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SET IN STONE? SOCIO-ECONOMIC REFLECTIONS ON HUMAN AND ANIMAL RESOURCES IN MONUMENTAL ARCHITECTURE OF LATE BRONZE AGE TIRYNS IN THE ARGOS PLAIN, GREECE

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While Mycenaean monumental architecture has been well-studied, its potential impact and contribution towards a better understanding of the socio-economic and political situation and changes taking place in the Late Bronze Age (LBA) palatial and post-palatial periods in the Argos Plain has received less attention. Both external (drought, plague, earthquakes, conflict, catastrophic erosion) and internal (conflict, social issues visible in burnt destruction layers) factors affecting and eventually causing the collapse of the Mycenaean palaces have been investigated,[1] and further studies are on-going.[2] The elites and other parties with vested interests were able to mobilize large-scale interlinked human and natural resources to implement the known monumental building programmes in the Argos Plain. These activities, however, have not been drawing much attention from a technological and socio-economic perspective despite the fact that the employment of these resources may have had large over-all implications on the society as a whole and may have impacted on the overall socio-economic well-being of the region at the close of the 13th and into the 12th c. BC.

In the 'Set in Stone?' project the built environment is discussed from a distinct human perspective and the constructions themselves are regarded as products of multiple human interactions. Through studying practical building processes and integrating these technical and socio-economic data sets within the broader

[1] Summarized in Bennet 2013, 253–54.

[2] For example, 'HERACLES', the archaeo-seismological programme at Tiryns and Midea since 2012, directed by J. Maran and K.-G. Hinzen: http://www.seismo.uni-koeln.de/projects/heracles/index.htm.

demographic changing situation of the region it is possible to assess the human and natural resources required to carry out the monumental Mycenaean building programmes in the Argive Plain in the period from c. 1600 to 1100/1070 BC. The 'Set in Stone?' project was started in 2011 to study the processes resulting in these awe-evoking citadels, *tholoi*, waterworks, roads and bridges as we know them in the landscape. Its diachronic approach aims to contribute to our understanding of the socio-political shifts and strategies that were staged top-down *and* bottom-up, and wants to illustrate the intimate and dynamic interdependent relationships that people had with their (built) environment over time. It combines the *chaîne opératoire*[3] and cross-craft interaction[4] approaches to capture all practical building processes and inherent social practices. The project analyses the data by applying fine-tuned and customized architectural energetics,[5] an econometric modelling procedure translating the material remains of buildings into cost-estimates with labour time-units invested, expressed in man-days (md).[6] Architectural energetics investigates each step executed in the building process (from quarrying, through transporting to constructing and decorating),[7] and it estimates costs involved in both human and animal labour which were required to complete each task and the volume of materials needed to accomplish each project. This bottom-up approach is merged with published data collected via surveys and Venetian published census information, archaeobotanical data on land-use activities and capacities, geomorphological and climatic considerations[8] and mortuary studies (numbers, gender, health and diet)[9] from the Argolid in order to arrive at a more holistic image of the economic mosaic of the Mycenaean society in the region, its changes over time and the subsistence and other products it may have provided to its population. Through revising and adapting existing total territory figures and land carrying capacity models,[10] estimates of population numbers, density

[3] After Leroi-Gourhan 1943–45.

[4] See first McGovern 1989. For a combined approach, see Brysbaert 2007; 2008; 2011.

[5] For the first usage at Tiryns, see Brysbaert 2014.

[6] Abrams – Bolland (1999, 264–69) fully describe the definition and method and refer to person-days but since construction work was/is often done by men (see DeLaine 1997, 106), I employ the more standard term of man-day (md).

[7] And, as such, it is very compatible with a *chaîne opératoire* approach as well, see also Brysbaert 2008; 2011; in press.

[8] Esp. Zangger 1993; 1994.

[9] Suggested in Bintliff 1989; see now Voutsaki & al. 2013 with references.

[10] Bintliff 1989; 1997; Hansen 2006.

and distribution, as well as predictions of economic activity zones it will become feasible to get a more complete picture of the total population of the region. These data sets together may thus fill certain gaps *in-between* the well-known sites with monumental architecture, thus lending a voice to the 'silent majority' who constructed everything.[11]

When tested against adapted land carrying capacity models[12] and aided by Linear B tablet analyses (e.g. on land tenure, food rations and labour management), these data may illuminate, diachronically, the local/regional resource potential in terms of construction labour input versus agricultural, domestic and other activities. The project employs the site of Tiryns as the principle case study to better understand the socio-political, economic, cultural structures of the Mycenaean society that were responsible for both the 'building' and the eventual demise of their palatial societies at the end of the LBA.

In the first study of the project I explored the role of the Lower Citadel or Unterburg wall (hereafter: UB wall), how it was constructed and by whom, and how it achieved both its defensive, socio-political and symbolic meanings.[13] Both the performative and military characteristics as they are embedded in Cyclopean architecture of this kind have previously been emphasized and discussed in some detail.[14] The practical logistics involved in constructing Cyclopean architecture, in general, have also been studied to some extent for the Argolid[15] and these as-

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[11] Cf. Cavanagh – Crouwel 2002.

[12] See, for example, Hansen 2006 for later periods than the Bronze Age, but see also Wright (2010, 250–53) on the potential usefulness of research on Mediterranean urbanism for the study of the Aegean Bronze Age microstates.

[13] Brysbaert 2014.

[14] On defensive aspects, see e.g. Grossmann 1967; 1980: based on his new observations and thus adapting earlier conclusions by Dörpfeld (e.g., 203 where they are discussed as storage areas). On the performative character of Tiryns citadel see especially the work by J. Maran 2006, 2012.

[15] E.g., Cavanagh – Laxton 1981; Loader 1998; Cavanagh – Mee 1999; Wright 1978; 2006; Fitzsimons 2007; 2011. Fitzsimons (2007, 110–12) generalizes several aspects of the *chaîne opératoire* of constructing with large blocks, especially the transport. Wright (1978, 229 n. 329 with references) refers to local sources, too, but Cavanagh – Mee (1999, 95–96) mention the use of high quality conglomerate from the quarries c. 1.5 km from e.g. the Atreus Treasury. Geological studies, e.g., Varti-Matarangas & al. 2002, have shown that blocks used at Tiryns came from quarries such as the bedrock outcrop itself, but also from the quarries of Profitis Ilias (c. 1 km away), and the conglomerate is from the Panagia and Kalkani ridges near Mycenae or its quarries another 1.5 km away, thus c. 15–18 km from Tiryns. This fits well with Dörpfeld's (1886, 289) original suggestion that limestone was brought from places east and south of Tiryns.

pects stand directly in relation to how the structures were imbued with meaning and who was involved in producing such meanings and why.

Over the last century, opinions about the labour involvement in the construction programmes at Tiryns have been expressed[16] but no systematic study has been conducted until now. In a pilot study I took a series of calibrated digital measurements forming the basic data sets from which it was possible to quantify several aspects related to architectural energetics of wall construction.[17] These were complemented, combined and compared with existing data on the natural resources that people at Tiryns had at their disposal; the labour-constants used in the econometric calculations were derived from both Old[18] and New World contexts.[19] This first Tiryns-based study presented preliminary results addressing the questions about the types and minimum amounts of resources which would have been needed to construct the UB wall at Tiryns.[20] In order to estimate the costs and achievability of the building programme, I evaluated both the human and animal investments revolving around quarrying,[21] the transport of materials

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Küpper (1996, 5–6) suggests very nearby sources of stone extraction without providing details on the materials used at Tiryns. Even if a block of c. 13 ton needs to be moved just 1 km, this is hardly possible by 'rolling' (my quotation marks) it in place in Tiryns, as Fitzsimons's general remark suggests (2007, 112). In my opinion, his idea that construction using these massive blocks was a reduction of technical expertise cannot be supported: employing interlocking polygonal blocks required perhaps less shaping of the individual stones than the use of regular ashlar blocks but the technique also typically resulted in very stable walls, so each stone had to be carefully chosen to stop toppling or to avoid destabilizing other courses. On techniques of placing blocks in such walls: Grossmann 1967; Küpper 1996; Brysbaert 2014.

16 See, e.g., Müller 1930.

17 Brysbaert 2014: table 1.

18 Burford 1960; 1969; DeLaine 1997; Bessac 2007; De Haan 2009; Pakkanen 2013.

19 Abrams 1994; Abrams – Bolland 1999.

20 Müller (1930, 208) suggests several decades for his 'third citadel'; Grossmann (1967) thinks that Müller's estimate is far too high but does not offer an alternative; Loader (1998, 65) suggests 5.5 years to construct the two faces of the circuit wall at Tiryns (but it is not clear whether she refers to the UB wall only), elsewhere she refers to almost 5 years for the entire circuit at Tiryns (1998, 69; again unclear what she means), and in appendix 3 she reports 55.9 years to construct entire Tiryns.

21 Contra Loader (1998, 67) who does not think that it is possible to calculate this, but instead, see DeLaine (1997, 109–22) who discusses the topic extensively; and Bessac (2007, 135–36) for extracting limestone blocks in Petra, Jordan; De Haan (2009, 3) on extracting masoned limestone blocks for Egyptian pyramid construction; Pakkanen (2013, 63–65) for Piraeus limestone quarrying calculations.

from the quarries to the site, and the construction of the actual UB wall in its most basic form; also, several models of how this construction was carried out were explored.

The emerging preliminary data sets and results have shown that the majority of stones employed for the UB wall likely came from the nearby quarries of Profitis Ilias, and these thus needed to be transported over approximately one km to the site, a large and necessarily organized effort not previously dealt with adequately.[22] I discussed in detail the calculations for both human and animal efforts but it was beyond that paper's scope to investigate the more intangible issues of how these efforts may have impacted on societal issues as a whole and, more specifically, on the resources readily available at Tiryns itself, or whether the resources had to be recruited beyond the local area.

The aims of this paper are thus to investigate, first, the usefulness of draft animals in the context of transporting heavy building blocks from the quarries to the site and their general use in the local area. Second, attention is drawn to the limited information on architectural construction in the published Linear B tablets while architectural efforts, at least in the Argolid, are of such a pervasive nature that the tablets' silence needs to be explained. The data presented in this paper thus combines Linear B resources with information collected through a combined *chaîne opératoire* and architectural energetics approach to monumental building. Third, if one accepts that oxen pairs were indeed involved in the transport of building materials, and not just used in agriculture,[23] the question remains how these were recruited, by whom, who owned them and what did this mean socio-economically? Parallel information is thus further extracted from Near Eastern tablets on rearing, maintaining and employing oxen in heavy traction labour, and this is compared, where possible, with the Aegean Late Bronze Age construction projects. The 'Set in Stone?' project thus investigates, diachronically, the physical and social impacts of these monumental building programmes on local, regional and interregional scales in order to get insights in whether these building activities were manipulated by *various*, possibly competing, societal groups as means to achieve socio-political and economic independence and power. Below, the paper starts with a review (section 1) of the past literature on architectural studies

[22] While transport may be ignorable for constructing at Mycenae (but see Cavanagh – Mee 1999, and note 15), it can be contested on the basis that large efforts of the entire *chaîne opératoire* of the wall's construction in Tiryns were delivered in time and human and animal resources, and thus had socio-economic impacts on people from the local and possibly regional communities who were involved in delivering these efforts (Brysbaert 2014).

[23] See Cavanagh – Mee 1999, 100.

in Tiryns and summarizes its achievements and lacunae. This is followed by the relevant Linear B textual evidence.

1. Current state of research and useful resources

Tiryns, whose citadel comprises c. 20,000 m^2, lies on a limestone hill outcrop sloping from the south to the north; it is c. 300 m long, 100 m wide and c. 22 m above sea-level. It was occupied since the Middle Neolithic period and it evolved into one of the largest Mycenaean palatial centres on the Greek mainland, and it possessed a major harbour, a still working dam constructed in the 13th century BC,[24] and two *tholoi*. A multi-phase palace with two Mycenaean *megara* occupied the Upper Citadel[25] and the last phase of the cyclopean fortifications around the entire hill dates to the mid-13th century BC.[26]

The earliest contributions to architectural research of Tiryns[27] are still pivotal but neither construction techniques nor building materials have been covered thoroughly. Müller conducted major architectural studies on the citadel and the palace in the 1920s attempting to determine the different phases of the fortification walls. His insightful study discusses building techniques of the inner and outer surfaces of each wall, the relation between the walls, their strength and capacity to serve as a proper defensive system,[28] but the actual construction practices or any specific building materials were not covered in great detail.

Both Grossmann and Schnuchel worked on parts of the fortifications of the UB wall and beyond in the 1960s and 70s. Grossmann discusses the construction techniques of the wall as a whole and the defensive nature of the citadel.[29] Based on photogrammetry, Schnuchel and his team produced a series of very accurate drawings of several wall sections all over the citadel, with the ultimate aim of completing a 3D reconstruction of all documented wall sections.[30] Especially the western part of the UB wall received thorough attention and these data can

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[24] Balcer 1974.

[25] Kilian 1987.

[26] Grossmann 1967; 1980; Maran 2008.

[27] Dörpfeld 1886; Schliemann 1886.

[28] Müller 1930, 15–20, esp. 17; but see Küpper 1996, 111.

[29] Grossmann 1967, 94; 1980.

[30] Schnuchel 1983 and the Tiryns Archive (Athens and Heidelberg).

be compared with new measurements of the northern tip and the eastern side of the UB wall. His report on the detailed description of its construction aids in understanding many other aspects of the UB wall as a whole as well.[31] Despite its great value, however, Schnuchel's project was neither completed nor published, leaving several lacunae to be filled.

Kilian investigated substantial areas in the UB near the fortification walls and he discussed aspects of architectural planning in relation to the choice of the specific location where the palace needed to be constructed.[32] He also studied evidence at Tiryns for a catastrophic earthquake dated to LH BIII1 or 2, as part of a widespread phenomenon in the Argolid.[33] Since this evidence is not without problems, it is of great interest also to this project and needs in-depth analysis, something which is ongoing at the time of writing.[34]

Maran mentions the careful planning for the fortifications and other monumental parts of the citadel.[35] His excavations in the UB have reinvestigated areas near the walls and the gate in the north sector and revealed new features of both waterworks, drainage and wall construction near the northern tip of the UB. This aided in understanding the relation between the newly discovered underground passage and the North Gate[36] and it ties in usefully with earlier studies on waterworks and water management systems in and near Tiryns.[37] A very insightful overview of the different building phases and excavation history of Tiryns has also been published recently by A. Papadimitriou.[38]

Very useful is T. Mühlenbruch's discussion of the post-palatial use and architectural constructions of the Tiryns citadel, especially the discussion of the 'Antenbau' and its importance within the walled area[39] but it does not expand on the techniques, construction materials, organisation or the personal involvement of the people in the making of this important construction. The 'Set in Stone?' project, therefore, aims to understand the relation of the palatial walled citadel

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31 Schnuchel 1983, 403–11.

32 Kilian 1987, 33–34.

33 Kilian 1996, 63.

34 See note 2.

35 Maran 2006b, 81–82.

36 Maran 2008, 41–45, with contribution by Marzolff: 97–109; Maran 2009, 255–56.

37 Knauss 1996, 78–89; 2001, 58; 2004.

38 Papadimitriou 2001.

39 Mühlenbruch 2009, esp. 314–15.

linked to the post-palatial appearance of the 'Antenbau', how that may have been practically achieved, and how that may have translated socio-politically into people's minds in the post-palatial periods.[40]

The monumental architectural works at Tiryns testify to the power, the self-image and the external connections of local elites during the final palatial period[41] and possibly also those preceding it. Beyond the citadel, an extensive settlement existed during the palatial and the post-palatial periods[42] and its role is a critical factor in our understanding of the Tirynthian socio-political system within the wider Argos plain as a whole. At the time of writing, a very well-studied restoration project of the citadel walls is being conducted by the Fourth Ephorate (Nauplio) under the direction of A. Papadimitriou, with J.-M. Klessing and F. Pachygianni as team leaders.

Beyond Tiryns itself, Mycenaean masonry work and construction techniques have been studied extensively and the processes and materials involved have been investigated.[43] Human investments have been limitedly discussed,[44] and few scholars have explored the '*chaîne opératoire*' of these constructions.[45] Other studies have considered architectural phenomena as active 'participants' in socially interactive groups with each other and their materials[46] but so far, mainly the finished products in the shape of buildings as containers or backdrops of scenes have been studied. The most recent excavation campaigns in the area of the Lower Citadel have clarified many aspects of its circuit wall, but Tiryns as a whole still awaits full-scale architectural investigations of each period and each section. Küpper's contribution to Tiryns' architecture lies, first, in his detailed study of the tools employed and various construction techniques. Second, he points out the connecting concepts and organised work achieved by

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40 Cf. Maran 2006a, 124; 2009, 255–56; 2012.

41 Maran 2004; 2006b.

42 Kilian 1978; Maran – Papadimitriou 2006.

43 See, e.g., Wright 1978; Küpper 1996; Loader 1998; Nelson 2001.

44 Loader 1998; on soil movement for the construction of *tholoi*: Fitzsimons 2007; 2011, 93–94. He mentions the total mass of stone needed for his rough calculations of the cyclopean wall at Mycenae (2011, 108) but does not provide calculations on the construction in stone of the *tholoi*. In contrast, see Cavanagh – Mee (1999) who also take into account the aspect of transport based on Burford's revaluation from 500 kg to one ton per oxen yoke, a value also used here.

45 Wright 1978; Küpper 1996.

46 Cavanagh – Laxton 1981; Cavanagh – Mee 1999.

the Mycenaean architects and engineers while he touches only lightly upon the acquisition of building materials, including different types of stone.[47]

The data produced in the first study of 'Set in Stone?'[48] have formed a start for the ongoing in-depth study of Tiryns as a whole of which this paper forms a part. Its first results calculating the efforts carried out by both human and animal resources to extract the building materials, transport them and construct the most basic form of the UB wall can be summed up as a calculated time-line developed per year, employing the spread-sheet model.[49] In year one, at least 82 men and five oxen teams[50] were needed to quarry, transport, load and unload blocks, build ramps, haul the blocks up and position them in place. In year two a minimum of 96 men and five oxen teams were required for the same types of tasks, and in year three at least 109 men and five oxen teams.[51] Placing these first results into the context of the socio-political and economic context of the final LBA and considering the above-mentioned previous studies, it is clear that lacunae in these data are still present, but the following further aspects are currently under study:

1. The efforts undertaken in clearing the terrain, on and around the hill outcrop, in order to be able to construct the various citadel parts.[52] That a general clearing of the Lower Citadel was executed is also clear in the stratigraphic study of the workshops based in the LH IIIB Middle Building, Lower Citadel South.[53]
2. The carefully cut blocks employed in the corners of the UB wall construction would have needed extra effort; this was likely carried out with diorite stone pounders.[54]

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47 Küpper 1996, 5–6, 111–18, esp. 115–18.

48 Brysbaert 2014.

49 See Abrams – Bolland (1999) for the 'spread-sheet' model; Brysbaert 2014: table 9 for details.

50 Each oxen team consists of a yoke of two oxen and a guide.

51 As mentioned above, these are the minimum calculations per year, per task and per resource which is, methodologically, the best way of proceeding.

52 E.g., the older LH IIIB1 stone rubble wall of the Lower Citadel: Kilian 1988, 139; the removal of large parts of the EH and MH mound (Wright 1978, 215), see also Maran 2010; Brysbaert 2014, n 10.

53 Brysbaert – Vetters in preparation.

54 Küpper (1996, 32) refers to the working of blocks in more detail while Grossmann (1980, 496) mentions that such work was carried out much more often in the area of the Upper Citadel

3. No alterations to the UB wall circuit were taken into account in the preliminary calculations, so inserting the slightly later North Gate[55] is not attested for, nor are the extra efforts likely carried out in planning and building the niches over one or two floors.[56]

4. The mass of wooden ox carts, wagons or sledges has not been accounted for in the amount of weight traction an oxen yoke could have pulled.[57] Using an ox-cart (2 wheels) or an ox-wagon (4 wheels)[58] instead of a sledge also opens the question of the difference in friction caused by the sledge being dragged over uneven terrain. Even if the road was evened out by employing runners or by filling up gaps between stones with packed earth, a friction coefficient (μ) would have to be estimated and the possible lubricants used would need discussing in case a sledge was employed.[59] The 2014 paper discussed the transport with traction animals without calculating potential friction coefficients.[60] Equally, the oxen themselves, de-

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than elsewhere. Worked blocks, however, were noted throughout the citadel complex.

[55] Maran 2010, 726–29.

[56] Brysbaert 2014, n. 65.

[57] Landels (1978, 179) points out correctly that ox-carts or wagons could not be light-weight either if they were supposed to transport very heavy loads, they therefore also needed solid heavy-duty wheels, rather than wheels with spokes, known from chariots as seen on wall paintings from Tiryns and also on Linear B tablets: e.g., Duhoux 2008, 274–76, fig. 9.16 of tablet KN So (1) 4440 + 8700 + 8702 + Frr. Cavanagh – Mee (1999, 96) suggested that heavy-duty carts for such massive transports may have been purpose-built for the occasion.

[58] One of the earliest depictions of oxen with a four-wheeled wagon is a light-on-dark clay figurine from MM I Palaikastro, East Crete: Bosanquet – Dawkins 1923, 17.

[59] Consiglio (1949, 92) discusses the usage of lubricants in transporting marble blocks from the Carrara quarries in Italy and soap is mentioned in the same 19th century AD context by *Il marmo...ieri e oggi* (1970, 24, 174), where blocks, up to 25 ton, were transported on sledges over soaped runners (for figures, see 1970, 73–76). Koutsoumpas and Nakas (in press): 12–14, fig. 8 show the use of runners and lubrication of these in their second transport option of triremes mounted on sledges, over the Diolkos (the type of lubricant is not specified): their work is based on observations made by M. Korres who pointed out the work done by the experienced quarrymen at Carrara.

[60] Loader (1998, 55–59) mentions four-wheeled vehicles with solid wheels suitable to transport the Cyclopean blocks; two-wheeled carts would have been less useful in the transport of heavy irregular blocks: their load may not have been very 'evenly' spread over the cart so there would have been the risk of tipping due to only having two wheels. She prefers, however, the use of sledges in heavy bulk transport, even though her parallels from Egypt and the Near East all illustrate that sledges were pulled by people, not oxen. She considers it possible that oxen

scribed in great detail in the Linear B tablets, need further investigation in terms of what they can pull. Various figures for the weight capacities they can manage have been published.[61]

5. The number of oxen yokes required in the UB wall erection was calculated as five throughout the minimum of three years of construction. These animals would no longer have been available for agricultural work. While five oxen teams is a relatively small workforce,[62] it is well-known that the UB wall was far from the only large-scale undertaking that was executed in the LH IIIB Final phase in Tiryns and in the Argolid overall.[63]

6. The minimum number of men involved in the UB wall erection could be determined based on the labour constants but the question remains whether that number would have been continuously available when needed, and not just for the construction of the UB wall at Tiryns. In most contexts, construction and agricultural labour may well have been mutually exclusive during ploughing and harvest times. Most members of the active workforce would have been tied up at the busy agricultural periods and thus no longer available for any other work, whether military, construction or craft-related. The question then poses itself how and from where these men may have been recruited for these types of jobs. Moreover, the calculated number of people involved in each job needs to be understood

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pulled sledges, too; likely these would 'glide' over the runners which would have protected the load from the uneven ground and would have reduced the friction. Loader suggests that such transport needed a flattish road surface which may not have existed but it could have been created for the occasion. Also Coulton (1977, 141) is in favour of sledges used for the transport of heavy blocks.

[61] Burford (1960) suggests that oxen could pull about 500 kg while she revised that number to 800 kg in her 1969 publication. This was also the number adapted by DeLaine (1997) after she originally also used 500 kg, based on Diocletian's Price Edict; and, subsequently, the load of 800 kg is also used in Brysbaert 2014. Loader (1998, 60) only allows for 500 kg per oxen pair, basing herself on Cotterell – Kamminga's (1990, 37) work in Australia. It is clear that many factors play a role in how much a pair of oxen can pull and the human factor is the most decisive one: Renger 1990, 267. Finally, the historical evidence of the Carrara marble workers who had generations of experience with quarrying and transporting heavy blocks with oxen could move between 800–1000 kg per oxen yoke; see Mannoni – Mannoni 1984. This stands in clear contrast to Adam (1977, 56) who mentions that one ox could pull one ton.

[62] For year one, they were needed only for part of the year since there was nothing to transport before the stones were quarried.

[63] See Maran 2008, 88; Maran 2010, 726, also 728 for chronological details.

as part of the *active* human workforces that form, themselves, a percentage of the overall population. It has always been assumed that the Late Bronze Age monumental building programmes in the Argolid must have been highly demanding both on human and natural resources. As such, it is implied that such construction needs would have impacted heavily on the resources make-up and socio-economic health of the region. But are these assumptions correct? And if they are, they need diachronic treatment and fine-tuning whereby the econometrics may help us a step forward in studying this phenomenon since such statements need to be substantiated with realistic figures and models. The exceptional quality of the constructions throughout the Late MH until the end of the LBA[64] was already known to Strabo and Pausanias.[65] It is not only the constructions themselves which require investigation but also the physical roads, communication lines and organizational talents of the people of this period and how these factors impacted upon each other within the builders' task-scape.[66] The ongoing project aims at enlightening us on the demographic make-up of each period, if and when possible, and how they could afford such constructions.[67]

7. Environmental realities may have slowed down work considerably. The figure of 220 working days[68] in a year allows work to be carried out from the start of April until the first part of November. However, any bad period of rainfall slows down some of the work substantially, especially tasks involving oxen yokes due to slippery and muddy roads.

The ultimate goal then of 'Set in Stone?' is to contribute to all these points, and the present paper specifically discusses points 5 and 6 and touches also upon points 4 and 7. Since the questions of this paper and the project in general pertain to the socio-economic sphere of the Mycenaean LBA, the Linear B tablets are an indispensable resource of information, of which relevant evidence has been brought together (sections 2–5) and which is discussed below.

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64 Bintliff 2010, 757, 761. On tumuli and their meaning: Voutsaki 1998.

65 Strabo 8,372; Paus. 2,16,5; 2,25,8; 7,25,5–6.

66 Ingold 2000.

67 Bintliff & al. 2007.

68 Brysbaert 2014, after DeLaine 1997.

2. Tablets from Tiryns

Linear B as a form of recording, including the language used and the media on which this writing is applied to sun-dried clay tablets, clay sealings and nodules, painted on ceramic vessels, seems to reflect astonishing similarities[69] as well as several differences between the Mycenaean centres in their socio-economic and political make-up.[70] The incomplete and selective nature of the tablet information is not only explained due to their state of preservation but also due to the fact that the palaces only seemed to record the matters in which they had an economical vested interest, noticeable in agricultural[71] and religious contexts.[72] Tablet information concerning groups of men as construction labour, the presence of oxen, their owners and numbers, land tenure, wheat rations, and building materials are of specific concern to this paper because I believe that all may, directly and indirectly, contribute to a better understanding of the posed questions. While the majority of tablets have been found at Knossos and Pylos, also Chania, Thebes, Mycenae, Tiryns, Agios Vasilios and Iklaina have produced some.

Especially the tablets from Tiryns are of interest here. Two of them illustrate the distribution of grain: TI Ef 3 refers to communal land (*ke-ke-me-no*) (see below); TI Ef 2 gives an amount of land in terms of grain that would have been needed to sow it.[73] Also the term *qo-u-ko-ro*, 'oxherd', appears on TI Ef 2, in association with large amounts of landholdings (GRA 6).[74] TI Cb 4 reports on oxen and possibly even mentions their names (see KN Ch 897, Ch 1029) but the state of preservation of tablet TI Cb 4 hinders any clear reading.[75] TI Al 7 mentions personnel although due to its very fragmentary state it is not clear how to interpret the function(s) of these men.[76] Finally, TI Sl 8–10 refers possibly to wheels but apparently not the spoked-type as known from many other tablets, since the inner

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69 Killen 2007, 114–15.

70 Galaty – Parkinson 2007, 4–5, but see also p. 13 where similar regional integrative strategies between Mycenaean states are pointed out.

71 Halstead 2001, 38–39 with references; Bennet 2013, 236.

72 Lupack 2008, 84–85.

73 Shelmerdine (2008, 148) refers to communal land from Knossos, Pylos and Tiryns.

74 Palaima 1989, 98. For Tiryns' tablets specifically, see Godart – Olivier 1975, 43–53.

75 Godart – Olivier 1975, 51–52. If, however, these would point out oxen names, this tablet could then indirectly be referring to palace-owned oxen, possibly of interest in relation to the oxherd and his landholdings.

76 Godart & al. 1983, 416–17.

part of the circle (wheel) only bears a smaller circle. This has been considered a scribal idiosyncracy next to the fact that the wheels are entered as single entities, not as pairs as usual, and they are associated with an unclear maker or recipient.[77]

Apart from this tablet information, two oxen figurines have been found, probably dating to the EH II period as they are painted in 'Urfernis'. It is not clear whether these are separate figures or part of a yoked pair since neither Müller's description or his images indicated yoke attachments at the back of the oxen's necks. Instead, he suggests that these figurines served as offerings even though they are more or less like mirror-images of each other.[78]

Information relevant to this paper and extracted from the Linear B tablets beyond Tiryns, is separated into three sections below even though there are clear overlaps between the groups; these are brought together in the discussion below. The sections are: (3) the context under discussion – architecture, (4) oxen as animal resources and (5) services as human resources. These sections were formed on the basis of useful content to answer the questions outlined at the start.

3. Architectural and related issues in the Linear B tablets

Tablets specifically referring to architectural issues are few and not always without interpretive problems:

1. PY Vn 46 and 879 have been interpreted in the context of shipbuilding[79] and architecture. If the tablets belong to the latter context,[80] and even though many terms remain unexplained,[81] they list building materials and

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[77] See Godart & al. 1983, 419 for details.

[78] Müller 1976, 61, pls. 5.6, 5.8, 25.1–2: figure 1 was well-stratified while figure 2 was less so but they were seen as part of a team due to their similarities.

[79] As did van Effenterre 1970 originally for tablet Vn 46, see Hocker – Palaima 1990–91. However, they admit that their attempt to interpret the texts in the context of shipbuilding ultimately bases itself on the unprovable hypothesis that *ka-pi-ni-ja* could be read as 'boat', 'ship' or 'hull' instead of 'chimney' or 'smoke hole'.

[80] Baumbach 1972, 385.

[81] Bernabé – Luján 2008, 211; also Baumbach (1972, 392–93) on the fact that some words only make sense to the trained architect or builder, even now. See also Melena (1998, 176) who links this tablet with tablet An 7; see also note 88 below.

may refer to one of the last repairs done to the *megaron* of the palace in Pylos itself.[82]

2. PY An 35 lists masons' assignments in four towns of the Pylos kingdom. These builders (*to-ko-do-mo*) seem to be based in Pylos town and in Leuktron (capital of the Further Province) where work needed to be done in addition to places in both the Hither and Further Province.[83] This tablet was written by Hand 3 who seems to be specialised in recording groups of builders.[84]

3. Joint tablets An 7 and Fn 1427,[85] now PY Fn 7,[86] mention 20 builders and refer to food rations for two named individuals and three groups of workers: *to-ko-do-mo*: 'wall builders/masons' and *pi-ri-e-te-re/si*: 'sawyers/splitters of wood' (possibly for building frames).[87] One individual receives higher rations than the menial workers and, therefore, seem to be a supervisor: *pa-te-ko-to*. He has been interpreted as either the 'carpenter of all work' or the 'architect'. The two named individuals, as specialists in architecture, receive very high rations of olives and likely grain that seem in line with salary wages for a mixed team of builders and sawyers engaged in construction or repair activities.[88] Nakassis suggests five teams (5 x 4 masons + 1 sawyer[89]) who would have been employed in constructing the IIIB

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[82] Blegen – Rawson (1966, 256) suggest that remodelling works were conducted at the palace of Nestor at Pylos, e.g. at the front wall of Hall 65, for instance, and p. 423 refers to the repair of the western angle and the enclosing Courts 42 and 47 as structures of the final phases. These repairs have been interpreted by Baumbach as having taken place at the time of its destruction but Hocker – Palaima (1990–91, 299) refute this interpretation and state that repair works were finished by then.

[83] Duhoux 2008, 296–98.

[84] Melena 1998, 176.

[85] Melena 1998.

[86] Nakassis 2012, 275.

[87] For *pi-ri-je-te-re* as sword makers: Gregersen 1997, 397. Carpenters at Thebes (*te-ka-ta-si*) are described by Montecchi 2011, 171–72, see also 2011, 182 where they are reported receiving wheat and wine rations.

[88] Melena 1998, 175–76.

[89] However, to be effective, carpenters should be grouped in teams of two if their task involved sawing and splitting larger-size timbers, see Pakkanen 2013, 62, notes 48 and 50. Also Montecchi (2011, 184) puts carpenters in groups of four, based on tablet TH Fq 247. She also confirms their skilled expertise since they receive, at Thebes, wine as a luxury commodity;

walls in Pylos, consisting of mortar mixtures, poured in a wooden frame until set.[90] The two named individuals would provide unskilled labour needed in this large-scale construction task, and the high rations would have been the wages for the unskilled labour, possibly up to 24 for a full month but called in whenever they were needed to supplement the masons' or sawyers' jobs.[91] PY Fn 7 was written by Hand 3, as was PY An 35.[92]

4. Linear B on oxen,[93] landholding and food/fodder rations issues

1. The Mycenaean palaces of Knossos and Pylos owned oxen.[94] The Pylos tablets suggested that these oxen were, on occasion, on loan to the *dāmos*

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see also Aravantinos 2010, 62.

90 Nelson 2001, fig. 84.

91 Nakassis 2012, 276–77 for details.

92 Melena 1998, 172–75.

93 Palaima (1989, 87–88) discusses the use of cattle and oxen also beyond what was attested in the tablets: meat, milk, cheese, hides for leather, tendons, oils from hooves and horns, glue and fats, bones into tools and marrow from within, next to breeding and traction for various purposes. In this context, he also mentions that in Mycenae, a yellow glue-like substance had been attested. Moreover, lubricants can be cattle-based (oil: from hooves and shin bones and fat). On very early evidence for cattle as traction animals, see Halstead (1987, 80) for sexable cattle bones dating to the 3rd and 2nd millennia BC. During these periods the use of oxen for ploughing or pulling carts has been widely documented in Europe and the Near East. For the earliest evidence in the Aegean, see Isaakidou (2006, 104–8) who derives the information from studying pathologies on cattle bones from Neolithic and Bronze Age Knossos (esp. EN II-FN): these pathologies are mainly present on the female specimen. Therefore, adult cows were the main traction animal on Crete (whether for ards or carts with loads) and they were kept being used for this purpose by small landowners who could not afford to maintain their own specialized oxen pair not providing milk and calves. She concludes that this Neolithic evidence contradicts the textual evidence from the Late Bronze Age and that male oxen for ploughing may have been more or less restricted to elite control, thus indicating social inequality. Also Pullen (1992, 48–49) discusses early traction based on clay painted figurines of oxen indicating yokes (esp. on figurine 1, 1992, 50–52) from EH II levels from Tzoungiza, and points out the scarce evidence on oxen and plough traction. He, furthermore, points out that it is not clear whether the figurines pull a plough or a cart but that wheels or vehicle models are rare in EH II contexts (1992, 52).

94 Evidence from Thebes in the form of nodules points in the same direction, Piteros & al. 1990, 183–84.

to aid in agricultural work.[95] The Ch tablets imply that these oxen had to be returned to the palace and their careful description ensured that they were returned in the same condition as they left.[96] Textual evidence from Ur III Girsu, Umma and Lagash seems to suggest that the Neo-Sumerian authorities closely inspected the plough animals in their possession: if the responsible person for a given herd of animals had lost one or more by death other than normal wear, they had to replace these themselves, costing the oxherd up to eight months of wages. If the animal had died naturally, its hide had to be returned to the palace.[97] So the hides were important to the palace: they stood for high value and its loss of an ox as a viable working animal. In the Mycenaean context, hides or skins were both secular commodities but also offered in religious contexts.[98] In Pylos, oxen were sent by people in military functions to *di-wi-je-u,* who was both 'inspector' and *heketās*. The palace also recorded these oxen because eventually they would be sacrificed there.[99] Of interest then is TI Uh 12 where skins are mentioned (but not clear of which animal).[100]

2. The agricultural work done with the palatial oxen was carried out on communal land owned by the *dāmos*.[101] The work done on such land at Knossos was cultivating wheat for which Halstead suggests a system of share-

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[95] Old Babylonian letters equally refer to the hiring of a plough team since their most important destination was to use their strength, and not let them sit around idling, thus including the oxherd as well, see Stol 1995, 184.

[96] Killen 1992–93; Halstead 1995; 2001; Kajava 2011, 60 n. 4; 2012, 60 n. 6 with refs: these oxen were described, allocated per herdsman, by means of their physical appearance, likely to avoid fraud committed by oxherds by bringing back an inferior ox after the job was done: Killen 1992–93, 102–3. On working oxen in the late 2nd millennium BC (versus sacrificial ones): Ventris – Chadwick 1973, 212; Palaima 1989, 91.

[97] Heimpel (1995, 102–3) on high death rates. Replacing was an important aspect dealt with in great detail in these texts and could cause a heavy debt burden if the animal could not be compensated for. The anonymous reviewer also drew my attention to the fact that in the modern Mediterranean, hides were returned for two reasons: as evidence for natural death and presumably also for their intrinsic value.

[98] For reference to oxhides in Linear B tablets, see Palaima 1989, 87–88. Melena (2000–01, 380–84) points out that hides could have been a special gift of honour.

[99] Palaima 1989, 118.

[100] Godart & al. (1983, 413, 420–21) on hides and their functions, (1983, 418) on the personnel tablet.

[101] Killen 1998; 2008, 172–73 n. 34; *ke-ke-me-no* land, see Shelmerdine 2008, 134.

cropping.[102] The palace only recorded those parts in which it had a vested interest: wheat as food rations for their dependent workers (and possibly also for the traction animals, see below), sheep, oxen-rearing, and grazing sheep on fallow land.

The *dāmos* also seems to own oxen: An 830 lists '60 oxherds of the *dāmos'* whose *ko-re-te-re* and others own communal land.[103] In the Near East, too, some cattle breeding existed in private hands.[104] It is unlikely that all oxen and oxherds/pasturers are registered on tablets, independent of their preservation,[105] especially if the palace had no direct interest in these. While very few tablets at Knossos deal exclusively with ox pasturers (KN L 480: *qo-u-qo-ta*) both ox pasturers and oxherds appear on the Pylos tablets. Tablet An 830 + 907a associates four groups of oxherds (18–66 per group) with *ke-ke-me-no* landholdings, an association also present on TI Ef 2, on PY Ea 781a where a single land plot is possessed by an oxherd, and on PY Ea 270a, 305a, 757a and 802a where in the latter three cases, *ke-ke-me-na* land was possessed by ox pasturers. Oxherds are present in at least five different locations over the Pylian kingdom and are sometimes associated with *ko-re-te-re* and possibly rations of fodder.[106] As several oxherds owned substantial land plots which they could also lease out, Palaima suggests that they may well have been associated with the central and possibly also with the religious authorities. Their main activities may not have been centrally controlled even though flax contributions (from that land) to the

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[102] Halstead 2001, 39–41. Halstead (1992, 72–73) also suggests that palatial crops were concentrated near major centres and sub-centres. This was probably done to keep closer control over the outcome and is also evidenced in Near Eastern contexts (Neo-Babylonian for example) where oxen, too, were bred close to the seat of the institutions and where also other agricultural interests were located; van Driel 1995, 216. Cattle/oxen breeding close to the palace also seem to be at least partially the case for Pylos where 90 oxherds are located in the Bay of Navarino, but other oxen are stationed further out near good grazing land and are sent to the centre, likely for sacrifice: see Palaima 1989, 115–18.

[103] Shelmerdine 2008, 133–34.

[104] van Driel 1995, 233.

[105] Godart – Olivier 1975, 47.

[106] See KN C 902. Palaima 1989, 100 for all details.

palace were required.[107] Their association thus likely lay in the fact that these oxherds looked after the palatial oxen.

3. PY Aq 64[108] suggests that the palace may have provided fodder to high-ranking individuals (some are landholders[109]) who temporarily borrowed oxen. The fodder meant to keep the oxen in good health during the labour-intensive ploughing period for which they were borrowed. Also Old Babylonian texts refer to the palace providing fodder for the oxen and stipulate how much is given per season and per month, possibly relating to the jobs to be carried out.[110]

4. In contrast to the evidence for working oxen,[111] a Knossian *ko-re-te* is listed with sacrificial bulls/oxen on KN C 902. The same tablet refers to rowers at Knossos, one or more of whom appear in company of koreters and other officials, and each of the rowers is required to provide an ox/other animals, possibly for sacrifice.[112] Also PY Cn 814 refers to bulls or oxen for sacrificial purposes.[113] The Neo-Babylonian texts from Mesopotamia (7th–6th c. BC) seem to indicate that an uncastrated strong adult bull was offered to the highest god while lesser gods received younger bulls or a castrated

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[107] Palaima 1989, 101–04. PY Nn 831 indicates an oxherd as a landholder on whose land flax is grown and on which he pays taxes to the centre. Foster (1981, 106) suggests that this oxherd had a supervisory status.

[108] According to Halstead 1999; 2001, 40, but see Killen 1992–93.

[109] See, e.g., Nakassis 2013, 209–10: *a-qi-zo-we* being one of the landholders.

[110] A ratio of 10 litres of barley and 30 litres of draff seemed to be the norm for working oxen in some contexts, see Stol 1995, 195–96. When barley was lacking, the oxen got reeds to feed on (in month XIII), but that was beyond the ploughing season (months V–VIII).

[111] E.g., Killen 1992–93, 101 n. 2: *we-ka-ta(-e):*'working' and mentioned as being in pairs. In any case, pairs were needed to pull a plough or a cart or wagon.

[112] Shelmerdine 2008, 133, 147. Evidence which recalls sacrificial bull iconography is, for instance, known from the Agia Triadha sarcophagus; on the date of the sarcophagus, see Long 1974, 11–14, 61–70; on the bull sacrifice, pl. 31.

[113] Palaima 1989, 104–06; Godart –Tzedakis 1993, 242–43. Cattle bones have also been found probably indicating the left-overs of 1000 people-strong festive (ritual) meals (bones were burnt as sacrifice and deposited in specific places); Bennet 2013, 252. Isaakidou – Halstead 2013, 89, 93 (with references): they contrast the usual bone deposits as typical heterogeneous faunal assemblages (including smaller female cows) versus specific deposits of adult, likely male cattle (age not determinable) and deer where heavily burnt bones were carefully deposited intact in specific places near the Pylos palace, probably after sacrifice. On bulls for sacrifice: Palaima 1989, 110–18.

animal.[114] This seems to correspond quite well with tablets from Knossos and later information about sacrifices to Zeus in which only a 'physically whole' animal was appropriate. It may therefore be a reasonable suggestion that, in the Mycenaean context, castrated animals (i.e. not complete) were not sacrificed to the gods whereas it is fairly standard to cut off horns of working oxen,[115] thus also rendering them incomplete and protecting them from hurting each other and anyone working with them. Both the Pylos wall painting and the Agia Triadha sarcophagus show clearly a large horned sacrificial bull.[116]

5. It seems that *ke-ke-me-na* land (PY Ep/Eb series) is administered and owned by the *dāmos* through its council *ko-to-no-o-ko* (see above). Palatial interest in recording this land lies in the tax commodities it receives from the landholders. Land called *ki-ti-me-na* (PY En/Eo series) was possibly also associated with the *dāmos* as it was granted by the *dāmos* to local elites, the *te-re-ta* (PY Un 718, Er 312), under the condition that these men performed service, possibly of military nature, in return for the freedom to manage and lease out their allocated land plots. These were recorded by the palace because the *te-re-te* contributed tax 'pay' to the *dāmos* which was, in turn, taxed by the palace.[117]

6. Far from all land in the Pylos kingdom is recorded by the palace, an issue well discussed by both Lupack and Halstead who compare textual and archaeological data: the palace would not record land that raised crops outside its sphere of interest and would not record land from which it may not have received commodities through taxation, e.g. privileged land in the hands of religious personnel which was exempt from taxes,[118] and possibly also land that was owned by the *dāmos* and was thus collectively used and supported only the *dāmos* members.[119]

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114 van Driel 1995, 220, 233.

115 Palaima (1989, 106–7) on prehistoric and later references to unblemished bulls for gods.

116 Pylos: Lang 1969, pl. 119; Agia Triada: Long 1974, pl. 31.

117 Lupack 2008, 44–85, esp. 69–72. In the second millennium BC Near East, holding land on royal estates and given as remuneration for delivered services entailed the obligatory contribution of specific produce (linen, sesame, etc.). This was described as the *ILKUM* system well-known from the Code of Hammurabi, see Joannes 2001, 407.

118 Lupack 2008, 84–85; Halstead 2001, 38–39 with further references.

119 Carlier 1987, 72. Bennet (2013, 247) postulates that possibly all land was in the hands of

5. Linear B on personnel and human labour service as taxation to the palace

1. PY An 18a mentions 90 oxherds in association with carpenters, wall builders and men of service. On PY An 852a oxherds are again associated with carpenters in smaller numbers (2–4).[120] Are these oxherds employing their oxen to help out the carpenters and wall builders, and thus maybe collaborate with the men of service?

2. PY An 1 is a taxation document that obliges men to contribute rowing service as taxation. These rowers are seemingly connected to landholdings. The Na series link more generic military services with landholdings, too. These landholders can go in person to serve or recruit and send others instead.[121] Nakassis also mentions specifically named individuals who contribute rowers, such as **we-da-ne-u* who, according to Palaima, is also in possession of oxen, goat and sheep.[122] Some such high-ranking landholders/officials seem to have the obligation to provide workers either directly or indirectly from people they had as their own dependents or people they hired for the requested job; the latter was likely the scenario for the named individuals on Fn 7.[123] Another possibility is that the palace gave men to these high official to start with – e.g. **we-da-ne-u* who received 20 men – who then put them to do different tasks.[124]

3. Several types of artisans were probably recruited to work via taxation: PY An 1282 recorded men brought in to make chariots for the palace in the NE building. In order to make chariots, administrators, specialists and unskilled labour were all needed.[125] PY Un 1322 recorded large amounts of food given as salary to artisans making nets or weaving.[126] The central

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the *dāmoi*, in the Pylos state, since their role was leasing it out.

120 Palaima 1989, 115–18.

121 Nakassis 2012, 269–72 with references for details.

122 Palaima 1989, 107.

123 Nakassis 2012, 283, and not through direct recruitment from the local communities on the basis of landholdings.

124 Nakassis 2012, 274.

125 Schon 2007, 136. The same configuration is needed for building: administrator, specialists and unskilled labour.

126 Chadwick 1964, 20–21, 25; he points out that this tablet is the first record where one commodity is exchanged for another: the disbursement of wheat was paid in amounts towards certain workmen (as salary) or as the price of certain garments.

administration recruited artisans from their home villages to come and produce prestige items for the palatial elites[127] that would confirm their social status through display and distribution and allow their participation in the Mediterranean-wide elite '*koinè*'.[128] Plots of *dāmos* land were given out to specific palatial artisans in return for specific services.[129]

4. The so-called 'collectors' (palatial and religious) received their main income through local transactions with the *dāmos* while their palatial transactions seemed to have been limited.[130] According to the tablets, these collectors may have been owners of substantial resources that are then taxed by the palace. These collectors may have been local lords/chiefs prior to the palace's existence but were given a position in the palatial administration by the *wanax*, possibly to court them into allowing him access to these resources.[131] The palaces thus seemed to have had only partial control over Mycenaean economic activity spheres and only controlled a fraction of the total labour.[132]

5. That highly-ranked named individuals, owning landholdings, provide men to serve the central authority as rowers, or in military service or even as unskilled labour force used in building activities is clear. Among these people, *a-ko-so-ta*, for example, is also known as one of the four Pylian 'collectors'. Moreover, he controls the raw materials for perfumed oil production (PY Un 267) and other craft activities, and functions as a land inspector (PY Eq 213). He is further responsible for distributing male workers (PY An 435), possibly to the *heketas* who is also *ereuter*, named *di-we-je-u.*[133] This latter individual also supervises the collection of oxen as recorded by the palace, traditionally seen as sacrificial animals; however, I wonder if these may have also been involved in working for palatial projects if their own were

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127 Voutsaki 2001. See now recently on the production of prestige items with 'exotic' character: Brysbaert – Vetters 2013. On elites' self-representation in showing their familiarity with exotica: Bennet 2013, 235.

128 Nakassis & al. 2011.

129 Gregersen 1997, 400–03: in relation/contrast to being remunerated in kind/rations.

130 Lupack 2008, 165.

131 Lupack 2008, 165.

132 Halstead 1992, 72–73.

133 Nightingale 2008, 576–77; see also Nakassis 2012, 279, but in 2013, 200, he is more careful about that statement that *a-ko-so-to* provided workers on An 435. See also Nakassis 2013, 233–34.

not sufficient. Moreover, *a-ko-so-ta* also seems to have benefited from or to have owned large flocks (maybe also through *di-we-je-u*?), spread out in both provinces. Certain of his activities show his longer-term involvement as a high official with the Pylos administration (see also his name on PY An 192) with monitoring, planning, controlling and distributing tasks.[134]

Discussion

The political economy of the Mycenaean states, as it is presently understood, clearly saw that an interaction between its palatial component and the non-palatial components was what made up the Mycenaean society as a whole.[135] This becomes amply clear in studying the econometrics of the construction via a *chaîne opératoire* approach: the level of detail (how many men and animals were needed to move *x* tonne?) blurs entirely the dichotomy between the elites and their labour. As Halstead has already pointed out, much of the Mycenaean economy did not seem to be under elite control, and all parties relied on each other to achieve their socio-economic status, their power and their economic independence.[136] To put it bluntly, if the workers could not show up at the building site during specific months of the year due to harvesting which required all their human and animal efforts, no citadel construction was likely to take place during those months. Unrealistic demands would have been very difficult to enforce upon people and crop failure would have harmed the palace just as much due to reduced crop income. Wright correctly points out that the land-reclamation projects and large-scale waterworks, such as the drainage of Lake Kopais and the dam construction at Tiryns, required considerable manpower. These projects reflected an enlargement and intensification of agricultural activities to supply foodstuffs and produce raw materials for the crafts and for the portion of the population engaged in specialized activities.[137] Wright basically points out the obvious but important fact that some people needed to produce extra food for those who temporarily could not do it themselves.

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134 Nightingale 2008, 579–86.

135 Pullen 2013, 439; already hinted at e.g. by De Fidio 2001, esp. 23.

136 Most recently: Halstead 2007.

137 Dabney – Wright 1990, 51–52.

The monumental building programmes of the LBA Mycenaean centres in the Argolid must have involved considerable investments in labour; but can we quantify this in a meaningful way and what do the numbers tell us subsequently? From initial calculations done at Tiryns, transport costs represent a hitherto largely ignored part in which oxen surely played a role. While this is only one aspect of monumental constructing in this period, considering the scale of investments in transport (expressed in labour costs, human and animal) and how they were met might contribute usefully to our understanding of Mycenaean political economies. Investigating the Linear B tablets for both direct and indirect information on any aspect of such extensive building projects is crucial.

While limited and mainly from Pylos, clear Linear B evidence on architectural work is present: repair activities, building materials, workers' assignments and locations, and who these workers were: a master builder, wall builders, carpenters, overseers and unskilled labour.[138] Their social hierarchy is further reflected in their payment rations likely linked to their level of skill, specialty and responsibilities, and the man-days for each of those was calculated for in the study of the UB wall at Tiryns.[139] Such a social structure of labour was also visible in PY An 1282 on chariot production. At Pylos, Hand 3 may have been associated with construction activities.

Oxen were owned by the palaces and the *dāmos*; palatial oxen could be on loan to the *dāmos* during agricultural labour-intensive periods of the year. These oxen were well-looked after and had to be kept in good conditions. In fact, fodder rations were given to specific people who had palatial oxen on loan which illustrates the high value attributed by the central authority to their working oxen or bulls.

Specific oxherds were landholders after the palace likely remunerated them with land plots for their possibly specialised services (which was also the case towards other artisans), and they could lease their possessions out and benefit from the crops. These oxherds had to contribute people and crops (wheat) to the palaces, they may have been looking after the palatial oxen and used them for agricultural work. Moreover, since oxherds were also associated with carpenters, wall builders and men of service, it can be argued that these oxherds must have been helping out the construction crews with their oxen as guides during the transportation of building material from the quarries to the site and at the site

138 Melena 1998; Nakassis 2012.

139 Brysbaert 2014, tables 4–5.

itself since they knew the oxen well and possibly even trained them.[140] As such, landholders, as some oxherds were, could either provide service by doing personal services (e.g. as ox guide) or send out their dependents as unskilled labour when and where needed in the many other construction tasks such as loading and unloading materials, hauling blocks up, digging earth and ramming earth for the ramps (see PY Fn 7). Palaima suggested an association between the oxherds and both the central and possibly also the religious authorities. The oxherd's main activities may not have been under central control even though they were required to contribute flax (from that land) to the palace.[141] Their association likely lay in the fact that they looked after the palatial oxen being under a high official's control who reported back to the palace.[142] As the palace gave plots of land to artisans as remuneration for their services it could also be assumed that land plots may have been the pay for architectural workers too, at least the specialists, supervisors, overseers and master-builders.

The *dāmos* gave land to local elites in return for services and the *dāmos* was subsequently taxed on this by the palace. It was also on *dāmos* land that wheat crops were grown that were taxed by the palace to be subsequently given as food rations for the palatial dependent workers and possibly to their own oxen as fodder during labour-intensive times. These tasks were agricultural but could have been equally well constructional, i.e. the transport of building materials. Finally, the palace recruited the construction crews indirectly, likely via the collectors and the *dāmos* (and its council *ko-to-no-o-ko*) who did the direct recruiting, but also the planning, monitoring, controlling and distributing of resources, both human and animal and related remunerations (e.g. *a-ko-so-to*'s multiple roles).[143]

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[140] Renger (1990, 271) pointed out that the oxen output depended on various factors but mostly on the human ones such as training and how well they were guided during the work, see also FAO 1972.

[141] Palaima 1989, 101–4.

[142] If so, another striking similarity can be seen with textual information from Old Babylonian tablets indicating that the palace put their herds (containing oxen) at the disposal of *land* stewards (my emphasis) who, sometimes, seemed to have also been local governors or overseers of merchants of specific regions; Stol 1995, 180. Simultaneously, the palace also entrusted cattle to low-ranking oxherds, too, who, themselves, were serving a chief herdsman (p. 181).

[143] See Stavrianopoulou 1999 on the organisation of the workforce, membership to groups and professional bodies in Mycenaean society; her category I comprises people belonging to a collective based on their specific skills; for *to-ko-do-mo* belonging to this category, see 1999, 577, 585. Compare the social and interlinked political structures of building organisation in all its facets: DeLaine 1997, 204–5.

It seems then that the palatial elites were not even 100% in control of all aspects related to the construction of their own residences.

Clearly, the Mycenaean central palatial authorities are highly interested in oxen/bulls for various reasons and this fact probably also explains why they are so well-recorded in visible bodily details.[144] Halstead suggests that the importance of the oxen in the Linear B tablets sits in the fact that they are likely located near the centres where also the palatial landholdings may have been and where cereal were thus harvested. He suggests a direct link between oxen and palatial agriculture.[145] When an oxen yoke is used, ten hectares can be worked, of which half are winter cereals and half fallow or summer crops. A minimum of four to five hectares was needed (i.e. for the winter cereal) to justify having an oxen pair which would produce enough food for a large family of several generations or yield surplus. Three hectares corresponds well with what a family of a subsistence farmer would need to survive (between two and four hectares) and it would also cater for significant crop failure of a nuclear family.[146] It is tempting to look back at all recorded landholders on the Linear B tablets whose plot size is known to see whether they could work it by hand or needed oxen and whether those with larger plots also had oxen or worked with additional labour in busy times.

Small landholders who could not afford oxen could rent or share them or use other animals for ploughing.[147] Renting and sharing, however, included risks since one had far less control over when one could plough or sow and this could

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144 For the most recent discussions of the oxen names and their relationship to later Greek literature, see Kajava 2011; 2012.

145 Halstead (1995, 18–19) sees a similar trend in the Near Eastern tablets which also record extensive cultivation with plough and oxen in elite contexts while small-scale cultivation was connected to the society as a whole. See also note 102.

146 See Halstead 1995, 15–17. I thank the reviewer for bringing to my attention the significance of three hectares and crop failures. Renger (1990, 267) reports the importance of the balance between the maximum possible plot needed for cereal production versus the minimum land area required for pasturing the animals that work the land for cereal production. Furthermore, the labour output of a given ox depends on the breed, the individual animal and its training and guidance, its speed, the length of time of sustained labour and rest periods, the feeding it gets and bodily care (typical yoke sores, foot and hoof wounds, broken legs). He gives further details on the food and water needed during working seasons and concludes that the role of the human in ploughing, training, guiding, feeding and care was the decisive factor in the animals' labour output and the effectiveness of the animal power at hand. Extra feeding regimes prior to heavy labour periods, for instance, were crucial to the animal's success.

147 See Isaakidou 2006.

cause lower yields or even crop failure.[148] Old Babylonian texts indicate the existence of shared ownership of oxen and that hiring oxen was expensive. Moreover, a strong rear ox was more expensive than the middle ones when plough spans consisted of more than the usual two plough oxen together under one yoke.[149] The price was expressed in barley or silver shekels (where a shekel equals one kor of barley). The use of oxen required for transport of building material would have created an additional demand on the time the animals needed to be working and increased the crop-related risks to the farmers.

Inasmuch as Halstead sees a direct link between the oxen and palatial agriculture, it is not far-fetched to also see a link between at least the palatial oxen and monumental building programmes as well. Moreover, the oxen which are so well-recorded in the tablets must have been the palatially owned ones: when the palace leased them out for agricultural work to the *dāmos*, it likely levied an income from the harvested wheat crop they were used for, so in fact, the wheat return is on the crops but likely on the use of the oxen, too.[150] Finally, the oxen that were levied from various people (from some of the rowers who owned land too) may have ended up in the palace for work as well.

Why is there no mention made, either at Knossos or Pylos, on the use of oxen in construction? While the production of chariots, textiles, *kylikes*, perfumed oil and monumental architecture has been placed firmly under central control[151] oxen used in the traction of construction materials were not needed in LH IIIB

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148 Halstead 1995, 17.

149 Stol (1995, 188–91) mentions textual evidence whereby ploughing could be drawn by two, four, six or eight oxen when deep ploughing and opening new land was intended. However, ploughing with more than two oxen in one yoke was only done on large estates of 'public' institutions, probably because only those could afford this set-up. He mentions the controversy around these large numbers of oxen involved, especially since deep-ploughing only really needs a heavier plough, not four animals to pull it.

150 That this income in wheat cannot be seen as a 'tax' income per se is clear from Perna (2004, 294) who makes the difference between privately-owned land which can be taxed, and leased land for which a form of fee, dues or a contribution (Perna's 'redevance') can be required in return. In a similar way, Halstead (2003, 260) argues for different ways of resource mobilization: through taxation, share-cropping and exchange. Also the cattle could have had a different fiscal status, see e.g. Piteros & al. 1990, 183–84. Such proportional sharing partnership can also be recognised in the Near East where pasture land for oxen was mentioned in Old Babylonian tablets but did not come for free. It was either paid for in silver or in specific amounts of barley; Stol 1995, 188 n. 60 and n. 188.

151 Schon 2007, 142.

Pylos since during that period large-scale masonry was not used.[152] Pylos also did not require the transport of Cyclopean-size blocks as was needed until the LH IIIB Final phase in Tiryns.[153] So far, only at Pylos and Knossos have major archives been discovered and while the Tiryns tablet evidence is rather small in comparison to the Knossos and Pylos archives, it seems, however, indirectly useful in the context of architecture and its related transport activities, and this may not be purely coincidental. Moreover, tablets recording architectural work may not have survived and the palace was not *directly* recruiting labour and animals for the work to be done, but possibly only indirectly via other agents and thus did not record these recruitments.[154] Equally likely, the centres did not record these activities because they were so obviously palatial and were not bringing in any form of taxation from which they would benefit (in a similar vain, see point 7 section 4). They were clearly building for themselves and if anything would be recorded it would be remunerations of sorts (in kind/land) for the workers and the specialists involved. Since the tablets reflect the economic activities of particular years, perhaps none of the economic activities of interest to the palace linked with construction took place in the year and season from which the tablets accidentally survived in the various centres. It has been pointed out recently that each Mycenaean state should be studied in its own right since differences are potentially as common as similarities between them. As is also evident from this study, the tablets from specific places cannot be employed to over-generalise or to argue for much unity within the economic sphere of the different Mycenaean states. There are obvious differences in the construction techniques and materials between the centres and this may have been indirectly reflected in the respective administrative recordings, if of relevance to the centres in one or another way.

Oxen were clearly important in the context of architectural construction and this can be observed in a various ways. Moreover, employing these traction animals in combination with large enough building crews had wider-reaching economic and thus social implications.

1. There seems to be enough evidence for the presence of working oxen by the LBA to warrant their potential usage beyond agriculture, i.e. in architectural monumental construction.

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[152] See Nelson 2001, 55–58, 180, fig. 84. In LH IIIB, it seems, Pylos only built with the pier-wall construction method.

[153] See Maran 2010 on the last changes on the UB wall in that phase.

[154] However, cf. Nakassis 2012.

2. Human labour capacity is understood well, especially when large numbers of men were available to work collaboratively. However, there are limits to what people are physically able to do[155] and the types of work to be carried out in monumental construction can go beyond these limits. Based on what we know from Classical Greece[156] and Near Eastern contexts about oxen employed in construction work, it is fairly safe to assume that the same was the case in the Mycenaean LBA building programmes, especially when massive stones were moved.

3. Having calculated the size, volume and mass of the limestone building blocks from the UB wall at Tiryns, it becomes obvious that additional labour by oxen would not only have speeded up the work but would have also made it possible over the covered distances. With c. 65% of large-size blocks of 2–13 tonnes,[157] c. 25% of medium-size blocks of 500 kg–2 tonnes and c. 10% small-size blocks of 30–500 kg, human crews would have fared much better with the help of (multiple) oxen spans.[158] In addition, a block the size of the Tiryns bathroom floor, 23 tonnes, may have needed 200 men pulling simultaneously, according to a recent experiment. If its quarry was just 1 km away, it would take this crowd minimum 1.5 days to just drag it over to the site.[159] If we then push the situation to its limits as far as Greece

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155 According to Landels (1978, 9), a healthy adult person can carry between 9 and 36 kg, most often between c. 23–27 kg of load over short distances of c. 50 m, depending on the strength, gender, age and health. These figures were surely higher for healthy male adults, both in amounts and distances, as some can now carry 50 kg cement or plaster bags over distances of 50–100 m. Moreover, even if joint efforts were planned, one still had to be able to fit, physically, the necessary amount of men around the heavy burden for it to be picked up and moved. Landels (1978, 9) gives an example of this: a Classical column drum would have needed c. 18 strong men to lift, turn and place it where desired but it would be impossible for the 18 men to fit around such a column drum. As mentioned before, these numbers seem far too high and the best parallel that can be found from photographic evidence are the workers from Carrara who had extensive experience in pulling heavy blocks forward, both by hand and by means of oxen yoke(s); *Il marmo...ieri e oggi* 1970, 74, 88–95.

156 On such engineering discussions, see Burford 1960; 1969.

157 Mylonas (1966, 12) mentions stones from Tiryns weighing up to twelve tons which corresponds well with my calculations, Brysbaert 2014.

158 For detailed resource calculations, see Brysbaert 2014: tables 1–9.

159 Details in Brysbaert 2014 and note 161. If oxen were used instead, a minimum of 25 oxen yokes (50 oxen) would be required; these would cover 1 km in one day but would also need two dozen oxherds to manage an organized traction. However, Renger (1990, 271) points out that even if guiding through oxherds is very well coordinated, there is loss of effort when several

is concerned,[160] the conglomerate lintel stone of the so-called Treasury of Atreus, Mycenae, weighing 120 tonnes[161] (not the only large stone in the construction, see the *dromos* blocks and the overall result[162]), would need 120 to 150 yokes of oxen to move it from the quarry to its location, based on the calculation of 800–1000 kg per oxen yoke. This does not include efforts required for moving it where it now still is. Whereas 18 men were needed to lift (vertically!) a one tonne column drum, calculating c. 2,200 men to move the Atreus lintel[163] is highly overestimated since the movement is largely horizontal; a more realistic calculation for an oxen yoke versus men is 1 : 8.[164] Instead, c. 1000 men may have moved the 120

yokes are used together due to mutual obstruction of the animals, see also FAO 1972, 24, 27.

160 Adam (1977, 51–52) discusses the transport and the handling of Baalbek's trilithons, world's largest monoliths apart from those left in the quarries. These blocks each weigh c. 800 ton and no oxen were employed in their transport for reasons explained above by Renger. We have to consider, though, that the Romans had access to lifting devices, cranes and pullies (Adam 1977, 60) which are well-known from various sources (textual and iconographic: Adam 1977, 41), which were not available until the latter part of the 6th c. BC; Coulton 1974.

161 Mylonas 1966.

162 The relative densities of conglomerates vary widely: essentially they are very coarse sandstones and their individual densities depend on the inclusions, their type and the ratio between the inclusions and the matrix; however, some conglomerates are very suitable for constructional purposes. For details on the stone masses of the Atreus Treasury: Cavanagh – Mee 1999, 96–97.

163 See the difficulties in the experiment of moving a 25-tonne obelisk in Egypt under the direction of M. Lehner and stone mason R. Hopkins with 200 men at the ropes and levers; see *http://www.pbs.org/wgbh/nova/egypt/dispatches/990314.html*, accessed 30/11/2012. These data is not dissimilar to Koutsoumpas and Nakas (in press: 6) whose triremes of 21 tonnes were pulled across by c. 200 men.

164 If 200 men pulled 25 tonnes (see above), and 1 oxen yoke pulls c. 800–1000 kg, c. 25 oxen yokes would have pulled 23 ton, in line with 35 yokes who pulled c. 32 tonnes (Carrara), these figures show each time a ratio of c. one oxen yoke : 8 men. Oxen, however, can pull with large force for much longer periods of time. That such mobilization of workforces and efforts done by both human and animal resources always needs to be contextualised is clear from a recent paper on the moving of the Moai on Easter Island. A replication experiment showed that these statues 'walked' with a minimal amount of people employing ropes, and no traction animals or wooden rollers were used. This experiment, based on well-studied archaeological evidence, illustrated that previous studies did not take into account the large variation of Moai statues, nor were the broader archaeological contexts studied in enough detail, such as the road systems along which these statues had to travel from quarry to the *ahu* (platform); for details, see Lipo & al. 2013, 2860–65. It is, therefore, crucial that the 'Set in Stone?' project places the Tiryns study in the broader context in which it was embedded originally, see Introduction.

tonnes lintel block forward with low inclination[165] and possibly c. 25 oxen yokes moved the bathroom floor block to Tiryns. This latter number is not exaggerated in comparison to the c. 35 oxen spans employed to pull one of the largest Carrara marble blocks cut in the early 20th century with an estimated weight of c. 32.5 tonnes.[166] However, with or without traction animals, the pure organisation of the moving of massive blocks would have been considerable since much effort is lost in employing multiple oxen spans. What would be guaranteed, though, is a memorable public performance for the workers, spectators and organizers alike, whether caused by the bathroom floor block or the conglomerate blocks employed at the East Entrance of the Tiryns citadel. Even though the massive lintel and other such blocks at Mycenae did not need to travel over long distances, they certainly would have been the cause of immense spectacles, too, due to their sheer size and the organised concentrated efforts needed to get them in place, probably by employing everyone around.[167]

4. Attempting to calculate the capital and running costs of large numbers of oxen spans and their oxherd guides may give an indication about the figures that are implied in terms of fodder to be generated and pasture land for grazing, labour required to work them, and labour to rear the oxen and train them. Pullen pointed out that in the EH II period, possessing a pair of oxen would be both care- and fodder-intensive, thus limiting the amount of farmers who could afford it.[168] Those that could afford oxen were in a position to lease the oxen out to others and to create higher production rates on their own land, thus accumulating a form of wealth based on surplus. This accumulation of wealth could have led to social and political status differentiation and to differential access to means of production, so a hierarchy of wealth, status, and power, headed by an elite, would emerge. One can imagine the oxen- and plough-owning farmer becoming the 'big man' in his community[169] and this may still have been the case in the LBA

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165 See Cavanagh – Mee 1999, 96, 100.

166 *Il marmo ... ieri e oggi* 1970, 94.

167 This is described by Santillo Frizell (1997–98) as a Via Triumphalis when blocks of massive size were hauled over to their final destination by huge crews, ordered and/or overseen by the ruler himself. I thank J. Maran for bringing this paper to my attention.

168 See also Halstead 1995 on this topic.

169 Pullen 1992, 53. Cato *agr.* 54 describes how much oxen should be fed extra during the heavy ploughing season (March-April) versus the other seasons and that this can be done based

Mycenaean palatial contexts, based on long-standing traditions, culminating in this palatial context, too. Halstead also discusses in great detail the question of how oxen were expensive both in capital and running costs.[170] The male animals were castrated around their third year[171] which meant that, until then, they just required care, food, and had no output yet.[172] For breeding, large pasture land plots, such as those known from the Linear B tablets for the Pylos region, were needed. Once the animals were put to work, additional food was crucial to compensate for the extra burnt energy and the lack of grazing time.[173] Moreover, if crops for fodder were grown, extra human labour may have been needed throughout the arable farming cycle to make this possible.[174] If the oxen were critical for agricultural activities and a cause of worry to small landholders, adding the request for these oxen to be available for construction for prolonged periods of time, stretched over several years, could have made or broken specific social classes, depending on how dependent their land and thus subsistence income would have been on their oxen rearing and subsequent working. From this perspective, the use of spread-sheet models, as a way to space out

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on what the farms produced, and thus kept 'on the cheap'.

[170] This question is also addressed by Palaima (1989, 102) who wonders whether Mycenaean grain production for its dependent workers would also produce surplus which could be fed to their oxen and which types of activities would warrant feeding such expensive crop to their traction animals, such as possibly fattening them for sacrifice. I would like to add to this strengthening the oxen before heavy intensive prolonged labour needed to be done.

[171] They were sometimes kept in the herd for another year to mature and become strong; see Stol (1995, 184) on Old Babylonian texts.

[172] See, e.g., Stol (1995, 177–78) who refers to Old Babylonian cattle breeding stations where male cattle were castrated and trained from year three onwards and then put to use. This change from bull to ox is reflected in the names of the 1–3 year-old animals: 'ox yoked to wooden implement'. The wood can refer to both the yoke but also to a wagon and, therefore, designates a trained ox (1995, 185). If they were not castrated, they may have been fattened to be sacrificed in the *nabrû* festival. Of further interest is that the breeding of the 1–3 year-old bulls was taken care of by princesses and were often part of the bride's dowry on which she was supposed to make a profit (1995, 180).

[173] Halstead 1995, 12.

[174] Halstead – Jones (1989, 47–49) and Halstead (1995, 13), emphasizing that farmers are already under time-stress during harvesting and threshing times, the former which cannot be delayed. Moreover, this time-stress is often not taken into account in the required labour of farming in antiquity (1989, 53). The same can be said for when construction is added into the equation.

the activities that are realistically achievable by active workforces for construction, serves very well to visualize the potential spread-out of planned labour-intensive activities while it can include other tasks too, especially agricultural tasks that are bound by specific seasonal-intensive activities that absorb all available hands. At a smaller scale, spread-sheet models also allow for unskilled labour to be called in to work whenever needed by the more specialist work crews. While of course a modern tool, spread-sheets may reflect the potential planning of architects and engineers to get large-scale and long-term jobs done.

5. If a minimum of five oxen spans and c. 82–109 men were needed, year round, for the construction of the UB wall alone for at least three years (but likely longer) and if similar activities were conducted at around the same time elsewhere in the Argolid such as the fortification walls at Midea and the expanded parts at Mycenae, it becomes possible to place the necessary resources in their socio-economic context. Even if the time estimated on the basis of the preliminary calculations of the UB wall is doubled, so calculating six years instead of three and thus allowing other important work such as agriculture to be conducted, we arrive at the following hypothetical figures:

   years one & two: 82 men + 5 oxen teams (10 oxen accompanied by 5 men) = 87 men + 10 oxen

   years three & four: 96 men + 5 oxen teams (10 oxen accompanied by 5 men) = 101 men + 10 oxen

   years five and six: 109 men + 5 oxen teams (10 oxen accompanied by 5 men) = 114 men + 10 oxen

   These numbers do not sound excessive in themselves but should be seen as representing a part of the total *active* workforce that may have been living in or near Tiryns. In order to estimate population numbers in the near vicinity of Tiryns, figures can be deduced from Pylos (15 ha[175] with 3000 inhabitants[176]) and Mycenae (32 ha with 6400 inhabitants[177]), as an exercise. This is supported the systematic approach of Hansen's shotgun

[175] Shelmerdine 2008, 148.

[176] Davis 2010, 687.

[177] Bennet 2013, 245.

method whereby small to medium-sized poleis are calculated to have 32 to 33 houses per hectare within the walled area of the poleis and that each house would allow six people to live there.[178] This results in approximately 200 inhabitants per hectare and matches what has been calculated for both Pylos and Mycenae. Following these calculations, the population figure for Tiryns, covering 24.5 hectares,[179] can be approximated as 4900 people. An average of 100 men and 10 oxen would be needed for a period of six years part-time for the construction of the UB wall alone. If we can follow the estimate that one in four of a general population is an adult male and thus represents the *active* workforce of that population,[180] this means that the 100 men form c. 8% of the active workforce of Tiryns (or 5.7% or 4% if Tiryns covered 35–50 ha after Wright 2004a). These figures, though, need to be taken as rough estimates only since they are derived from different sources, here brought together for the exercise: inherent dangers in employing such figures have been pointed out[181] and should be kept in mind. As I said, these figures do not include supportive activities towards the building industry. The five oxen yokes, converted into agricultural work, would be able to plough 50 hectares between them.[182] However, if other large-scale building works needed to take place as well, such numbers may have had to be doubled or tripled again, unless such projects were carefully scheduled sequentially, by Mycenae, for instance, in collaboration with Tiryns, Midea and possibly Argos. *If* these projects had been done in sequence, as can be suggested and visualized by the spreadsheet model, this could imply three things: (1) possibly a constant amount of people were at work, from one project to another, over longer periods of time during agricultural slack times; (2) such sequential work may have been done on purpose in order not to stretch the resources of both skilled and unskilled workers available in the realm of the Argolid and near Tiryns more specifically; (3) this chronological spacing of building works between centres in the Argolid, *if* done as suggested here (but there is no proof for this and several *may* have

178 Hansen 2006, 51, 59, with varieties possible.

179 Shelmerdine 2008, 148. But see Wright 2004a, 121, mentioning 35–50 ha for Mycenae and Tiryns.

180 After DeLaine 1997, 201.

181 Iacovou's 2007 paper is a real eye-opener in certain persistent size estimation figures for LBA Cyprus.

182 See the discussion below and Halstead 1995.

been going on simultaneously, for any variety of reasons), may help in considering the sequence, and the inherent fine-tuned chronology of these works, in which these were conducted.

6. Oxen traction (or any heavy transport) would not be advisable, or would be even impossible in the rainy seasons due to muddy and thus slippery road surfaces.[183] The amount of work oxen could achieve per day depended on the size and health of the animals, the soil they worked and the weather before and during the ploughing, the distance from farmer's base to the fields, among other factors.[184] Several of these factors would affect the employment of oxen for heavy burden transport as well, causing e.g. delays.

7. Finally, one may wonder if the circles on TI Sl 8–10 from Tiryns show unspoked wheels and may be meant to be a solid wheel and not a spoked one, possibly of a wagon or cart. In such a case, this situation could refer to repairs of these vehicles by replacing single broken wheels. From Old-Babylonian texts of the Diyala region (East Iraq), wagons there were issued by the authoritative institutions, including the palace, for the harvest season. Each wagon required two men, an oxen pair pulled the wagon while being linked to the yoke; in Chagar Bazar (North Syria) and Shemshara (Northeast Iraq), oxen are associated with *majjaltum*: the wagon or sledge.[185] Wagons could have been used for the transport of heavy blocks, too, as we see in the photographs of the 19th century AD Carrara marble transport.[186] If we were to draw the parallel to the Mycenaean context, the palace would potentially provide both oxen and wagons for monumental and large-scale construction since the latter were likely used for this specific purpose.[187]

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[183] This was already pointed out by Müller 1930, 208. While being on fieldwork in Tiryns during the time of writing (early November), the weather turned from very dry and sunny to extremely wet and muddy with torrential rains that took place in the span of 20 hours and turned the terrain into inaccessible pools of mud in places where the surface was uneven and drainage was poor. However, on flat ground and packed earthen surfaces, most of the water was led away and absorbed into the ground during the next day. If road surfaces consisted of well-compacted rammed earth with good drainage on both sides, it may have been possible to use them even under partially rainy conditions.

[184] Halstead 1995, 13–14.

[185] Stol 1995, 185.

[186] Wagons with solid wheels (*Il marmo ... ieri e oggi* 1970, 94–95) and with spoked wheels (p. 91, for smaller loads) were used at the Carrara quarries.

[187] This fits very well with Cavanagh – Mee (1999, 96) who state that these heavy carts were

Concluding remarks

"Since architecture is an expression of socio-political configuration, architectural changes over time may reflect different political strategies in discreet spatial, temporal or socio-cultural circumstances".[188] In the LH IIIB Mycenaean context, the palaces would have mobilized materials and people where needed to obtain their quota of luxury commodities that served to display their status and prestige. Furthermore, distribution of such goods was an expression of their wish to be included as a part of the East Mediterranean exchanges between the elites and they were part of this system to some degree. These actions consolidated the centres' power and prestige[189] through large-scale public events such as feasting.[190] Wright suggests a close link between feasting and mobilizing labour in the context of massive building programmes,[191] and since monumental architecture was a way of displaying high status, feasting may thus be seen as part of palatial planning in creating societal bonds and obligations that could be called upon for future work. The feasts acted also as remuneration of successful finished building projects.[192] Inasmuch as substantial feasting impacted on large and diverse groups of the population of a given territory, it seems probable that the same can be stated about building activities as well, especially if we consider how these came about and which resources were tapped for that purpose. Workers involved in such tasks were not likely to have been employed full-time throughout the year; some may have combined oxherding with the transport of building materials, but were called upon when needed, as would have been the case with unskilled labour. This could likely be done in the form of requesting labour through taxation as was the case for military service, crafting, rowing and other such tasks. Some persons belonging to this labour force may also have been requested to deliver traction animals, or the palaces could have called upon the resources, human and animal, of high-placed officials within the realm of their territory. These people likely had land plots at their disposal and could have been asked to deliver labour

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likely built for the occasion.

188 Englehardt – Nagle 2011, 357.

189 Nakassis & al. 2011, 180.

190 Halstead 1992; but based on group membership: Nakassis & al. 2011, 181.

191 Wright 2004b, 167 with references.

192 One could compare such a feast with the traditional 'glenti' held after a successful excavation season where also the work for the coming season is discussed between excavation directors and the workers' foreman.

services in return for the use of the land. Tablet Fn 7 shows that there were social differences in the ways the palace may have been remunerating its people since some workers received daily rations of food for the work done (wall builders and sawyers) while others, the named individuals, received large rations, either as compensation for bringing and overseeing unskilled workers or to pay these unskilled workers their daily wage. As such, working in construction would have affected a wide range of people and their families, and intersecting social groups, with or without land or animals. The social implications of how these political instances and different groups (palace, religious institutions, *dāmos*, skilled and unskilled people) operated economically and socially with each other are among the most important aspects of this study.

The estimated figures of human and animal labour at Tiryns outlined at the start seem small[193] but they only give a minimum estimate for the UB wall construction. As 'Set in Stone?' continues to collect also published data from beyond Tiryns, on construction projects of the LBA Argolid, and into the post-palatial period, these figures will be revised and fine-tuned to include information of architectural phases set against the work done per phase. When these figures are subsequently compared with the estimates of the size of the active working population, it will become possible to suggest how and how much these building activities in the Argolid, alongside the other daily activities impacted on the Mycenaean society as a whole. It is already clear that while involved in constructing these men and animals could not do anything else and thus needed constant support for their food and tools, indirectly resulting in work opportunities for others.[194] A thorough and fine-grained chronological study will aid in solving these pending issues.[195]

The research literature is filled with references to 'huge' or 'enormous' workforces envisaged as being engaged in monumental construction in the Argolid, but the data presented here and later in the project will result in a better-argued indication of the level and type of influence (if any) the large-scale building programmes may have had on local resources and in the demise of the palaces at the end of the 12th c. BC. Overstretching the population through these construction programmes by the palace powers has been seen as one of the possibly

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193 Compared, for instance, with the numbers reached by DeLaine for Roman imperial construction projects (1997, 193–94).

194 See Lepetit (1978) on such exponential effects during the building works at Versailles.

195 See Maran (2008; 2010) for two building phases of the UB wall.

many (economic and other) reasons for the collapse of the palatial system.[196] The tablets make clear, however, that this mobilization of workforces certainly was not just in the hands of the palace alone, far from it. Therefore, it is all the more important to understand the numbers of people involved in such projects, the full context of the building programmes and what was their relation to the size of the active workforce present per period. It is clear from the Linear B tablets from Pylos, especially An 35, that wall builders were not recruited from beyond the immediate palatial area *because large numbers of them would have been needed*. Instead, their recruitment from further away had, most likely, much more to do with their well-known skills (same practice as for other crafts) or possibly with their personal relationship with the recruiters.

The process of architectural construction – thus *not only* the end-product – may now be understood in the context of the socio-political structures at work in the LH IIIB phase. Once decisions were made to build (by the *wanax*), he must have met with a master architect (or perhaps several architects) to commission the start of the preparations for the procurement of raw materials at the sources, e.g. stone at the quarries and wood from the forests. Also, the authorities at Mycenae and Tiryns must have co-operated for Mycenaean conglomerate to be used at Tiryns. These raw materials were brought to the centres by means of men and/or oxen with wagons or sledges. These materials came, when possible, from nearby the construction site but sometimes also from a certain distance, thus requiring considerable efforts. Such efforts possibly evoked plenty of public attention and thus added value through the technological effort and the potential for a public spectacle embedded in the activities such as transport by means of masses of people and animals (e.g. the transport of conglomerate blocks to Tiryns). The strength of the men involved may have materialized, over time, in the mythological stories of the Cyclopean giants, as if through Chinese whispers. In the meantime, tools, equipment, food and other materials employed during these activities had to be produced and brought in, thus employing a wide range of people with a wide range of skills and capacities. Investments in large-scale construction projects invariably had far-reaching social and economic effects on the population as a whole. Both skilled and unskilled builders and artisans added value to these raw materials[197] by turning them into finished composite multifunctional and impressive structures which were, at least in part, well-planned in advance (cf. the planning and construction of the drainage systems). These end products

[196] See note 1; De Fidio 2001, 16 and n. 12, n. 49, n. 53; also Galaty – Parkinson 2007, 14–15.

[197] See also Brysbaert – Vetters 2013.

then became imbued with even more value and meaning through their selective consumption where only specific high-ranked persons had access to the inner core of complexes while the masses knew only them from the outside.[198] As such, the overall value was imbedded in getting the building materials from various distances and getting people's attention, by employing considerable and available workforces (human and animal), by composing and building, and by finally utilizing the complexes. Gaining the elevated status was a social strategy of the ruling class to be part of the LBA East Mediterranean elite *koinè*[199] consisting of the large empires around. As such, these monumental palaces materialized various social relationships, personal bonds and palatial ideologies, over and beyond defensive ones while the local population, involved directly or indirectly in the construction of these were equally joined together through their labour efforts.

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198 See the idea of who was present and where, what each ate and with what table ware during public feasting activities: Wright 2004b; Bendall 2004; Issakidou – Halstead 2013, 92–93.

199 Brysbaert 2008, 24–25, 83, 184.

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