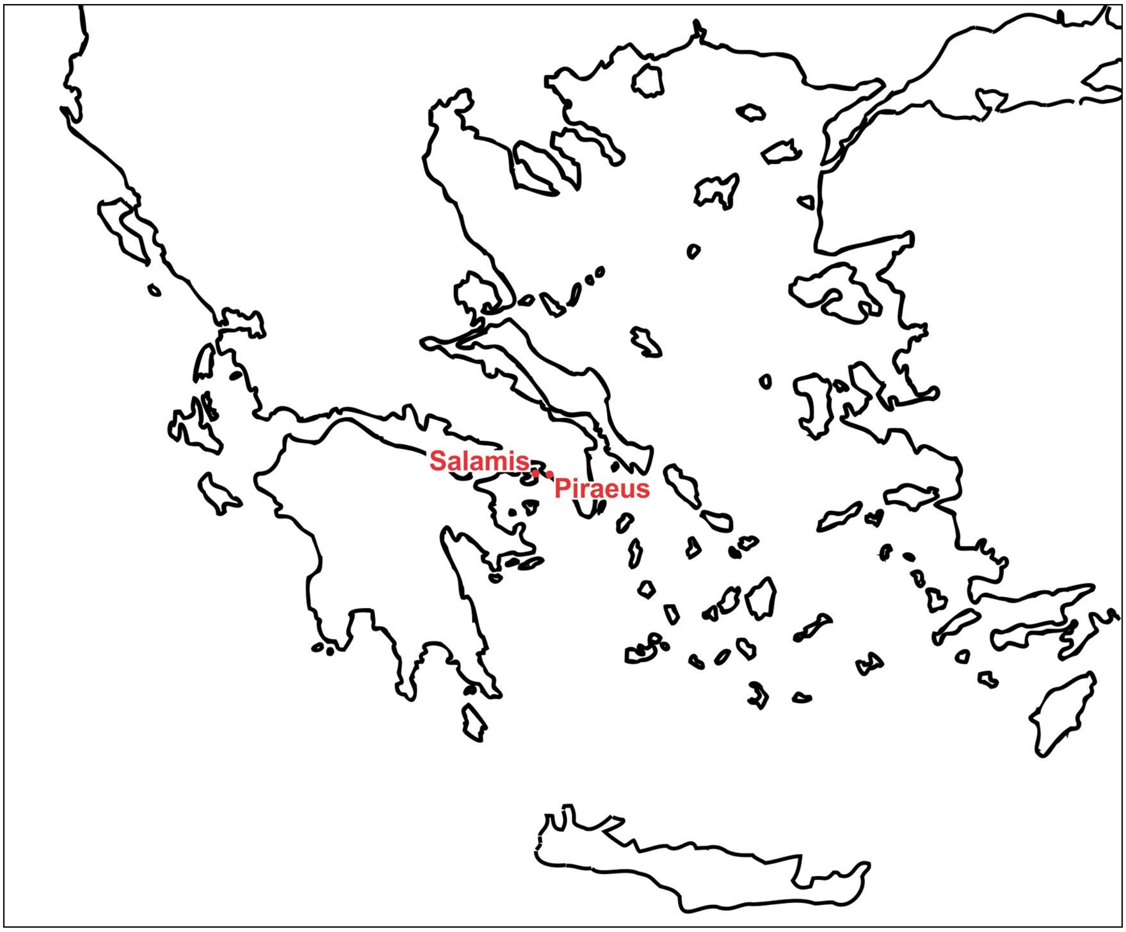

Fig. 1: Map of Greece with discussed sites indicated.

Greek inscriptions can approximately be translated into man-days by using for the fifth-century a day-wage of one drachma and for the fourth-century two drachmas a day.[7]

Econometric approaches to ancient building can be criticised for the impossibility of reaching precise figures for estimating the 'true' costs of construction projects.[8] However, it is more fruitful to compare labour cost analyses to a 'Fermi question' in physics: it is often constructive to give an approximate estimation for a quantity, which cannot be measured directly or which is very difficult to measure.[9] This approach emphasises the process how these questions can be tackled in different ways and also facilitates evaluating whether a significant amount of further research to reach a more precise estimate could conceivably give new results. It is important to keep the calculations transparent: they do not have to clutter the main text, but they should be presented in the footnotes, tables or appendices. It is not possible to arrive at an exact or 'correct' answer, so keeping in mind the number of significant digits, just as in physics, is important.[10] For example, unrounded figures should be used in the calculations and rounding can then take place at the end of the process. For example, Hurst gives in

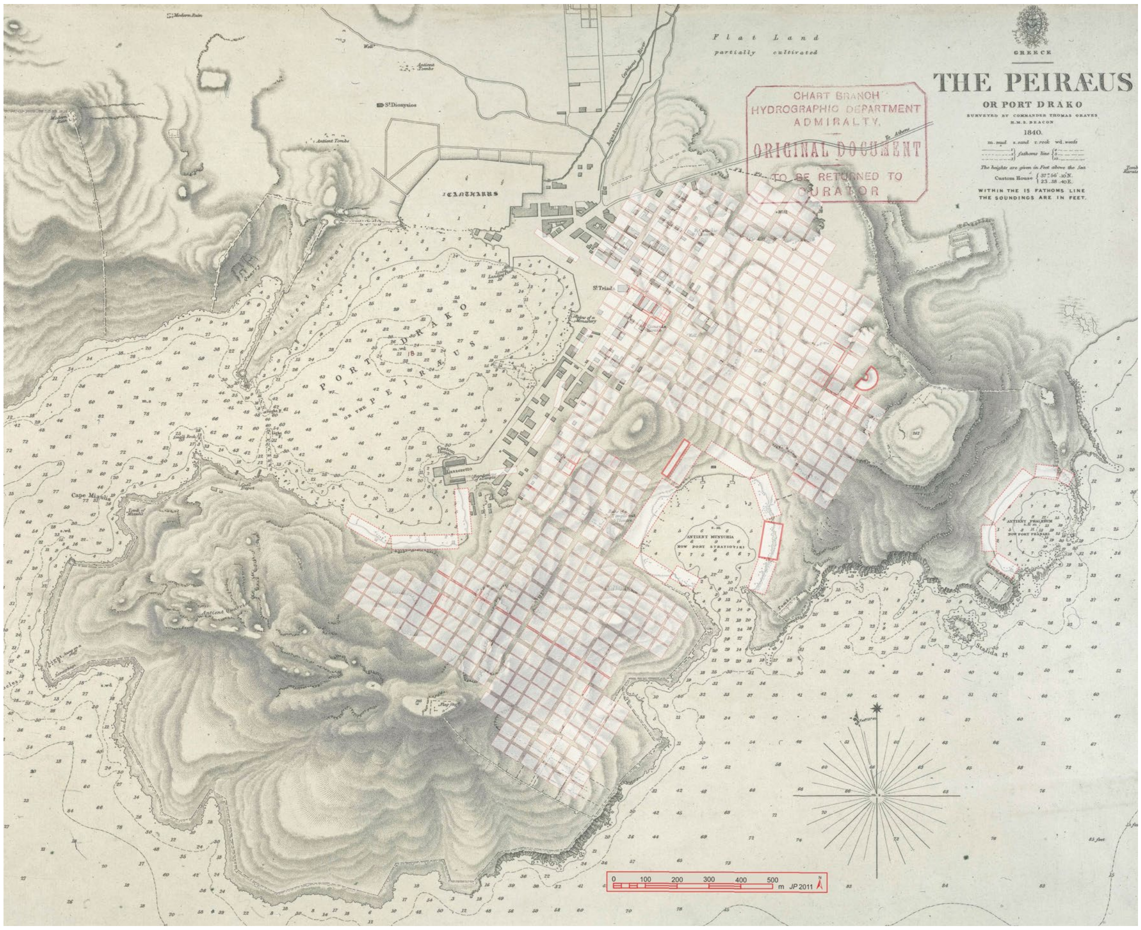

Fig. 2: The Piraeus. New reconstruction of the fourth-century city grid superimposed on top of Graves 1843.

his architectural handbook an estimate that a labourer can excavate a cubic yard of earth mixed with gravel in 1.5 hours,[11] which can be translated to ca. 0.196 man-days per cubic metre, assuming a ten-hour working day. Based on Hurst's figure, the labour constant could be rounded either to one or two significant digits, so 0.2 or 0.20 md/m^3. In this paper, I have systematically followed the procedure of using the precise figures in multiplications and then at the end rounding the results. In the tables the intermediary results are rounded to the nearest full man-day.

City Blocks and Houses in the Piraeus

After the victory over the Persians in 479 BC, the fortifications of Athens and the Piraeus were quickly built[12] and the Piraeus with its three natural harbours was developed as an outport of Athens. Hippodamos of Miletos designed the grid plan of the new town, most

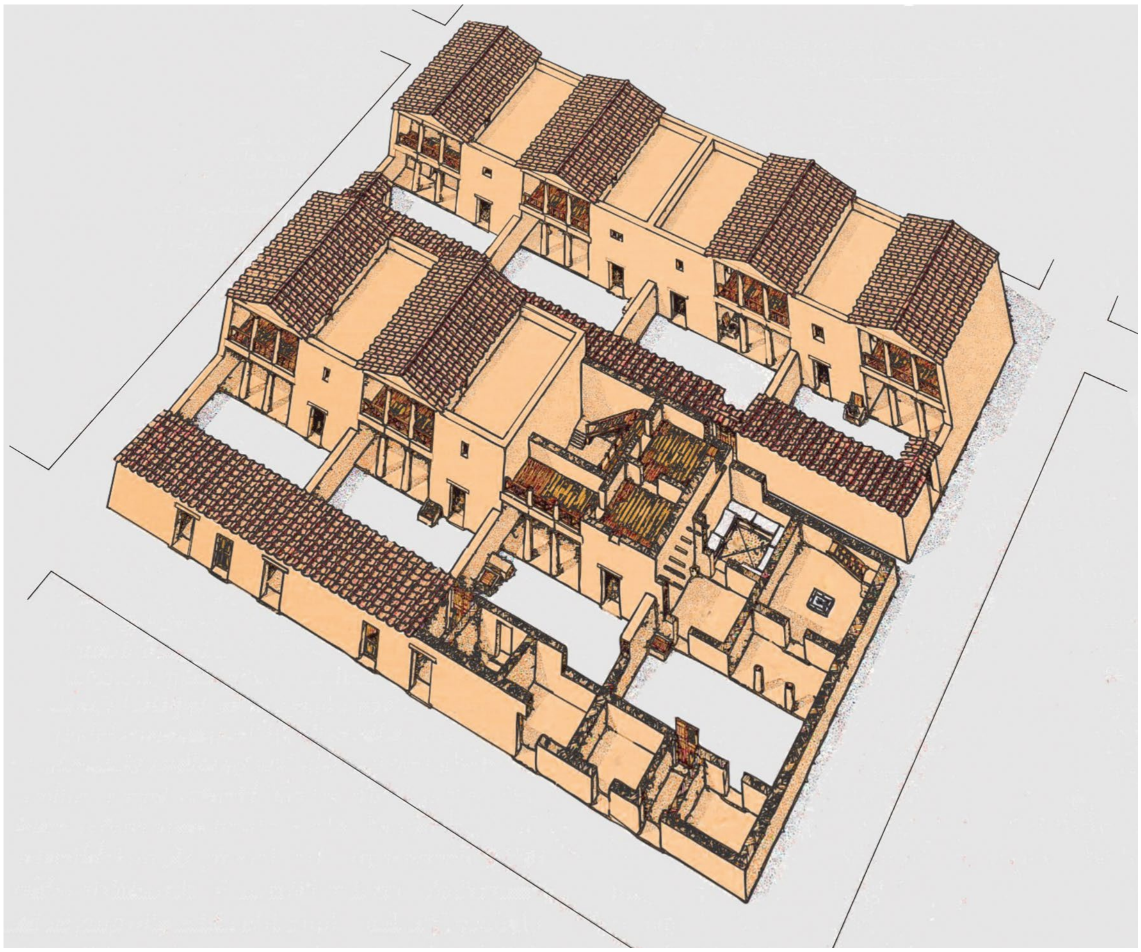

Fig. 3: The Piraeus. Perspective reconstruction of a city block.

likely in the years following the Persian Wars.[13] The ancient city is entirely covered by the modern urban development so that only the shape of the peninsula and the harbour basins are currently visible. However, the excavations of the Classical street grid and house plans have since 19th century brought to light enough details to reconstruct the city grid.[14] Graves's admiralty chart gives the best idea of the town topography before modern building started changing its outline.[15] Graves surveyed the Piraeus in 1840 and he recorded all visible features of the landscape including the ancient remains.

The reconstruction of the city blocks and the features of the harbours in fig. 2 are in many places hypothetical, but Graves' chart gives a better starting point for placing the archaeological features than later city plans of the Piraeus.[16] The solid red lines in fig. 2 superimposed on the chart indicate excavated structures and streets.

The econometric calculations of the cost of building a house in the Piraeus is based on Hoepfner and Schwandner's *Typenhaus* (fig. 3; table 1). They argue that there is enough

A1. Excavating the foundation trenches 3 md Volume: depth 0.25 m, width 0.60 m, total length of trenches 90.2 m = 13.5 m^3 Soil used for lifting the floor levels, no transport Digging and throwing behind: 0.196 md/m^3 (Hurst 1902, 376) 2.65 man-days, supervision (10%) 0.26 md
A2. Excavating a cistern 2 md Volume: 3.9 m^3 Quarrying rubble limestone (meteogene travertine): 0.250 md/m3 (DeLaine 1997, 111) 1.96 man-days, supervision (10%) 0.20 md
A3. Stone rubble foundations 47 md Volume: height 0.50 m, width 0.55 m, total length 78.6 m (excluding door openings) = 21.6 m^3 (2.6 tonnes/m3; Kidder-Parker 1946, 1924) Quarrying rubble (as above): 0.250 md/m^3 4.61 man-days (cistern volume subtracted), supervision (10%) 0.46 md Loading & unloading: 0.396 md/m^3 (Pakkanen 2013b, 63, esp. n. 55) 7.01 man-days (cistern volume subtracted), supervision (10%) 0.70 md Carting 500 m: 0.75 md/tonne/km (Pakkanen 2013b, 62–63, esp. nn. 45, 55) 17.26 man-days (cistern volume subtracted), supervision (10%) 1.73 md Construction of rubble foundations: 0.629 md/m^3 (half skilled; Hurst 1902, 381) 13.59 man-days (cistern volume included), supervision (10%) 1.36 md
A4. Stone threshold blocks 22 md In an insula of 8 houses: 27 large (2.0 × 0.9 × 0.3 m) & 26 small (1.5 × 0.6 × 0.3) blocks Average volume per house: 2.7 m^3 Quarrying limestone blocks in the Piraeus: 2.0 md/m^3 (Pakkanen 2013b, 64–65) 5.40 man-days, supervision (10%) 0.54 md Loading & unloading: 0.396 md/m^3 (as above in A3) 1.07 man-days, supervision (10%) 0.11 md Carting 500 mm: 0.75 md/tonne/km 2.63 man-days, supervision (10%) 0.26 md Finishing: 4.0 md/m^3 (Pakkanen 2013b, 65, esp. n. 81) 10.80 man-days, supervision (10%) 1.08 md
A5. Mudbrick walls 248 md Total floor height 3.0 m, total height to apex of pediment 6.8 m Volume of mudbrick in walls 192.1 m^3 (door openings subtracted) Price per cubic meter including transport in man-days: 0.853 md/m^3 163.87 man-days Construction of mudbrick walls: 0.4 md/m^3 (Devolder 2005, 169) 76.83 man-days, supervision (10%) 7.68 md
A6. Timber and doors 177 md Doors, door frames, posts, steps, floors, timbers for flat & tiled roofs Doors (numbers for the 8-house insula): 13 double doors: 20 dr per double door (Pritchett – Pippin 1956, 238), 16.25 md per house 63 single doors: 10 dr per door, 39.38 md per house Door frames: 27 × 2.0 m (width) + 26 × 1.5 m (width) Each frame would have needed 3 pieces of 10–14 footers priced at 3.667 dr (Clark 1993, 247–249), no construction or sawing costs due to extra material, 36.44 md per house Posts + beams (architraves): 8 × 4 × 3.667 = 117.344 dr; beams 8 × 2 × 3.667 = 58.672 dr, so 11.00 md per house Steps: one 14-footer cut into 3 planks, third plank cut into steps Sawing: 0.143 md/m2 (Pakkanen 2013b, 62, esp. n. 50) 2 cuts of 0.3 m × 4.2 m + construction 1 md, so 3.19 md per house Floors: 14 beams for the floor above anteroom & andron: 14 feet not enough, so price 5 dr per piece; 4 timbers sawn lengthwise into 16 beams; anteroom: one 10-footer sawn into 4 beams, 15.76 md per house (includes construction, 2 md) Planks for floors: 61.8 m2, 23.44 md per house Tiled roof above shops: 15 rafters of 5.2 m needed, from one 16-footer 9 rafters, 7.28 md per house (includes construction 0.5 md) Flat roof: similar to first part of constructing floors, 14.65 md per house (includes 3 md for construction; also reeds & clay included) Ridged roof: ridge timbers, one 10-footer, one 22-footer, 9.53 md per house (includes 3 md for construction)
A7. Roof tiles 119 md Recorded price of a pair of Laconian roof tiles in late 4^{th} c: 4 ob. (so 1/6 md per tile) Ridged roofs: 180 pantiles, 170 covertiles Inclining roofs: 153 pantiles, 144 covertiles 107.80 man days Setting the roof tiles: 15.2 m^2/md (Pakkanen 2013b, 70, esp. n. 128) 9.88 man-days, supervision (10%) 0.99 md

Table 1: The Piraeus. Cost averages for a single house in an eight-house insula based on the reconstruction of a ‘modular’ house by Hoepfner and Schwandner.

evidence from the Piraeus that the houses were built on plots of equal size and had a similar ground plan with limited range of variation.[17] Because of modern construction the extent of archaeological evidence is limited, but what has been uncovered is consistent with an interpretation of high degree of uniformity.[18] Each city block very likely had eight house plots and the total number of city blocks in the reconstruction is 472.

Layout of the Town Plan and Houses at Salamis

Based on the new survey of the excavated areas of the town and the geophysical prospection carried out in 2016–2018 the street network at Salamis is orthogonal but the sizes of the city blocks are not uniform (fig. 4). Archaeological remains could be detected in nearly all the surveyed areas inside the city walls. The limited areas of previously excavated remains of the ancient town have very recently received a thorough evaluation by Chairetakis.[19] The city walls are partially preserved on three sides of the town but the extent of the built area on the south side and in the submerged parts can only be estimated. The area covered by housing inside the walls was most likely 60–80 per cent. The single so far entirely excavated house, *Oikia Theta* (fig. 5), forms the basis of the figures presented in table 2. It is dated to the early Hellenistic period but it is built on top of an Archaic house.[20]

Cost Estimates of Houses in the Piraeus and at Salamis

The analysis presented here includes a partial departure from estimating the minimum costs used in analyses of large monumental building projects:[21] an individual constructing a private house in the Piraeus and at Salamis very likely had to resort to buying more of the materials such as mudbricks, timber and rooftiles than the official Athenian building programmes, which could have relied on the continuity, scale and infrastructure of the *polis* projects. Therefore, for several cost categories inscriptional evidence of the 'market' prices of these commodities in Attica has been used instead of estimating the minimum costs.[22] The private individuals are also likely to have been involved themselves in the construction.[23] In the presented calculations skilled and unskilled work is not separated to reduce the complexity of the tables.

The detailed estimates of the cost in man-days of a single Hoepfner and Schwandner *Typenhaus* in the Piraeus is presented in table 1 and *Oikia Theta* at Salamis in table 2. The tables give the detailed cost calculations and references. The results are summarised in table 3. I have recently analysed most of the construction cost categories in Attica in the context of econometric assessment of the shipshed complexes in the Piraeus.[24] However, the cost of mudbrick walls and rooftiles in private houses require an additional discussion here.

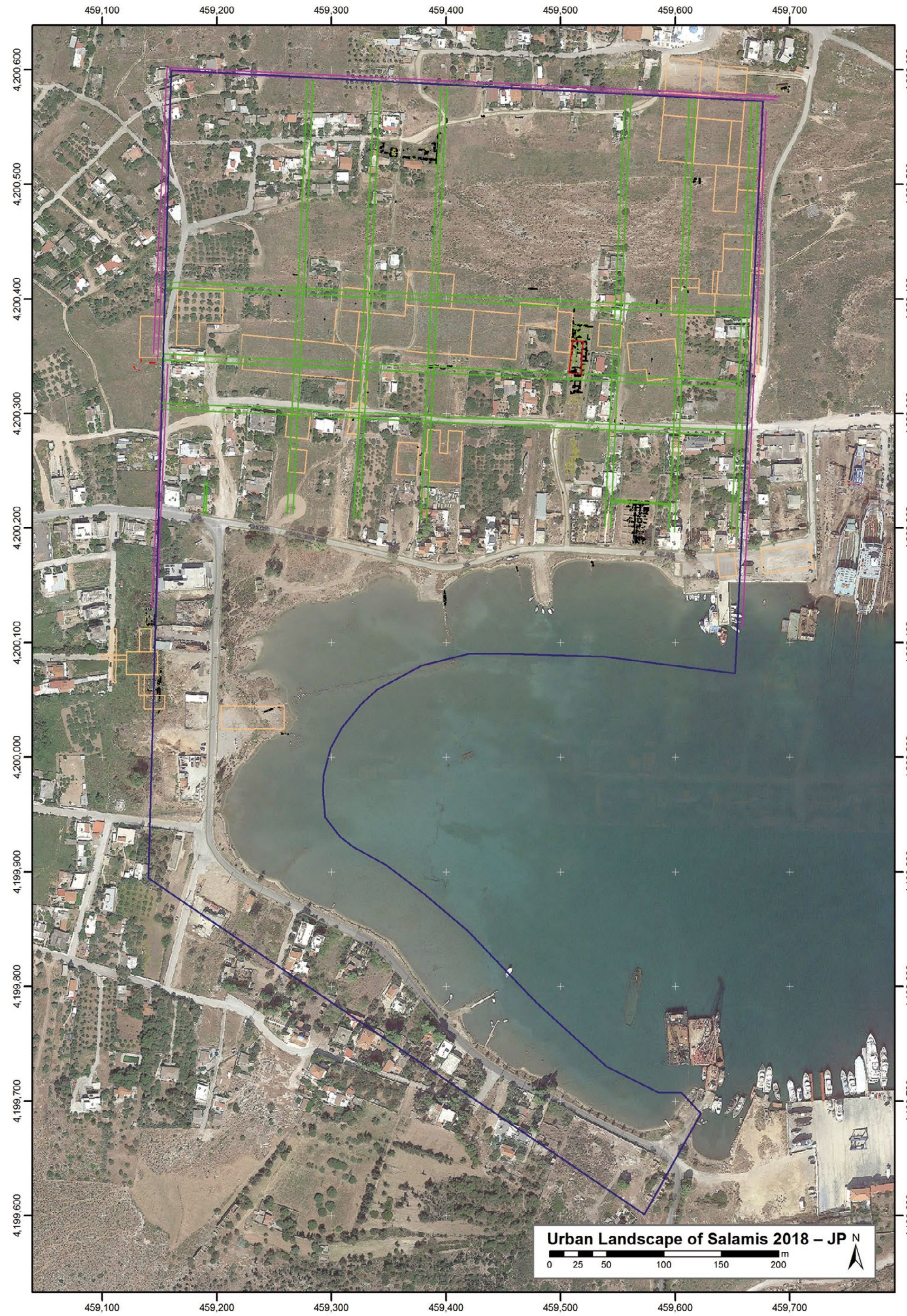

Fig. 4: Salamis. Reconstruction of the probable extent of the area of the ancient town at Ambelakia based on past excavations and new fieldwork 2016–2018. Total station survey data and reconstruction superimposed on top of Google Earth satellite image. Orange = GPR survey areas; green = reconstructed grid; red = *Oikia Theta*.

Fig. 5: Salamis, *Oikia Theta*. Total station survey of 2018 superimposed on the 2016 aerial orthomosaic of the excavated area.

B1. Excavating the foundation trenches 3 md Volume: depth 0.25 m, width 0.50 m, total length of trenches 117 m = 14.6 m^3 Soil used for lifting the floor levels, no transport Digging and throwing behind: 0.196 md/m^3 2.86 man-days, supervision (10%) 0.29 md
B2. Excavating a cistern 2 md Volume: 3.9 m^3 Quarrying rubble limestone (meteogene travertine): 0.250 md/m^3 1.96 man-days, supervision (10%) 0.20 md
B3. Stone rubble foundations 52 md Volume: height 0.50 m (measured 0.4–0.6 m), width 0.45 m, total length 105.6 m (excl. door openings) = 23.8 m^3 Quarrying rubble (as above): 0.250 md/m^3 4.96 man-days (cistern volume subtracted), supervision (10%) 0.50 md Loading & unloading: 0.396 md/m^3 7.85 man-days (cistern volume subtracted), supervision (10%) 0.79 md Carting 500 m: 0.75 md/tonne/km 19.34 man-days (cistern volume subtracted), supervision (10%) 1.93 md Construction of rubble foundations: 0.629 md/m^3 14.95 man-days (cistern volume included), supervision (10%) 1.49 md
B4. Stone threshold block 4 md One large threshold block (others of timber): volume: 0.54 m^3 Quarrying: 2.0 md/m^3 1.08 man-days, supervision (10%) 0.11 md Loading & unloading: 0.396 md/m^3 (as above) 0.21 man-days, supervision (10%) 0.02 md Carting 500 mm: 0.75 md/tonne/km 0.53 man-days, supervision (10%) 0.05 md Finishing: 4.0 md/m^3 2.16 man-days, supervision (10%) 0.22 md
B5. Mudbrick walls 136 md Floor height 3.25 m (inwards sloping roofs, no pediments, average height) Volume of mudbrick in walls: 104.9 m^3 (door openings subtracted) Price per cubic meter including transport in man-days: 0.853 md/m^3 89.51 man-days Construction of mudbrick walls: 0.4 md/m^3 (Devolder 2005, 169) 41.96 man-days, supervision (10%) 4.20 md
B6. Timber and doors 112 md (with 75% tiled roof); 149 md (with flat roof) Doors, door frames, timber thresholds, timbers for flat & tiled roofs Doors: 1 main entrance, 6 interior doors 1 double door: 20 dr = 10.00 man-days 6 single doors: 10 dr per door = 30.00 md Door frames: 1 × 2.0 m (width) + 6 × 1.5 m (width) Each frame would have needed 3 pieces of 10–14 footers No construction or sawing costs due to extra material, 38.50 md Small timber thresholds: 6 thresholds of 1.5 m × 0.6 m × 0.3 m 6 pieces of 10–14 footers No construction or sawing costs due to extra material, 11.00 md Beam (architrave): 1 × 3.667 dr (opening next to dining room), 1.83 md Tiled roofs above E & S parts: 13 + 32 rafters of 5.2 m needed, from one 16-footer 9 rafters, so 5 of them, 5.96 md (includes construction 1.5 md & sawing) Flat roof above NE part of house: 4 timbers of 4.5 m sawn into 16 beams, 14.54 md (includes construction 3 md; reeds & clay) Alternative of a flat roof above the whole house (area 4 times NE part) Cost of tiled roof rafters subtracted + additional area of flat roof: -5.96 md + 3 × 14.54 md = 37.66 md
B7. Roof tiles 154 md Price 4 ob. per pair of Laconian tiles Tiled roof: 459 pantiles, 387 covertiles 141.00 md Setting the roof tiles: 15.2 m2/md 11.50 man-days, supervision (10%) 1.15 md

Table 2: Salamis. Cost estimate of constructing *Oikia Theta* (275–250 BC).

An inscription from Eleusis gives the price of 1000 mudbricks including transport as 38 dr. in 329/8 BC.[25] Since the size of standard mudbricks at Eleusis is known from excavations,[26] the cost can be calculated as 0.853 md/m^3. This price would have included extraction of clay, production and drying of the bricks and their transport to the building site. Comparison with modern scholarship indicates that the market price at Eleusis was quite well in line with the probable production costs.[27]

	The Piraeus (plot size ca. 240 m², total floor area ca. 340 m²)	Salamis with 75% tiled roof (plot and floor area ca. 280 m²)	Salamis with flat roof (plot and floor area ca. 280 m²)
C1. Excavating the foundations	3 man-days	3 man-days	3 man-days
C2. Excavating a cistern:	2 man-days	2 man-days	2 man-days
C3. Stone rubble foundations			
quarrying:	5 man-days	5 man-days	5 man-days
transport:	27 man-days	30 man-days	30 man-days
construction:	15 man-days	16 man-days	16 man-days
C4. Stone threshold blocks			
quarrying:	6 man-days	1 man-day	1 man-day
transport:	4 man-days	1 man-day	1 man-day
finishing:	12 man-days	2 man-days	2 man-days
C5. Mudbrick walls			
material & transport:	164 man-days	90 man-days	90 man-days
construction:	85 man-days	46 man-days	46 man-days
C6. Timbers, including the cost of construction	177 man-days	112 man-days	149 man-days
C7. Rooftiles			
material:	108 man-days	141 man-days	
construction:	11 man-days	13 man-days	
Totals	ca. 620 man-days	ca. 460 man-days	ca. 350 man-days
Converted to 4th-c. day wage 2 dr.	ca. 1,200 dr.	ca. 900 dr.	ca. 700 dr.
Cost per m² of floor area	ca. 1.8 md/m²	ca. 1.7 md/m²	ca. 1.2 md/m²
In the Piraeus estimated 472 city blocks of 8 houses: Total cost ca. 2.3 million man-days or ca. 780 Talents (day wage of 2 dr)			
Cost estimate ranges for Salamis 60-80% coverage inside city walls: 80–110 Talents if all built with flat roof; 110–150 Talents with tiled roof			

Table 3: Comparison of costs of private houses in the Piraeus and at Salamis.

The type of rooftiles used in the Piraeus and at Salamis for private houses would have most likely been simple Laconian tiles with a large concave pan-tile and narrower convex cover-tile.[28] Fourth- and third-century inscriptional evidence points towards a price of four obols for a pair of tiles.[29] This is only one third of the typical cost of more complex Corinthian tiles used in monumental buildings.[30] Interestingly, the minimum production cost of a pair of Corinthian tiles would have been less than two obols calculated in fourth-century prices.[31] The difference between the sale price of approximately two drachmas for the pair and the low manufacturing costs is most likely explained by the profits made by the craftsmen and the risk of breakage of large ceramic tiles in production and transport.

Conclusions

Based on table 3, it can be argued that the mudbricks, timbers and rooftiles formed the main cost categories of building a private house. Production of mudbricks could have been carried out by the owner of the house to drive down the cost: it did not require any special expertise but a large open space would have been needed. After the initial phases of construction, it is unlikely that such a space would have been available for all households at a reasonable distance from the Piraeus, though that is more likely in the case of Salamis. Both the Piraeus and Salamis were built on limestone promontories with easy access to rubble and ashlar blocks for construction, so the cost of stone for the rubble foundations and threshold blocks would have been reasonable. The households had few alternatives to buying the needed timbers at market prices. The greatest opportunity for saving costs would have been in the choice of roof material: a flat clay roof would have required annual maintenance to keep it water resistant, but its material and construction costs were a fragment of buying rooftiles at the recorded Attic prices.

The total cost of a single storey house with a flat roof would have been approximately the same as an annual salary of a craftsman, which is quite reasonable. If the owner could not afford to have a tiled roof from the beginning, the houses could have been upgraded later. The more complex house in the Piraeus with two storeys on the northern side of the plot would have been considerably more expensive but it also utilised the available space more efficiently than at Salamis. Despite the smaller plot in the Piraeus, due to having two storeys in the main part, the total area of usable space is slightly larger than at Salamis (ca. 340 and ca. 280 sq. m.). The construction costs of the three options per square metre of floor area are presented in table 3. The greatest difference in the total price of a house in the Piraeus and at Salamis was made by the choice of either using a pitched roof with tiles or a flat clay roof.

Pritchett and Pippin have collected the epigraphical and literary evidence for house prices in Classical Attica. In the sales lists the fourth-century prices for a private house, *oikia*, varies between 145–575 dr. and the only recorded price of a tenement house, *synoikia*, is 3705 ⅓ dr.; in the speeches of Attic orators the price range for an *oikia* is 300–5000 dr. and the two cases of a *synoikia* 1600 and 10000 dr.[32] Based on the cost of materials and constructions costs (tables 1–3) it is quite probable that sums related by the orators include in most cases the price of the plot and not only the house. The relatively low sums of the realised sales could be explained by the unusual circumstances of the sales of confiscated properties. Occasional underestimation of the importance of a house as part of personal assets[33] might be due to fact that it is difficult to gain a full understanding of the overall importance and scale of the domestic architecture and construction[34] – the literary sources are able to paint only one part of the picture, but an econometric assessment can fill in the gaps by combining the information from both archaeological and inscriptional sources.

The cost estimates explain also why Athenians considered the window shutters, doors and rooftiles of the private properties as movable property: they were expensive and transportable, so they could be taken by the tenant when moving house and evacuated from farm houses when there was a risk of plundering during campaigns of war.[35] Razing of a private house, *kataskaphe*, was in some cases used as a punishment for a crime in Archaic and Classical Greece.[36] This chapter gives the practice an economic context in addition to its legal and symbolic one. The analyses presented here also highlight the risks of partial econometric calculations using, for example, only the cost of stone to estimate the total labour and material expenditure involved in monumental and private construction.[37]

The number of metic households in the fourth century has been estimated as 10,000 in Attica and most of these would have been in the Piraeus.[38] In order to accommodate this number, most of the house plots would have been shared between several families (*synoikiai*): the reconstructed plan has space allocated for 3776 plots (fig. 2). I have calculated the total cost of private houses in the Piraeus as 2.3 million man-days or ca. 800 talents and at Salamis in the region of 100 talents using the inflated day wage of two drachmas per day (table 3). This could be contrasted with the approximate fifth-century prices of 500 talents for the Parthenon[39] and 200 talents for 300 shipsheds in the Piraeus,[40] both calculated using the day wage of one drachma per day. Even though these sums are impressive, the costs of private and public construction projects can be set into perspective by keeping in mind the level of Athenian income and expenditure in the Classical period: for example, Xenophon gives the annual fifth-century Athenian income from the Delian league as 1000 talents,[41] and 200 talents would have been able to pay the wages of the rowers of 100 triremes only for a month or a little more.[42]

Acknowledgements

The project at Salamis has been funded by generous private donations from Finland to the Foundation of the Finnish Institute at Athens. The collaboration between the Ephorate of Antiquities of West Attica, Piraeus and the Islands and the Finnish Institute is directed by Jari Pakkanen and Stella Chrisoulaki. The geophysical prospection has been conducted under the direction of Apostolos Sarris.

Earlier versions of the work on econometrics of houses in the Piraeus have been presented at the Finnish Institute at Athens in 2015 and in the session organised by Ann Brysbaert and Anna Gutiérrez Garcia-M. at the 23rd European Association of Archaeologists meeting in 2017, Maastricht. The comparison between the Piraeus and Salamis has been presented at AIAC and Royal Holloway in 2018. Very warm thanks are due to all the audiences for their questions and comments.

Notes

[1] For the project by the Ephorate of Antiquities of West Attica, Piraeus and the Islands and the Finnish Institute at Athens, see acknowledgements at the end of the paper.

[2] Hoepfner et al. 1994; Pakkanen 2013a, 52–56.

[3] Pakkanen 2013b.

[4] Cf. Salmon 2001, 195.

[5] For discussions of the habited area inside the cities, see Muggia 1997; Hansen 2006, 35–63.

[6] DeLaine 1997, 106; Pakkanen 2013b, 56.

[7] Loomis 1998, 104–120. Stanier (1953, 70) already points out that inflation and regional differences in drachma standards complicate calculation of day-wages; cf. Pakkanen 2013b, 64–65, esp. nn. 70, 78.

[8] For an assessment of the range of studies and principles used in econometric studies in Greek Classical contexts, see Pakkanen 2013b.

[9] Morrison 1963. On estimation problems in general, see Weinstein – Adam 2008.

[10] Cf. DeLaine 1997, 109.

[11] Hurst 1902, 376.

[12] Thuc. 1.93.2–3; Diod. Sic. 11.41.2; Plut., Them. 19.2. On the walls of the Piraeus, see Garland 1987, 163–166.

[13] Arist. Pol. 2.5.1267 b 22–1268 a 14. For a discussion of the sources and archaeological material on dating the grid, see Pakkanen 2013b, 52. There is a recent tendency to date the plan towards the middle of 5th cent. or even later (see e.g. Shipley 2005, 352; Gill 2006). However, these arguments do not take into account the house remains under the Skeoutheke at Zea dated by pottery to the first half of the 5th cent. The house follows the typical Classical ground plan in the Piraeus and orientation of the 'Hippodamian' grid (Kraounaki 1994). On the role of Hippodamos in city planning, see Gehrke 1989 and Shipley's perceptive analysis (2005, 356–375).

[14] Hoepfner et al. 1994; Kraounaki 1994.

[15] Graves 1843; Rankov 2013, 423–435.

[16] Most of the features in fig. 2 follow Hoepfner et al. 1994 and Steinhauer 2000; for the suggestion of topography Zea, see Pakkanen 2013b, 57, esp. n. 16; see also Rankov 2013, 423–435.

[17] Hoepfner et al. 1994.

[18] However, as Shipley (2005, 368–373) points out, uniformity does not need to be interpreted as an expression of democracy as has been argued by Hoepfner and Schwandner (1994, 306).

[19] Chairetakis 2018, 97–257.

[20] Chairetakis 2018, 145–148.

[21] For the argument why the principle of estimating maximum output and minimum costs is often the most suitable approach, see DeLaine 1997, 105.

[22] Pritchett and Pippin (1956) provide a survey of textual evidence of construction materials in Attica; for more recent work with discussions of the building inscriptions and other textual sources, see Clark 1993; Pakkanen 2013b.

[23] Acton 2014, 226 f.

[24] Pakkanen 2013b.
[25] IG II2 1672, line 26; see also Pritchett – Pippin 1956, 286.
[26] Martin 1965, 56: 0.492 m × 0.492 m × 0.092 m (range 0.088–0.095 m).
[27] Wulff 1976, 109–111; Devolder 2005, 170–173; Lancaster 2017, 66–68.
[28] For a summary of the archaeological evidence, see Jones et al. 1973, 427, esp. n. 187.
[29] Pritchett – Pippin 1956, 281–283: IG II2 1672 from Eleusis gives the price for a pair as 4 ob., and 11 other prices from Epidauros and Delos are 3.5 ob.–1 dr. 2 ob.
[30] Pritchett – Pippin 1956, 283.
[31] A kiln-load of 1900 Corinthian pan-tiles had a minimum cost of 162 md and 4,100 cover-tiles of 197 md (Pakkanen 2013b, table 5.2), so manufacturing a pair would have cost ca. 0.13 md or ca. 1.6 ob.
[32] On the texts and terminology, see Pritchett – Pippin 1956, 261–276. On similar variation of property values at Olynthos, see Nevett 2000, 334–336.
[33] See, e.g., Acton 2014, 226.
[34] See also Nevett 2000.
[35] Thuc. 2.14.1; Dem. 24.197; 29.3; Lys. 19.31; Hell. Oxy. 12.4. For a discussion of the textual sources, see Hanson 1998, 108–110.
[36] Connor 1985.
[37] De Angelis (2003, 164–166) uses the cost of stone construction estimates as a proxy for the total costs of monumental temples in Sicily and Fitzjohn (2013) for private houses at Megara Hyblaia. For a more thorough discussion of the econometrics and early Greek architecture in south-eastern Sicily, see Lancaster 2017.
[38] Thür 1989, 118.
[39] Stanier 1953, 68–73.
[40] Pakkanen 2013b, 72–74.
[41] Xen. Anab. 7.1.27.
[42] Pakkanen 2013b, 72.

Image Credits

Fig. 1, 4–5: by the author. – Fig. 2: by the author, based on a map by Graves 1843. – Fig. 3: by the author, based on Hoepfner – Schwandner 1994, fig. 33. –Tables 1–3: by the author.

References

Acton 2014
P. Acton, Poiesis. Manufacturing in Classical Athens (Oxford 2014).
Blackman et al. 2013
D. Blackman – B. Rankov – K. Baika – H. Gerding – J. Pakkanen, Shipsheds of the Ancient Mediterranean (Cambridge 2013).

Chairetakis 2018

I. Chairetakis, Οικιστική οργάνωση και χωροταξία στη Σαλαμίνα από τον 6ο ως τον 1ο αι. π.Χ (Ph.D. diss., University of Athens 2018).

Clark 1993

M. G. Clark, The Economy of the Athenian Navy in the Fourth Century B.C. (Ph.D. diss., Oxford University 1993).

Connor 1985

W. R. Connor, The Razing of the House in Greek Society, TransactAmPhilAss 115, 1985, 79–102.

De Angelis 2003

F. De Angelis, Megara Hyblaia and Selinous. The Development of Two Greek City-States in Archaic Sicily (Oxford 2003).

DeLaine 1997

J. DeLaine, The Baths of Caracalla. A Study in the Design, Construction, and Economics of Large-Scale Building Projects in Imperial Rome, JRA Suppl. 25 (Portsmouth 1997).

Devolder 2005

M. Devolder, Hâte-toi de bâtir la demeure, hâte-toi d'édifier le palais. Creta Antica 6, 2005, 165–186.

Fitzjohn 2013

M. Fitzjohn, Bricks and Mortar, Grain and Water: Tracing Tasks and Temporality in Archaic Sicily, WorldA 45, 2013, 624–641.

Garland 1987

R. Garland, The Piraeus. From the Fifth to the First Century B.C. (Ithaca 1987).

Gehrke 1989

H.-J. Gehrke, Bemerkungen zu Hippodamos von Milet, in: W. Schuller – W. Hoepfner – E. L. Schawandner (eds.), Demokratie und Architektur. Der hippodamische Städtebau und die Entstehung der Demokratie. Konstanzer Symposion vom 17. bis 19. Juli 1987 (Munich 1989) 58–68.

Gill 2006

D. W. J. Gill, Hippodamus and the Piraeus, Historia 55, 2006, 1–15.

Graves 1843

T. Graves, The Peiraeus or Port Drako Surveyed by Commander Thomas Graves. H.M.S. Beacon 1840. British Admiralty Chart No. 1520 (London 1843).

Hansen 2006

M. H. Hansen, The Shotgun Method: The Demography of the Ancient Greek City-State Culture (Columbia 2006).

Hanson 1998

V. D. Hanson, Warfare and Agriculture in Classical Greece (Berkeley 1998).

Hoepfner – Schwandner 1994

W. Hoepfner – E.-L. Schwandner, Haus und Stadt im klassischen Griechenland 2(Munich 1994).

Hoepfner et al. 1994

W. Hoepfner – E.-L. Schwandner – G. Steinhauer, Piräus, in: Hoepfner – Schwandner 1994, 22–31.

Hurst 1902

J. T. Hurst, A Hand-book of Formulae, Tables, and Memoranda for Architectural Surveyors, and Others Engaged in Building 15 (London 1902).

Jones et al. 1973

J. E. Jones – A. J. Graham – L. H. Sackett, An Attic Country House below the Cave of Pan at Vari, BSA 68, 1973, 355–452.

Kidder – Parker 1946

F. E. Kidder – H. Parker, Kidder-Parker Architects' and Builders' Handbook 18(New York 1946).

Kraounaki 1994

I. Kraounaki, Ein frühklassisches Wohnhaus unter der Straße II. Merarchias im Piräus, in: Hoepfner – Schwandner 1994, 32–38.

Lancaster 2017

J. Lancaster, Syracusan Settlement Expansion in South-Eastern Sicily in the Archaic Period (Ph.D. diss., Royal Holloway, University of London 2017).

Loomis 1998

W. T. Loomis, Wages, Welfare, Costs and Inflation in Classical Athens (Ann Arbor 1998).

Martin 1965

R. Martin, Manuel d'architecture grecque I. Matériaux et techniques (Paris 1965).

Morrison 1963

P. Morrison, Fermi Questions, American Journal of Physics 31, 1963, 626–627.

Muggia 1997

A. Muggia, L'area di rispetto nelle colonie magno-greche e siceliote. Studio di antropologia della forma urbana (Palermo 1997).

Nevett 2000

L. Nevett, A Real Estate 'Market' in Classical Greece? The Example of Town Housing, BSA 95, 2000, 329–343.

Pakkanen 2013a

J. Pakkanen, Classical Greek Architectural Design: a Quantitative Approach, Papers and Monographs of the Finnish Institute at Athens 18 (Helsinki 2013).

Pakkanen 2013b

J. Pakkanen, The Economics of Shipshed Complexes: Zea, a Case Study, in: Blackman et al. 2013, 55–75.

Pritchett – Pippin 1956

W. K. Pritchett – A. Pippin, The Attic Stelai: Part II, Hesperia 25, 1956, 178–328.

Rankov 2013

B. Rankov, Piraeus, in: Blackman et al. 2013, 420–488.

Salmon 2001

J. Salmon, Temples the Measures of Men: Public Building in the Greek Economy, in: D. J. Mattingly and J. Salmon (eds.), Economies beyond Agriculture in the Classical World (London 2001) 195–208.

Shipley 2005
G. Shipley, Little Boxes on the Hillside: Greek Town Planning, Hippodamos, and Polis Ideology, in: M. H. Hansen (ed.), The Imaginary Polis. Symposium January 7–10 2004, Acts of the Copenhagen Polis Centre 7 (Copenhagen 2005) 335–403.

Stanier 1953
R. S. Stanier, The Cost of the Parthenon, JHS 73, 1953, 68–76.

Steinhauer 2000
G. A. Steinhauer, Ο αρχαίος Πειραιάς· η πό¬λη του Θεμιστοκλή και του Ιππόδαμου, in: G. A. Steinhauer – M. G. Malikouti – V. Tsokopoulos (eds.), Piraeus: Centre of Shipping and Culture (Athens 2000) 9–123.

Thür 1989
G. Thür, 1989. Wo wohnen die Metöken? in: W. Schuller – W. Hoepfner – E.-L. Schwandner (eds.), Demokratie und Architektur: der hippodamische Städtebau und die Entstehung der Demokratie, Konstanzer Symposion vom 17. bis 19. Juli 1987, Wohnen in der klassischen Polis 2 (Munich 1989) 117–121.

Weinstein – Adam 2008
L. Weinstein – J. A. Adam, Guesstimation. Solving the World's Problems on the Back of a Cocktail Napkin (Princeton 2008).