

Chapter 6

The Economic Archaeology of Roman Economic Performance



Willem M. Jongman

Abstract Recent years have witnessed a paradigm shift in the study of the Roman economy. Methodologically modern economic analysis is now far more acceptable than it once was, and archaeology has become the major source of empirical data for many questions. On the substantive side there is now a far clearer appreciation of the major changes that the Roman economy underwent, with substantial growth of population and aggregate production and even some improvements in standard of living, but followed by equally dramatic decline. This economic success was not limited to the imperial core, but also extended to the provinces.

Keywords Economic analysis · Roman Empire · Demography · Living standards

6.1 Introduction

‘What did the Romans ever do for us’? Few have nailed the fundamental question of Roman provincial history and archaeology with greater precision than the Monty Python team in their ‘Life of Brian’. To put it more academically, the question of Roman economic performance should indeed be the core of research on the Roman economy: how well did the Roman economy succeed in providing scarce goods and services to its population, and how does that performance compare with earlier and later periods of preindustrial economic history, or in other regions of the world, such as beyond the frontiers of the Empire, or with a faraway Empire such as China?

For decades, however, this fundamental question has been ignored by ancient historians and to a lesser extent by archaeologists. Until the mid-1960s the dominant paradigms in ancient history had been that of the philological tradition that isolated the study of Greco-Roman society from the dominant narratives and methodological advances in other periods. Ancient history was a backwater taken less and less seriously by more modern historians, or by society at large, and quite rightly so.

W. M. Jongman (✉)

Department of History, Rijksuniversiteit Groningen, Groningen, The Netherlands

e-mail: w.m.jongman@rug.nl

© The Author(s) 2019

P. Verhagen et al. (eds.), *Finding the Limits of the Limes*, Computational Social Sciences, https://doi.org/10.1007/978-3-030-04576-0_6

95

This started to change in the 1960s, and that change owed much to the towering eminence of the late Sir Moses Finley. Educated in America, and principally as a social scientist, he began to ask fundamental questions about the nature of ancient society, about antiquity's place in world history, and about our methodologies (Finley 1985). Introduced to his work by my teachers, for me as a young student it was a breath of fresh air and at the first opportunity I moved to Cambridge to work with him.

Yet, for all its uniquely innovative qualities his work was also a very particular take on comparative social history, steeped as he was in a very personal mix of neo-Marxist thought, substantivist economic anthropology, and later also Weberian sociology. As a result, Classical Antiquity was reduced to a relatively primitive forerunner of the Medieval and Early Modern economy, without integrated markets, with only small-scale trade and manufacturing, and with a low standard of living for the mass of the population (Jongman 1988). His explanation was a cultural one: the Greco-Roman elite disdained involvement in trade and manufacturing, and hence these potentially innovative sectors of the economy remained small and underdeveloped. The wealth that no one could deny that there was, given the splendour of elite residences in, for example, Pompeii, or the impressive public buildings of many Roman towns, was ultimately the product of rent extraction by the elite and of provincial exploitation. So altogether the picture of the Roman economy was a quite pessimistic one, unless you were rich. Standard of living of the mass of the population was and remained barely above minimum subsistence, there was little or no economic growth, and for many provinces inclusion into the Empire meant plunder and hardship. In contrast, and in a kind of post-colonial discourse, pre-Roman society was often viewed as successful. The resulting picture was necessarily a static one, and also implies that Late Antique decline was vastly exaggerated by earlier scholars. With Peter Brown, the world of Late Antiquity was one of transformation rather than decline (Brown 1971).

Methodologically, in Finley's view, and in line with his earlier mentor Karl Polanyi, the alleged absence of economic growth and innovation and of a market economy implied that modern economic analysis was useless as a tool: Antiquity was different. The gap between this and what other innovative social science historians were doing at the time was enormous, and as a result ancient history remained intellectually separate from mainstream historiography—it still remained what Finley himself once critically called 'a funny kind of history'.

Recent years have seen a major paradigm shift, however. That shift has happened along two lines. The first was theoretical and methodological. The aversion to modern economic theory had created an unholy alliance between modern substantivist social science historians, traditional philologists who abhorred having to learn the mathematics of economics, and fashionable neo-Marxist demands for an alternative economic theory. I guess my book on the economy and society of Pompeii was the first explicit critique of all this, and the first example by a professional ancient historian of how one might apply the logic of the dismal science of economics (Jongman 1988). I tried to show that using modern economics does not immediately make Antiquity into the mirror of the modern world. In fact, I used it to unravel the logic

of Roman economic stagnation and underdeveloped such as I perceived it at the time. The book was widely reviewed, but the shift in the theoretical paradigm was hardly noticed, even if not criticized either. However, all this did change in more recent years. The turning point was the work for the Cambridge economic history of the Greco-Roman world, and its publication in 2007 (Scheidel et al. 2007). It reflected the two lines of the paradigm shift: the use of economics, even if of the neo-institutionalist kind, and the second more substantive of the introduction of archaeological data into the debate on a scale not seen before (best examples in Greene 1986 and Brun 2012). And indeed, the inclusion of the vastly increased corpus of archaeological data has critically changed the content of recent debate, from one that was mostly concerned with the paucity of data, to one that needs to harness an unheard-of quantity of data in a systematic way.¹ Not surprisingly, therefore, aggregate statistical analysis has become a highly productive tool, changing both ancient historians' apprehension about statistics, and challenging archaeologists' post-processual dislike for generalization, and their insistence on the unique and individual. In short, I think we, ancient historians and archaeologists, have finally become grown-up numbers of the historical discipline.

6.2 How Can We Understand the Roman Economy?

6.2.1 *Estimating Population Numbers and Demographic Trends*

So how can we understand the Roman economy? What are the most important variables that an economist wants to know about an economy, how can we know about them, and what have we learned about them and what not (yet)? The most important variable in human history is that of population numbers. How many people were there, and how does that relate to resources and to aggregate output in particular? Remember: per capita income, the most common measure of personal prosperity, equals total production/consumption divided by the number of people. The long-term trend in human population history has been decidedly upwards, and increasingly so. Data are highly speculative, but what all estimates have in common is that for a long time the planet was pretty empty. The most commonly quoted estimates are from McEvedy and Jones (1978), who estimated that at the beginning of the Neolithic world population was only four million. This slowly began to increase in the Bronze Age, and from then on at an increasingly rapid rate as well, particularly since the Industrial Revolution. Their estimate for world population at the beginning of the first millennium is 170 million, and this is a very low estimate. It implies that roughly a third of world population lived in the Roman Empire, another third, or a bit less, in Han China, and yet another third in the rest of the world. For the Roman

¹The Oxford Roman Economy Project is the best example of this trend.

Empire, this is based on the relatively low estimates by Beloch, about a century ago (see Scheidel 2007 for an overview). These, however, are increasingly criticized, with alternative estimates up to about 90–100 million for the Roman Empire. In the end, these estimates are little more than wild guesses, without much in the way of hard empirical data. Also, they tend to be quite static, pretending to be valid for long periods of time.

Recent archaeological research has begun to address both problems, using field survey data. The method is to assign hypothetical population numbers to particular site types, and multiply these by the number of sites of that type. For long-term population history Andreas Zimmermann and his team have produced an impressively robust population reconstruction from the early Neolithic to the Early Modern period for the Rhineland, using unique data from the lignite mining region (Zimmermann et al. 2009). Apart from the rapid rise in the modern period, what really stands out is the dramatic peak in the Roman period, with populations some eight times higher than in the pre-Roman Iron Age, and some 13 times higher than in the subsequent Merovingian period. What these Rhineland data lack is sufficient chronological resolution (but more precision is easily possible). What they have in their favour is the exceptionally long timeframe. And it is precisely this long timeframe that shows that the Roman period is indeed extraordinary, even in relatively remote provincial areas: for northern Gaul (north eastern France, Luxembourg and Western Germany) Xavier Deru (2017) has recently demonstrated a similar trend of rapidly rising site numbers followed by a steep Late Antique decline for a multitude of regions, this time with much greater chronological resolution and smartly using index numbers rather than absolute numbers for the site numbers to make them comparable. The weakness is of course that these are site numbers and not people.

To move from site numbers to numbers of people, Lisa Fentress (2009) has pioneered assigning putative numbers of inhabitants to the different site categories, and then multiply these for the number of sites in that category. Since then, archaeologists from the University of Groningen team have applied the same methodology for the Nettuno data of their survey in the Pontine region (De Haas et al. 2011; Fig. 6.1).

The absolute numbers are of course guesses that depend on many unknowns, but it is important to note that the trends in relative change over time are far more secure. And the trend that we see is pretty clear: a dramatic rise in population, particularly from the late fourth and early third century BCE onwards. This growth probably reached its peak in the late second century CE, to then move in pretty dramatic reverse: decline and fall were steep. The second thing that can be seen in this graph is that population trends in these two regions roughly moved in sync, and resemble the trends in site numbers for northern Gaul. A few years ago, Alessandro Launaro already observed the same for many of the Italian surveys, even if not using these more sophisticated methods (Launaro 2011). I am quite sure that many, though probably not all parts of the Empire, will show similar trends of considerable population growth, followed by equally dramatic decline, even if that decline may well be later in, for example, the Roman East.

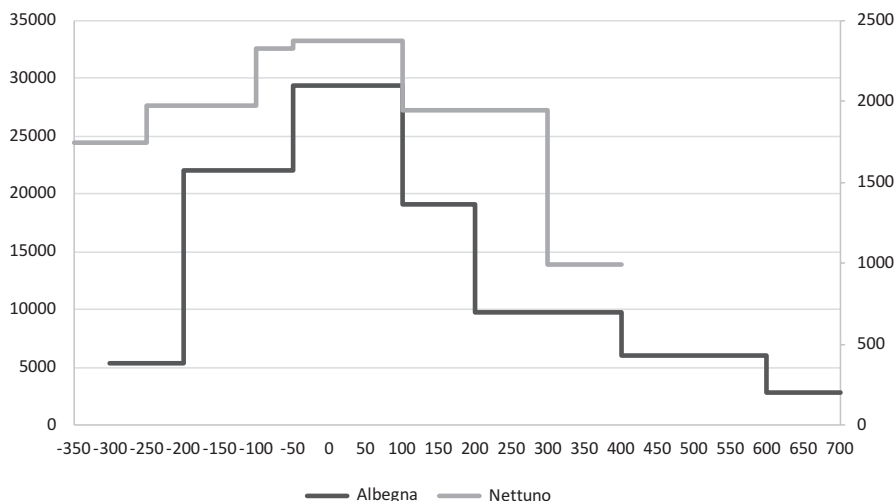


Fig. 6.1 Population estimates for Albegna and Nettuno. (Sources: Fentress 2009 and De Haas et al. 2011)

Conceptually this is a wake-up call to abandon the tradition to avoid generalization, only looking for local differences in what I like to call the ‘my-valley-is-different-syndrome’. Of course, regional differences matter, but primarily in relation to a general trend. If we do not identify that larger trend, we cannot even identify what is locally specific.

Therefore, three survey teams working around Rome, the British School at Rome’s Tiber Valley Project, the Suburbium Project at La Sapienza, and the Groningen Pontine Region Project, have joined forces and have recently succeeded to integrate their datasets, mostly down to the level of individual sherds. Doing so was a big job, and many said it was impossible, but we are pleased that we have succeeded, and have solved many thorny issues of pottery and site classification, and chronology. The ambition of the consortium is to use our concepts and methods to extend this integrated dataset first to some other parts of Italy where conditions are likely to be quite similar to what we experienced thus far, and then to other parts of the Empire, where as yet unpredictable conditions will probably pose new challenges for which our methods may or may not provide solutions. The analytical ambition is of course to have good empirical data to reconstruct the big story of Roman population trends, rural social relations and material culture, if possible for the empire as a whole, but also regionally, to differentiate the local from the global.

This population boom and the subsequent decline that we see in so many surveys are perhaps the most important things one can say about the Roman economy, but their identification is really quite a recent thing. I think it represents the complete refutation of the old static paradigm of a preindustrial Roman economy without any change. And it is reflected in many other data, of course, such as pollen diagrams that show a receding forest and its return in Late Antiquity.

6.2.2 The Economic Effects of Population Increase

The next question is, of course, what such a population boom meant for the economy. As I said earlier, per capita income is the result of dividing aggregate production and consumption by the number of people. If aggregate production and consumption went up to the same degree as population, per capita income would obviously remain the same. But that is not necessarily the case. In the modern world, population growth is usually outstripped by the growth of production, and as a result in Western society per capita incomes have typically grown by about 2% per annum, roughly doubling standard of living every generation.

For many preindustrial economies, however, the story was often a more depressing one: population pressure resulted in a declining standard of living for the mass of the population.

The graph in Fig. 6.2 by Bob Allen gives what he calls the welfare ratio, i.e. the extent to which incomes of ordinary families exceeded bare subsistence (Allen et al. 2005; Allen 2009). There are a few important things to note. The first is that after the Black Death of the fourteenth century people were quite prosperous, but this declined under the population growth of subsequent centuries. The second observation is that the Netherlands and later also England were an exception to this grim scenario, and were already far more prosperous than other countries. And a final observation is that at least in Late Antiquity, by the time of Diocletian's price edict, life does not seem to have been very cheerful (Allen 2009).

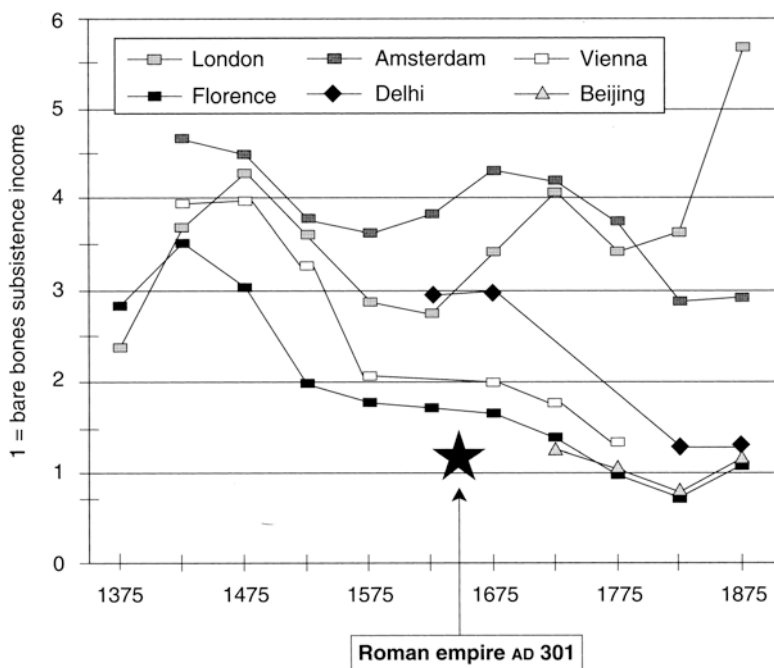


Fig. 6.2 Preindustrial welfare ratios. (Reprinted with permission from Allen (2009, 342))

Theoretically, it is not surprising that population growth depressed the standard of living. A preindustrial economy is essentially a system with two factors of production: land and labour. Of the two, land is in more or less inelastic supply, so population growth changes the land/labour ratio. Technically, this means a move along the production function. If nothing else happens, the economy will suffer from decreasing marginal labour productivity. In normal words: if you double the labour force on a given plot of land you will increase output, but you will not double it. Such lower marginal labour productivity inevitably implies lower labour incomes. So if nothing else happens, population pressure depresses the standard of living. The only escape is technological change of one kind or another, meaning that the movement along the production function is compensated by a shift of the production function. And that increased efficiency is why we have become so much more prosperous, and continue to do so. Such increased efficiency can originate in technology in the narrow sense of the word, such as using watermills, but also in the wider sense of using different crops, more division of labour and trade, better management or better institutions. The list is a long one. So, once we have established that the Roman Empire experienced a population boom, the first challenge is to reconstruct incomes and standard of living for the mass of the population. Did they deteriorate under population pressure, or not? What is the true answer to the Monty Python team's question?

Unfortunately, the normal wage data to answer this question are few and far between. For the Roman Republican period we have the extensive set of slave prices from the Delphi manumission inscriptions (Jongman 2007a; Hopkins 2018). These show that slave prices went up significantly, suggesting that during the last two centuries BC real wages for free labour did as well. Roman slaves were expensive because free labour cost quite a bit more than the cost of subsistence. For the subsequent Imperial period we have a fair number of wages and prices from Roman Egypt, and these have recently been studied extensively by Kyle Harper (2016; Fig. 6.3).

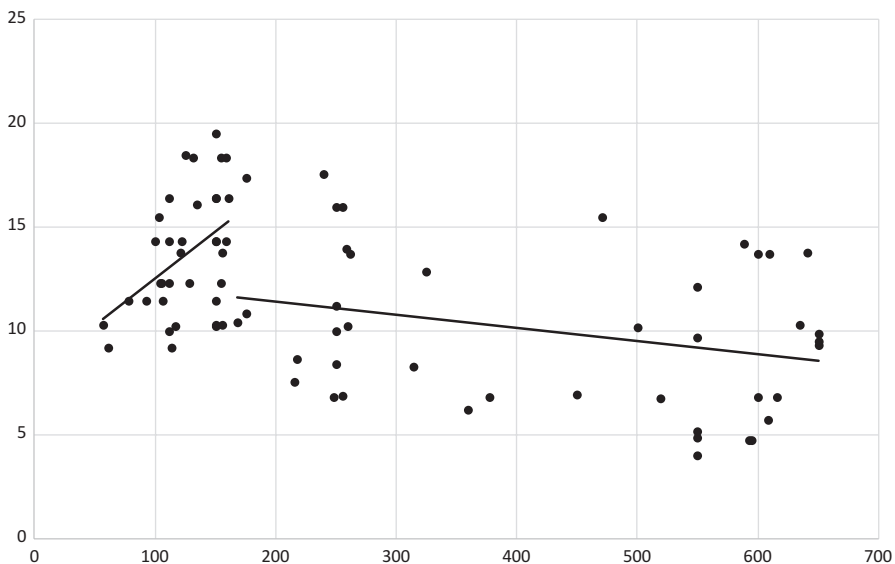


Fig. 6.3 Wages (in wheat) in Roman Egypt. (Source: Harper 2016)

Clearly, the Antonine plague marks a turning point, not only in the amount of written documentation but also in wage levels (Jongman 2012). Population pressure had eased, and yet this did not improve labour productivity and standard of living, on the contrary. Therefore, and unlike Harper, who included one linear regression for the entire date range, my version of the graph includes separate regression lines for the period before and after the Antonine Plague. The last set of wage data is from Diocletian's price edict of 301 CE. As we have seen from Bob Allen's analysis, by that time, standard of living was barely above subsistence (Allen 2009). To summarize these pretty meagre wage data, the standard of living seems to have moved with population rather than against it, and theoretically that is quite unusual for a preindustrial society.

However, these data are not very good. Fortunately, archaeology now offers far better data on material culture and lifestyle. If you cannot measure income, these archaeological datasets measure what is done with that income. A first example is a dataset on animal bones from archaeological sites, using bones as a proxy for trends in meat consumption (Jongman 2007b, 2014b; Fig. 6.4).

This graph represents animal bones from provincial sites, and as can be seen, not only is the number of assemblages enormous, but there is also a very clear trend. Other data on food consumption trends show a similar pattern, from wine and olive oil,

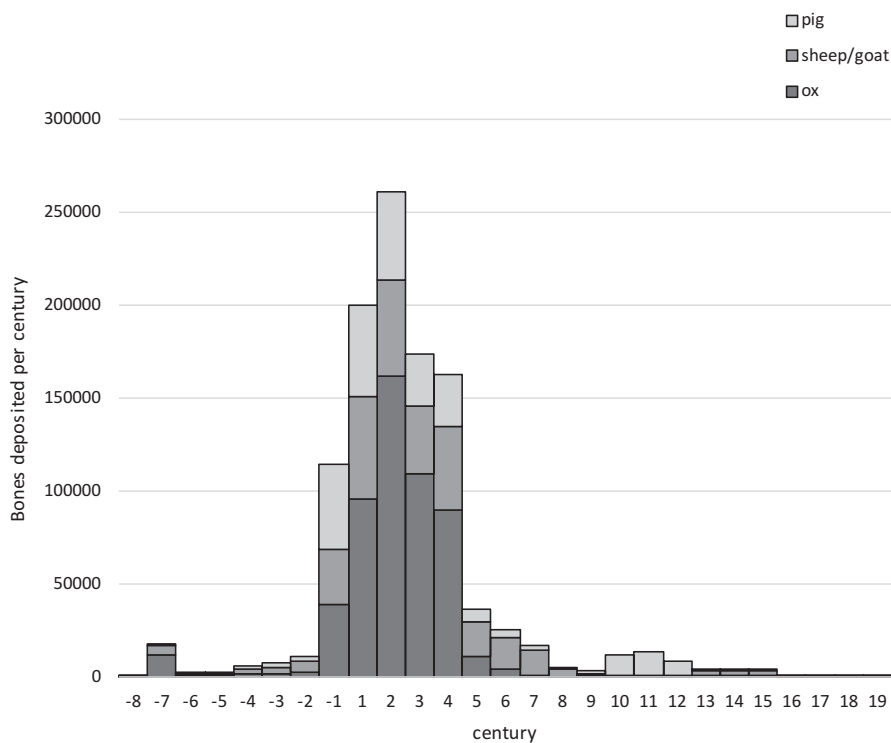


Fig. 6.4 Animal bones from Roman provinces as a proxy for meat consumption

fruits and vegetables to fish salting installations (Bakels and Jacomet 2003; Wilson 2006; Van der Veen 2016). And the consumption boom was not restricted to food: housing quality also improved, with larger and more comfortable dwellings, with even some window glass. That trend is also visible in the quantities of wood for building from Western Germany (Holstein 1980).

What all these types of consumer expenditure have in common is that they are not bare bones subsistence goods: they are not the cheapest calories, but the icing on the cake. In economic language, they are high income elasticity goods, i.e. goods that are consumed more than what you would expect just from income growth. So if incomes grow by, for example, 10%, consumption of these goods increases by more than 10%. As such they represent the qualitative change in consumption patterns that comes with greater prosperity.

6.2.3 Why Did Roman Population Growth and Wealth Go Together?

So all in all, I want to claim that Roman population growth did not produce a deterioration of standard of living, on the contrary. Similarly, Roman population decline in Late Antiquity did not improve standard of living like it would do after the Black Death of the fourteenth century (Borsch 2005; Campbell 2016). Therefore, the pessimistic Malthusian model did not apply. Instead the period of population growth went hand-in-hand with greater labour productivity. This leaves us with the final question: how could this be? I think there are three possible answers, and they probably all apply.

The first is that of market integration and increased division of labour. The Roman Empire had created an enormous more or less integrated market, connected by cheap water transport, and enjoying more or less uniform and effective institutions, ranging from military security to a stable monetary system, good laws and pretty good government. The high urbanization rate was where all these processes came together (Hanson 2016).

Secondly, however, none of this would have been possible without growth in agricultural productivity. New crops managed attentively catered for a taste for better and more expensive food, but also produced much higher returns, as long as people were prosperous enough to afford them. The prime examples would be wine and olive oil. In the end, farmers can choose from a wide range of crops and a wide range of strategies. The prevailing carrying capacity modelling fatally ignores alternative and more intensive strategies. For example, in the Italian context, producing wine and oil could generate perhaps five times more calories per hectare, and 10–20 times more revenue, but it was labour-intensive, and presupposed a prosperous market for these far more expensive calories (Jongman 2016). They presuppose an escape from life at the bare subsistence. And that, of course, also made the system unstable. When things went wrong, they would go badly wrong.

The third possible explanation is that these few happy centuries also experienced favourable climatic conditions. Economically, that is of course the same as technological improvement: the same quantities of land and labour began to produce more. All this started to go wrong from the mid second century CE, with a deteriorating climate, bad harvests, followed by the first in a series of epidemics, which in turn was followed by urban decline, social disintegration, and political and military upheaval (Manning 2013; Harper 2017). In the West at least the Empire did not really recover, even if in the East it did, at least for a while, until another round of bad weather and epidemics and the Justinian Plague in particular put an end to much of the eastern Empire as well.

6.3 Conclusions

These tentative and provisional conclusions require a far larger and more detailed empirical basis, to validate the broad contours, to extricate regional and temporal differences and to provide potential explanations. So what do we need for that, and what can we do?

First, to create the right analytical framework, I think historians and archaeologists of the ancient economy should involve themselves with proper economic theory, just like historians of medieval or early modern Europe have done (Jongman 1988). There is no reason to be on a different planet. And they should do so in a comparative framework: where does Antiquity stand in comparison to the modern world, and perhaps more usefully, in comparison to other preindustrial societies?

Second, they should follow the example of those same Medieval and Early Modern historians and the paradigm shift of exhaustive empirical data collection exemplified by French *Annales* historiography and American New Economic History. The choice is not between on the one hand big histories based on generalizations from secondary literature and on the other hand deeply factual microhistories. Modern economic historians have shown that it is possible to write big history from large aggregate datasets (e.g. Fogel 2004; Broadberry et al. 2015). For the Roman world, the written documentation will never give us those datasets, but archaeology can. Over the last few decades archaeology has moved from a subject of few and isolated data to one where the biggest concern should be to develop methodologies and practices that explore the current abundance of data. The challenge is to develop methods and concepts to serialize those data (the *mise en série* of the *Annales*) and harness them as proxies for economic variables. A famous early example was Keith Hopkins' use of Parker's catalogue of Mediterranean shipwrecks as proxies for long distance shipping (Hopkins 2018). Since then, many other examples have followed (Jongman 2014a, b, 2018).

Third, it is time we (and Medieval and Early Modern historians as well) pay more attention to the rapid progress made in scientific archaeology (e.g. McConnell et al. 2018). Apart from progress in established fields of archaeological science such as archaeobotany and archaeozoology, biological standard of living (human body

length) or scientific dating methods, we now have more and more stable isotope analyses of skeletal material to the extent that for the first time statistically meaningful datasets are becoming available to reconstruct diet or patterns of migration. Dental plaque is revealing past infectious disease, and DNA studies show our genetic origins. Climate reconstructions are rapidly becoming more realistic and uncontroversial. There is no doubt that here we are at the threshold of completely new fields of historical knowledge, bringing us closer than ever to our ancestors and their quality of life.

Finally, we need more experimental archaeology to reconstruct the logic of many ancient practices. What were the opportunity costs of choosing one process over another, in terms of labour productivity, total output or risk? If and when agriculture is the dominant productive activity, this is something that has to be done within constraints and mechanisms from nature, and hence it should be relatively easy to model. What strategic alternatives did our ancestors have, and how successful were their choices? In short, I am convinced we are witnessing the end of traditional histories of the Roman economy, both substantially and methodologically.

References

- Allen R (2009) How prosperous were the Romans? Evidence from Diocletian's price Edict (AD 301). In: Bowman BA, Wilson A (eds) *Quantifying the Roman economy: methods and problems*. Oxford University Press, Oxford, pp 327–345. <https://doi.org/10.1093/acprof:oso/9780199562596.003.0016>
- Allen RC, Bengtsson T, Dribe M (eds) (2005) *Living standards in the past: new perspectives on well-being in Asia and Europe*. Oxford University Press, Oxford. <https://doi.org/10.1093/0199280681.001.0001>
- Bakels CC, Jacomet S (2003) Access to luxury foods in Central Europe during the Roman period. *World Archaeol* 34:542–557. <https://doi.org/10.1080/0043824021000026503>
- Borsch SJ (2005) *The Black Death in Egypt and England. A comparative study*. University of Texas Press, Austin
- Broadberry S, Campbell BMS, Klein A, Overton M, Van Leeuwen B (2015) *British economic growth 1270–1870*. Cambridge University Press, Cambridge
- Brown PRL (1971) *The world of late antiquity: from Marcus Aurelius to Muhammad*. Thames and Hudson, London
- Brun JP (2012) *Techniques and economies in the ancient Mediterranean*. Inaugural lecture Collège de France, 5 April 2012. Collège de France, Paris. Available at <http://books.openedition.org/cdf/2999>. Accessed at 18 June 2018
- Campbell B (2016) *The great transition: climate, disease and society in the late-medieval world*. Cambridge University Press, Cambridge
- De Haas T, Tol G, Attema P (2011) Investing in the colonia and ager of Antium. *Facta* 5:111–144
- Deru X (2017) *Croissance et crise dans le nord de la Gaule romaine*. Proceedings of Crisis Auxesis. Crise et croissance dans les économies des mondes anciens. Lyon, 11–12 Octobre 2013. *Topoi* 21:217–232
- Fentress E (2009) Peopling the countryside: Roman demography in the Albegna valley and Jerba. In: Bowman BA, Wilson A (eds) *Quantifying the Roman economy: methods and problems*. Oxford University Press, Oxford, pp 127–161. <https://doi.org/10.1093/acprof:oso/9780199562596.003.0005>

- Finley MI (1985) *The ancient economy*, 2nd edn. Chatto and Windus, London
- Fogel RW (2004) *The escape from hunger and premature death, 1700–2100: Europe, America and the Third World*. Cambridge University Press, Cambridge
- Greene K (1986) *The archaeology of the Roman economy*. Batsford, London
- Hanson JW (2016) *An urban geography of the Roman world, 100 B.C. to A.D. 300*. Archaeopress, Oxford
- Harper K (2016) People, plagues, and prices in the Roman world: the evidence from Egypt. *J Econ Hist* 76:803–839. <https://doi.org/10.1017/S0022050716000826>
- Harper K (2017) *The fate of Rome. Climate, disease and the end of an empire*. Princeton University Press, Princeton
- Holstein E (1980) *Mitteleuropäische Eichenchronologie*. Philipp Von Zabern, Mainz
- Hopkins K (2018) Taxes and trade in the Roman empire (200 BC-AD 400). In: Kelly C (ed) *Keith Hopkins: sociological studies in Roman history*. Cambridge University Press, Cambridge, pp 213–259. <https://doi.org/10.1017/CBO9781139093552.008>
- Jongman WM (1988) *The economy and society of Pompeii*. J.C. Gieben, Amsterdam
- Jongman WM (2007a) The early Roman Empire: consumption. In: Scheidel W, Morris I, Saller RP (eds) *The Cambridge economic history of the Greco-Roman world*. Cambridge University Press, Cambridge, pp 592–618. <https://doi.org/10.1017/CHOL9780521780537.023>
- Jongman WM (2007b) Gibbon was right: the decline and fall of the Roman economy. In: Hekster O, De Kleijn G, Slootjes D (eds) *Crises and the Roman Empire. Proceedings of the Seventh Workshop of the International Network Impact of Empire* (Nijmegen, June 20–24, 2006). Martinus Nijhoff/Brill, Leiden, pp 183–199. <https://doi.org/10.1163/ej.9789004160507.i-448.38>
- Jongman WM (2012) Roman economic change and the Antonine Plague: endogenous, exogenous or what? In: Lo Cascio E (ed) *L'impatto della "peste Antonina"*. Edipuglia, Bari, pp 253–263
- Jongman WM (2014a) The new economic history of the Roman Empire. In: De Callatay F (ed) *Quantifying the Greco-Roman economy and beyond*. Edipuglia, Bari, pp 153–168
- Jongman WM (2014b) Re-constructing the Roman economy. In: Neal L, Williamson J (eds) *The Cambridge history of capitalism, vol 1*. Cambridge University Press, Cambridge, pp 75–100
- Jongman WM (2016) Italian urbanization and Roman economic growth. In: Capogrossi Colognesi L, Lo Cascio E, Tassi Scandone E (eds) *L'Italia dei Flavi*. Atti del Convegno, Roma, 4–5 Ottobre 2012. L'Erma di Bretschneider, Rome, pp 105–117
- Jongman WM (2018) Afterword to "Taxes and trade in the Roman empire (200 BC-AD 400)". In: Kelly C (ed) *Keith Hopkins: sociological studies in Roman history*. Cambridge University Press, Cambridge, pp 260–268
- Launaro A (2011) *Peasants and slaves: the rural population of Italy (200 B.C. to A.D. 100)*. Cambridge University Press, Cambridge
- Manning S (2013) The Roman world and climate: context, relevance of climate change, and some issues. In: Harris WV (ed) *The ancient Mediterranean environment between science and history*. Brill, Leiden, pp 103–170. https://doi.org/10.1163/9789004254053_007
- McConnell JR, Wilson AI, Stohl A, Arienzo MM, Chellman NJ, Eckhardt S, Thompson EM, Pollard AM, Steffensen JP (2018) Lead pollution recorded in Greenland ice indicates European emissions tracked plagues, wars, and imperial expansion during antiquity. *PNAS* 115(22):5726–5731. <https://doi.org/10.1073/pnas.1721818115>
- McEvedy C, Jones R (1978) *Atlas of world population history*. Penguin, Harmondsworth
- Scheidel W (2007) Demography. In: Scheidel W, Morris I, Saller RP (eds) *The Cambridge economic history of the Greco-Roman world*. Cambridge University Press, Cambridge, pp 38–86. <https://doi.org/10.1017/CHOL9780521780537.004>
- Scheidel W, Morris I, Saller R (eds) (2007) *The Cambridge economic history of the Greco-Roman world*. Cambridge University Press, Cambridge. <https://doi.org/10.1017/CHOL9780521780537>
- Van der Veen M (2016) Arable farming, horticulture and food: expansion, innovation, and diversity. In: Millet M, Revell L, Moore A (eds) *The Oxford handbook of Roman Britain*. Oxford University Press, Oxford. <https://doi.org/10.1093/oxfordhb/9780199697731.013.046>

- Wilson A (2006) Fishy business: Roman exploitation of marine resources. *J Roman Archaeol* 19:525–537. <https://doi.org/10.1017/S1047759400006760>
- Zimmermann A, Hilpert J, Wendt KP (2009) Estimates of population density for selected periods between the Neolithic and A.D. 1800. *Hum Biol* 81(2–3):357–380. <https://doi.org/10.3378/027.081.0313>

Open Access This chapter is licensed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

