Princeton/Stanford Working Papers in Classics

In search of Roman economic growth

Version 1.0

June 2008

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Abstract: This paper seeks to relate proxy indices of economic performance to competing hypotheses of sustainable and unsustainable intensive economic growth in the Roman world. It considers the economic relevance of certain types of archaeological data, the potential of income-centered indices of economic performance, and the complex relationship between economic growth and incomes documented in the more recent past, and concludes with a conjectural argument in support of a Malthusian model of unsustainable economic growth triggered by integration.

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Introduction

In 2002, Richard Saller urged Roman historians to define their terms in discussing 'economic growth'. He emphasized the necessity of distinguishing gross or extensive growth from per capita or intensive growth and argued that the observed upturn in economic indicators in the late republican and early monarchical periods may well be compatible with a fairly low annual rate of intensive growth of less than 0.1 percent. He also identified the need for explanations of the abatement of signs of economic expansion and the timing of this phenomenon.[1] A new paper by Peter Temin meets this demand by introducing alternative models of the nature of growth that are susceptible to empirical testing. He invites us to choose between "a single spurt of productivity change whose effects were gradually eroded by Malthusian pressures" and the notion "that Roman productivity growth continued until some unrelated factors inhibited it".[2] Testable working hypotheses about the nature of Roman economic growth are essential but have so far been absent from the debate. Instead, recent years have witnessed a surge in publications that merely seek to demonstrate the existence of Roman economic growth and identify factors that are considered to have been conducive to this process. Some of this work draws on quantifiable proxy data taken to reflect economic growth.[3] While this drive toward explicit quantification is to be welcomed, Temin is right to remark on the undertheorization of these studies.[4] They share the implicit assumption that the data speak for themselves in the sense that increases in a given proxy variable are interpreted as a signal of economic growth, but fail to marshal these observations for the purpose of formulating or testing specific models of development such as the 'Malthusian' and 'sustainable growth' scenarios that are familiar to economic historians of the more recent past.[5]

The real question is not what the data reveal about change over time: it is what we would need to know in order to determine whether these data reflect extensive or intensive economic growth; why any such growth occurred, abated, and ceased; and how it related to the distribution of incomes. This paper responds to Temin's challenge by probing the economic relevance of archaeological proxy data, by considering the potential of income-centered indices of economic performance, and by drawing attention to the complicated relationship between economic growth and incomes documented in the more recent past. I conclude with a highly tentative argument in support of a Malthusian model of unsustainable growth triggered by economic integration.[6]

Thanks are due to three Peters (Bang, Garnsey, and Temin) for their helpful comments.

[1] Saller 2002 = 2005.

[2] Temin forthcoming a. For a non-Malthusian variant of the unsustainable growth scenario, see Silver 2007: 227, 237-41, who blames the eventual cessation of Roman economic growth on what he elects to call "perverse economic policies".

[3] Wilson 2002 and in press; de Callataÿ 2005; Hitchner 2005; Jongman 2007a, b; Silver 2007.

[4] Temin forthcoming a. The only relevant paper by an economist, Silver 2007, does little to address this deficit. For a detailed discussion of what we would need to know to explore Roman economic growth that implicitly highlights the shortcomings of existing work in this field, see Temin forthcoming b.

[5] For the former scenario, see Temin forthcoming a; and already Frier 2001; Scheidel 2003b: 120-121, 136; 2004b; 2007a: 50-74, esp. 57-60; 2007 b: 323-329, 341-343. The best theoretical-historical discussions are Lee 1986a, b; 1987; Wood 1998.

[6] This summary demarcates the limitations of my study, which furthermore focuses primarily on the late republican and early monarchical periods. Evidence suggestive of economic growth and abatement in late

Archaeological proxies of economic growth

In order to distinguish between (ideal-typical) scenarios of 'one-off' intensive growth curtailed by population pressure and of sustainable growth, we need to know whether an abatement of economic expansion occurred ahead of what we might call 'exogenous shocks' such as the Antonine Plague of the late second century CE and the war-driven dislocations of the third century CE or whether it coincided with these events. The former would lend support to a Malthusian scenario of endogenously unsustainable real growth. *Prima facie* the most promising type of pertinent evidence are quantifiable data series relating to the volume of production, exchange, and consumption that show substantial change over time. Several surveys of the chronological distribution of particular artifacts have yielded bell-curve-shaped frequency patterns centered on the late republican and early monarchical periods. This is true of samples of Mediterranean shipwrecks, levels of lead and copper pollution derived from arctic ice cores and lake sediments, and deposits of domesticated animal bones at Italian sites (Fig.1).[7]

antiquity does not affect my argument. I privilege material that has received attention in recent scholarship at the expense of the role of the peasant economy, which is crucial in principle but poorly documented in practice.

[7] Shipwrecks: Parker 1992: 549 fig.3 (solid line), representing the distribution of the mid-points of the date range for each wreck; Wilson in press (broken line), representing a more sophisticated probability distribution. (I am grateful to Andrew Wilson for sharing his paper with me in advance to publication.) Pollution: Kylander et al. 2005: 474 fig.3. I chose this sample because of its chronological precision. The overall shape is remarkably consistent across European deposits (ice cores and lake sediments): see Hong et al. 1994; Renberg et al. 1994; Hong et al. 1996a, b; Cortizas et al. 1997; Weiss et al. 1997; Rosman et al. 1997; Shotyk et al. 1998; Brannvall et al. 1999; Renberg et al. 2000; Kempter and Frenzel 2000; Branvall et al. 2001; Alfonso et al. 2001; Cortizas et al. 2002; Boutron et al. 2004; Schettler and Romer 2006. For surveys of some of these case-studies, see Weiss et al. 1999 and Makra and Brimblecombe 2004. This evidence has only been very selectively used by Roman historians: cf. the secondary discussions by Wilson 2002: 25-27 and de Callataÿ 2005: 361-69. Animal bones: Jongman 2007: 613 fig.22.1, based on King 1999.

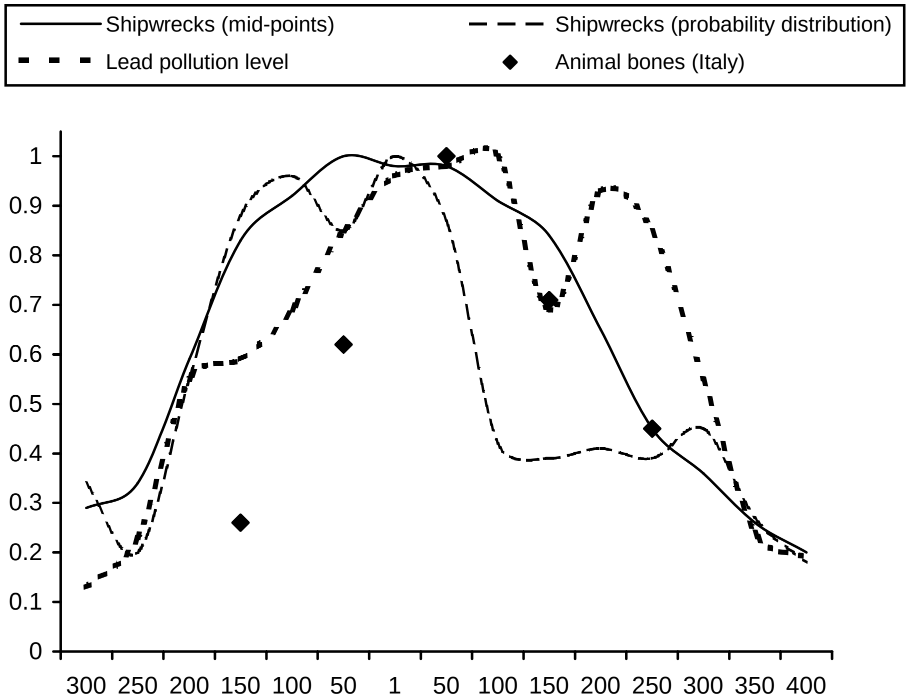

Fig.1 Standardized distribution of Mediterranean shipwrecks, lead pollution caused by Iberian mining, and animal bone deposits in Italy (1 = highest level)
Source: Parker 1992: 549 fig.3; Wilson in press; Kylander et al. 2005: 474 fig.3; Jongman 2007: 613 fig.22.1

Two separate issues are at stake: whether these distributions reflect economically relevant developments – such as trade volume in the case of shipwrecks or meat consumption in the case of animal bones –, and whether we are able to relate them to trends in gross or intensive economic growth if we are indeed prepared to interpret them as reflections of economically relevant developments.

In principle, increases in the volume of maritime trade can be expected to be positively correlated with economic growth, at the very least with extensive growth and – if the increases are rapid – with intensive, per capita growth as well. However, a number of confounding variables interfere with straightfoward extrapolation from the time distribution of shipwrecks to changes in exchange volume. Our sample is bound to *under*estimate the expansion in the amount of traded goods in this period: merchant ships had grown in size, which means that the observed rise in the number of wrecks per period translates to an even more prominent spike in the amount of cargo. Moreover, we might speculate that in as much as ships in this period were more likely to choose direct routes across the Mediterranean rather than hugging the coast, they would have sunk more frequently in deep waters where they elude discovery.[8] At the same time, changes in the nature of the cargoes – most notably in the presence of ceramic containers and marble –

[8] Larger ships: Parker 1992: 26; Wilson in press; cf. also Rathbone 2006: 199-201. Routes: Arnaud 2005: 217, and more generally 98-148.

render wrecks from this period more visible and thus more likely to be found and studied than those of vessels that had carried organic products in sacks and barrels, which may arguably have happened more often in later centuries.[9] This causes us to *over*estimate variation in the actual amount of shipping. We cannot hope to ascertain to what extent these countervailing factors canceled each other out, and cannot simply assume that they did. Moreover, finds from the eastern Mediterranean are greatly underrepresented in the present sample, a situation that is changing with more intense underwater exploration and will require re-mapping of the overall distribution patterns.[10] Yet even if we take the current picture as indicative of conditions in the western Mediterranean, as confirmed in Fig.2,[11] and assuming that in keeping with the Law of Diminishing Returns future discoveries will have only limited impact on the observed distribution,[12] we still need to take account of the three confounding variables identified above.

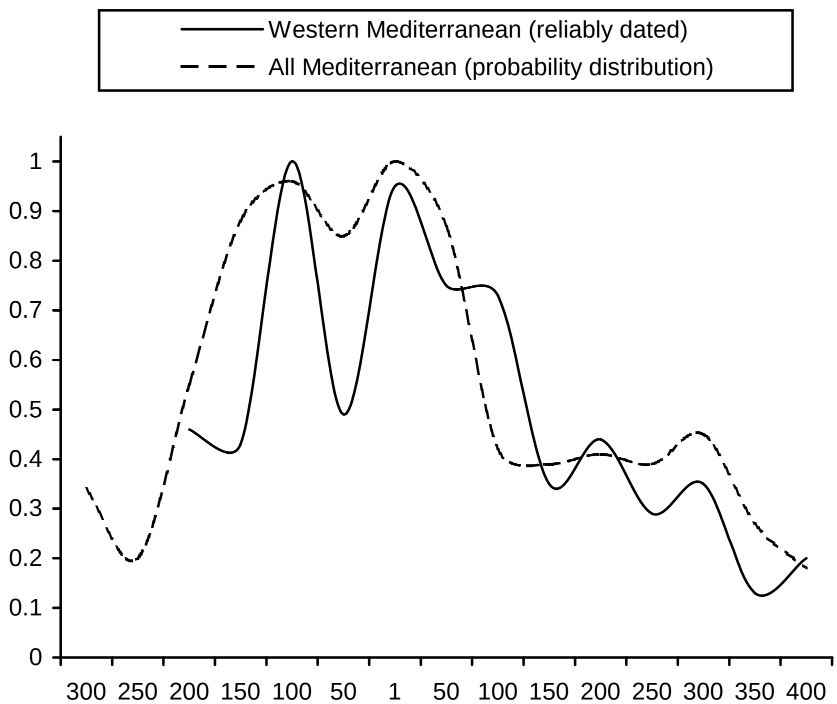

Fig.2 Standardized distribution of Mediterranean shipwrecks (1 = highest level)
Source: Parker 1992: 551 fig.5; Wilson in press

The observed surge in the degree of lead and copper pollution in the Greenlandic ice cap and in peat bogs and lake sediments in western Europe was caused by the deposition of windborne contaminants generated by the smelting of mineral ores, most

[9] See Wilson in press for a detailed discussion.
[10] See below, in the final section, at n.81.
[11] Source: Parker 1992: 551 fig.5 (western); Wilson in press (all).
[12] Cf., e.g., the updates for French waters in the *Bilan Scientifique* of the Département des recherches archéologiques subaquatiques et sous-marines.

notably in the Iberian peninsula. The mutual consistency of different data samples confirms that this evidence may be considered as a reliable index of variation in the scale of Roman mining activity. Even so, its relevance to our understanding of Roman economic growth is less clear. Strictly speaking, this distribution measures change in metal extraction and processing rather than economic growth per se, and while these variables might conceivably be related – as they clearly are in the case of modern increases in air pollution levels –, their relationship was less straightforward in earlier economies. The evidence from the Roman period marks the improved capacity of an unprecedentedly large imperial state to secure and develop mineral resources in relatively marginal areas for the purpose of expanding its increasingly monopolistic currency system. The numismatic evidence independently shows that Roman levels of precious-metal coin production were unique in Europe prior to the modern period: in that sense, we have long known what the physical evidence for air pollution has only more recently begun to document. The key question here, however, is to what extent this expansion in mining activity reflects economic performance rather than state power? A simple comparison illustrates the nature of the problem. When the Spanish empire exploited mineral resources in South America on a massive scale during the sixteenth and seventeenth centuries CE, how did this affect the economy of Spain? Modern guesstimates suggest that Spanish per capita economic growth from 1500 to 1700 did not exceed the western European average and fell far short of that in the Netherlands or England.[13] In the same period, Spain also experienced a series of sovereign debt defaults while its competitors did better. More generally, the inflow of bullion reinforced what is known as the early modern 'Price Revolution' that raised nominal prices across Europe while wages tended to lag behind.[14] In brief, no modern economic historian would be inclined to relate changes in mining output directly to per capita GDP. (I address further implications of these data below.)

The connection between animal bone deposits and economic performance is if anything even more tenuous. Willem Jongman has argued that the observed spike in the overall number of animal bones in Roman Italy and elsewhere denotes an increase in meat consumption, taking this as a sign that the population was better off than before or after.[15] Conversely, Mamoru Ikeguchi has drawn attention to the fact that if we follow Michael MacKinnon in trying to reconstruct meat weight from bone finds, a very different picture emerges: while pig bones first peaked in the early monarchical period, bovine deposits became more common in late antiquity. Due to the massive weight differences between animal species, implied meat consumption was much higher in the late monarchical period than it had previously been (Fig.3).[16] Taken at face value, this finding is consistent with a Malthusian scenario according to which the movement of real incomes and consumption is inversely correlated to the direction of change in population density: in late antiquity, a smaller population size would have facilitated extensive cattle-raising. Moreover, as A. King has argued, the earlier spread of pig bones should in the first instance been regarded as a sign of culture change ('Romanization'), that is, a change in tastes. This interpretation readily accounts for the delay in the expansion of

[13] Maddison 2007: 383.
[14] E.g., Lynch 1991: 174-184; Fischer 1996: 80-85.
[15] Jongman 2006: 245-246; 2007a: 613-614; 2007b: 191-193.
[16] Ikeguchi 2007: fig.3-2, based on MacKinnon 2004.

pork consumption in the western provinces where this acculturative process occurred correspondingly later.[17]

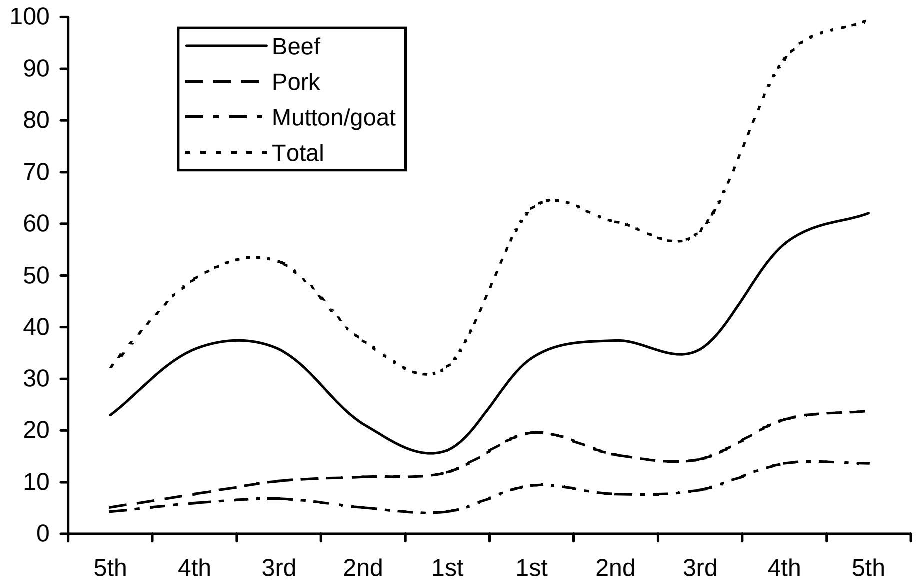

Fig.3 Aggregate meat weight in Roman Italy, 500 BCE – 500 CE
(100 = maximum total amount)
Source: Ikeguchi 2007: graph 3-2, based on MacKinnon 2004

In view of the various weaknesses of these indices, their apparent chronological coincidence had always been the strongest argument in favor of their broader relevance: according to this line of reasoning, if shipping and mining and meat consumption in and around Italy all peaked at roughly the same time, we are justified in considering them as manifestations of a more general phenomenon that was associated with economic expansion.[18] This argument from convergence has now been weakened by the asynchronicity of the meat consumption index for Italy but nevertheless deserves a hearing. Let us assume, albeit strictly for the sake of argument, that both the data series for (western) Mediterranean shipping and for Iberian mining do indeed reflect changes in economic output in gross and even per capita terms. I label this position a 'strong' or optimistic reading of the evidence, as opposed to a 'weak' or skeptical reading that allows for the possibility that productivity in farming and manufacturing and exchange had remained unaffected by changes in mining output, or that expanding trade might

[17] Pork consumption and Romanization: King 2001. See Jongman 2007a: 614 fig.22.2 for a provincial spike around 150 CE.

[18] De Callataÿ 2005: 370-371; Jongman 2006: 246; 2007a: 613; and esp. 2007b. It deserves attention that the meaning of matching distribution patterns is not always clear: compare the convergence of the temporal distribution of Egyptian papyri, military diplomas, brick-stamps, marble quarrying, dated inscriptions from Rome, and imperial and private building activity in Italy between 90 and 180 CE as illustrated by Greenberg 2003: esp. 420 fig.14.

indicate greater stratification through enhanced surplus control by the state and its elites rather than genuine improvements in overall output. I ought to stress that I do not wish to commit to either one of these starkly drawn positions but merely seek to clarify the nature of the 'strong' reading and explore its implications. This approach, which is – usually implictly – favored by scholars who have recently utilized archaeological 'growth proxies', is optimistic in that it assumes a meaningful link between these data sets and economic development that cannot be independently verified, a linkage that is posited at least in terms of the direction of change (up or down) if not in terms of scale. While no-one will want to argue that x times as many shipwrecks or pollutants translate to y percent more gross or per capita output, these changes are nevertheless taken to mirror *some* – necessarily indeterminate – degree of economic growth.

However, if we employ a 'strong' reading – and I repeat that whenver I do so in the following I do so merely for the sake of argument –, we must also take account of the logical corollaries of the shape of the distribution curves for these proxy data. Conventional representations of this material present it in absolute terms by focusing on quantity per period rather than the rate of change between periods. This mode of visual or verbal presentation serves to direct attention to the elevated levels of activity – and hence putative output and consumption – observed in the early monarchical period. It also puts emphasis on absolute decline, which is usually observed in the later second century CE.[19] If we re-configure these datasets in order to portray the rate of change per period, the focus shifts to the fact this period was bereft of further increases in the measured activity and hence – at least according to a 'strong' reading – further economic growth (of whichever kind). We are dealing with two different issues: the popular question of when levels of activity were high relative to other periods, and the commonly ignored question of when most of the observed increase occurred. Although overall levels of economic performance are by no means irrelevant, from an economic perspective the latter question is of even greater importance. Thus, in order to appreciate the character and growth potential of the Roman economy, and more specifically to be able to test rival models of growth as outlined at the beginning of this paper, we must identify the circumstances in which the economy appeared at its most dynamic and those in which it appeared stagnant. This alone will allow us to determine the factors that drove economic development.

[19] Among many examples, see most recently Jongman 2007b: 195-196, on the 'rupture' in that period.

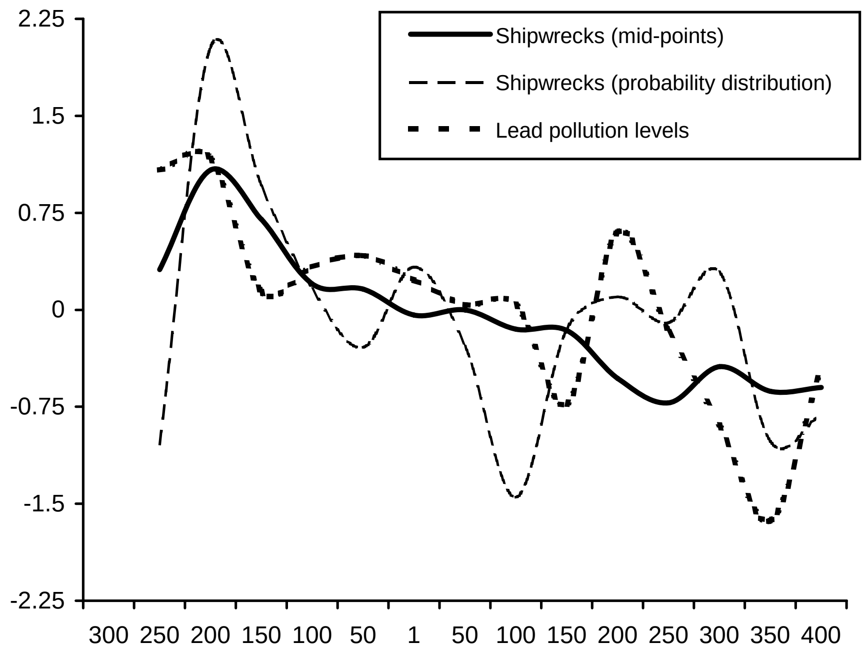

Fig.4 Mean annual percentage rates of change between *x*-50 and *x*
Source: Fig.1

This perspective strongly privileges the late republican period. As shown in Fig.4, the bell curves in Fig.1 logically translate to substantial annual rates of increase early on and to stagnation and eventual net contraction later.[20] There are no further increases in the annual number of shipwrecks after 50 BCE in A. J. Parker's sample or after 1 CE in Andrew Wilson's revised sample, and no appreciable net increase in air pollution levels after 1 CE. The last one of these findings is reinforced by other pollution measures: for example, the charts of lead and copper pollution presented by Francois de Callataÿ both show peaks in the first century BCE followed by a strong drop in the first century CE and only partial recovery in the second century CE.[21] Other potentially relevant time series are likewise consistent with this pattern. Wilson's forthcoming survey of the aggregate capacity of 26 well-documented fish salting factories in the Iberian peninsula and Morocco indicates stagnation from 50 to 200 CE.[22] Jongman's preliminary attempt to measure body height mostly in the western Roman provinces shows that femur length peaked in the first century CE.[23] Ian Morris's novel index of 'social development' in western Eurasia – derived from estimates concerning energy capture, organizational capacity, information processing, and warmaking capacity – peaks in 1 CE, with negative growth thereafter.[24] In so far as it is at all legitimate to put much weight on these observations – and once again I do so merely for the sake of demonstrating the

[20] First noted by Saller 2002: 263 with regard to shipwrecks.
[21] De Callataÿ 2005: 370-1 (unnumbered graphs).
[22] Wilson in press: fig.10.
[23] Jongman 2007b: 194 fig.7.
[24] Morris 2009: ch.3 and appendix.

consequences of a 'strong' reading of the data –, they would seem to suggest that economic expansion stalled sometime around the beginning of the Common Era. If taken at face value, these proxies consequently accord crucial importance to the preceding centuries. In this case, the Mediterranean economy would have expanded during the violent dislocations brought about by Roman conquest and civil war rather than in the peaceful stability of the early monarchical period. I return to this scenario in the final section below.

Our choice is simple. We may prefer to dismiss these and other time-series because of their perceived shortcomings or uncertain relevance, thereby inviting charges of hypercritical minimalism. Yet if we accept them as potentially flawed but ultimately usable proxies of economic expansion, we must pay attention to chronology and its implications for the causes and limitations of growth. More specifically, we need to re-think the customary characterization of the early monarchical period as an era of unprecedented economic development. Apparent stagnation is an improbable sign of economic growth, especially at a time when considerable population increases are likely to have occurred: one recent guesstimate reckons with an overall demographic expansion by one-third between 14 and 164 CE, above all in the western provinces.[25] A leveling off of growth in putative economic indicators that coincides with population growth logically implies falling per capita output.

Critics will object that my focus on a few quantified data series is unduly narrow and that other proxy variables ought to be considered as well, especially urbanization and technological innovation. Urban settlements undoubtedly proliferated during the early monarchical period, especially in the northwestern and southwestern provinces of the Roman empire. This process is quantifiable at least in principle, although a comprehensive systematic survey has yet to be undertaken.[26] In any case, economic interpretation of this phenomenon is far from straightforward. For instance, it may not be appropriate to relate estimated levels of urbanization in the Roman empire to per capita GDP, an approach explored by Peter Temin.[27] One problem is that Temin compares estimates of Roman urbanization that pertain to all formally (i.e., legally) 'urban' settlements (such as the more than 400 towns of Italy, some of which were smaller than large 'villages' in Roman Egypt) with urbanization rates for later societies that are based on cities of 10,000 or more inhabitants. This method greatly inflates the level of urbanization (and thus implied GDP) in the Roman world: while Roman historians routinely operate with urbanization rates of 10 or even 15 or 20 percent for the empire as a whole, Josiah Russell estimated that only 4.1 percent of the imperial population lived in cities of 10,000+ residents.[28] And even if we wanted to consider changes in the relative demographic weight of *all* urban settlements instead, we would need to grapple with the political and social dimension of nucleation that has been highlighted by Mogens Hansen's recent finding that by the fourth century BCE maybe half of all Greeks lived in 'urban' settlements, many of which were of course very small.[29] This basic point is

[25] Frier 2000: 811-814. Note that the notion of population growth is independent of absolute population size, which is important given continuing controversy about Roman population numbers: see most recently Scheidel 2008.
[26] We can expect the Oxford Roman Economy Project (OXREP) to advance our knowledge on this issue.
[27] Temin 2006: 41-43.
[28] Russell 1958: 65-83 as summarized by Maddison 2007: 41-42.
[29] Hansen 2006 and in press.

further illustrated by Susan Alcock's survey of nucleation and denucleation in Roman Greece.[30] While to some degree contingent on the capacity of the agrarian economy to produce surpluses to sustain non-farmers, Roman urbanism was also conditioned by the urban residence patterns of local elites and the consequent concentration of resources, employment, and people (including suburban farming populations) in urban settlements.[31] To the extent that socio-cultural forces promoted urban residence of parts of the farming population – with the 'agro-towns' of nineteenth-century Sicily serving as an extreme example of this pattern –, urbanization rates create an exaggerated impression of the scale of the non-agrarian sector.[32] The Greek case in particular should warn us against simplistic assumptions and in any case makes it impossible to infer either the cumulative scale of economic growth or changes in its rate.

My aim is not to question that urban expansion coincided with a measure of gross and intensive economic growth, especially in the western provinces of the empire. What matters here is how evidence for urbanization can be used to shed light on different models of Roman economic growth. To name just a single example, in medieval Central Europe the incidence of new town charters, which had been rising throughout the thirteenth century, dropped considerably during the first half of the fourteenth century, at a time when Malthusian constraints strenghtened but before the Black Death decimated the population.[33] It would be important to know if a similar abatement can be observed in different parts of the western Roman empire and at what time. Thus, urban growth in Italy that stalled while expansion was still underway in more peripheral regions might be indicative of economic growth that could not be endogenously sustained. In this context, we must wonder whether the notions of urban building booms in Italy during the first century of the monarchy and in Gaul in the first and early second centuries CE reflect spatially staggered economic growth and whether their abatement was driven by economic change or by unrelated causes such as shifts in spending priorities.[34]

Recent scholarship on the diffusion of technological innovation in the Roman period provides a valuable counterweight to earlier sweeping claims about the supposed cultural marginalization of technology or the failure to exploit the economic potential of various inventions.[35] In the final analysis, technological progress – both narrowly defined in engineering terms and more broadly conceived as encompassing innovation in crop use and labor techniques – is the key driving force behind intensive economic growth. Productivity and hence per capita output have long trended upwards in the very long run and there is no reason to suspect that the Roman period was an exception to this trend.[36] In this basic sense, the question of whether technological innovation induced intensive

[30] Alcock 1993: e.g. 114-115

[31] See esp. Erdkamp 2001 for a lucid exposition of the frequently misunderstood concept of the ancient 'consumer city'.

[32] 200 years ago, about two-thirds of the population of Sicily resided in urban settlements but most of them worked as farmers: e.g., Malanima 2005: 98-99. Hansen's calculations suggest that in this respect many Greek towns resembled Sicilian 'agro-towns'.

[33] Pounds 1994: 102 fig.3.4.

[34] Compare Patterson 2006: 90 with Woolf 1998: 123. Patterson emphasizes changing priorities rather than overall decline in later Roman Italy (ibid. 89-183).

[35] See esp. Greene 2000; Wilson 2002; Schneider 2007. The contributions to Oleson (ed.) (2008) offer a state-of-the-art survey of Greco-Roman technology. Cf. Cuomo 2007: 3-5 for the misleading notions of *blocage* and marginalization in much of earlier scholarship.

[36] Long-term trend: e.g., Kremer 1993; Simon 2000. Roman period: e.g., Schneider 2007: 167-171.

growth in the Roman economy is moot. Instead, we must ask whether we can hope to determine where and when and for how long the generation and dissemination of innovation supported economic growth on a scale that made it likely to outpace the demographic expansion enabled by this very process.

For example, to return one more time to the issue of variation in Roman mining output on the Iberian peninsula, the question is not whether the expansion of mechanization in mining that accounted for the spike observed in the air pollution data was impressive (in premodern comparativist terms) – what Wilson calls "some of the most advanced and large-scale applications of technology to economically critical work ever to be practised before the European industrial revolution" – but rather why this process was not sustained in the absence of mineral depletion. The textual sources are silent; Wilson speculates that this abatement or downright abandonment might have been linked to the failure of military protection in the mining districts or alternatively that the "vast levels of capital investment necessary" could no longer be sustained.[37] He also posits a nexus between the extraction of precious metals for minting purposes and Roman economic performance more generally: "In a very real sense, the Roman economy during the first two centuries A.D. was highly dependent on advanced technology and mechanization to keep the money supply going. […] [T]he economic performance of the first and second century, and to a certain degree the high level of imperial or state spending […] was partly dependent on the use of advanced technology and industrial-scale operation in the mines. The importance of technology to the ancient economy, and to wider historical processes, can be measured by what happened when the larger-scale hydraulic operations were no longer active."[38]

These claims invite a number of critical observations. The 'military' explanation for the abatement of mining activity is not only implausible but also logically incompatible with the notion that this activity was of vital importance to the state or the economy. It would make little sense to entertain the notion that the Roman state was unable to restore order after a simple raid across the Straits of Gibraltar at a time when it expanded its legionary forces by almost one-fifth, sacked the Parthian capital Ctesiphon, created a new province in northern Mesopotamia, and had resources to spare for wasteful campaigning in distant Scotland. It would be equally unwise to believe that under these circumstances the Roman state would have withdrawn military units from other mining districts even though these assets were of crucial importance in sustaining military funding. A drying up of capital – i.e., cost – might seem a more plausible explanation. This, however, would imply that the economy was already in decline at the time when the exploitation of mines that had not been exhausted diminished or ceased altogether. This, in turn, would seem hard to reconcile with the image of a flourishing imperial economy fueled by the Iberian bullion supply in which growth was supported by technological progress in the mining sector. Capital scarcity could only have been the main culprit if the economy had failed to generate sufficient incentives for continuing investment in

[37] Wilson 2002: 28-9, referring to a (short-lived) Moorish incursion in 171 CE that may have interrupted mining activity in south-western Spain, and noting that with respect to the roughly simultaneous abandonment of unaffected hydraulic gold mines in north-western Spain "one might speculate that the army units who oversaw or protected the mines may have been withdrawn or moved elsewhere in response to other military needs". Capital needs are invoked ibid. 32.
[38] Wilson 2002: 27 and 29.

mining: in other words, a lack of demand. This could mean that the ratio of investment to profit ceased to be satisfactory, which would undermine the notion of sustainable economic net gains from the application of certain types of technology, and/or that the state and the economy were not as critically reliant on new bullion as Wilson suggests. The latter is borne out by the facts that the state was capable of massive spending military increases in the early third century CE and that, at least as far as we can tell, the ensuing rapid debasement of the imperial silver currency did not trigger corresponding price inflation for almost an entire century, until the 270s CE. This highlights the well-known – and frequently puzzled-over – fiduciary element of the Roman imperial currency system of that period.[39] Thus there is nothing to suggest that the Roman state or the economy of the empire faced crisis because of a bullion shortage. Instead, economic abatement appears to have preceded and contributed to the cessation of costly hydraulic mining. In a genuinely thriving economy, bullion supply constraints would more likely have resulted in deflation and an expansion of credit money (which was well-known in the Roman empire), as happened in Song China when mining could not keep up with growing demand for cash.[40] From this perspective, hydraulic mining can hardly claim a vital role in accounting for the performance of the Roman economy.

The diffusion of water-mills is another popular example of technological progress. Wilson's point that reliance on textual sources distorts our vision by emphasizing the spread of this techology in late and very late antiquity (from the fourth to seventh centuries CE) and that archaeological data – which have greatly increased over the past twenty years – indicate a (feeble) peak in the second and third centuries CE is well taken.[41] One will also readily accept his carefully supported conclusion that the water-mill had spread earlier and more widely in the Roman period than ancient and especially medieval historians used to assume.[42] Once again, however, the relationship between this process and economic growth is far from straightforward. First of all, we have to ask, with Yan Zelener, what impact innovation at one point of what he calls a 'production pipeline' of different processes can be expected to have had unless it was accompanied by innovation in other areas: thus, milling was only one step in a complex process of cereal cultivation from ploughing, sowing, weeding and harvesting to threshing, winnowing, storing, milling and baking. As Zelener points out, "only improvements along the entire pipeline or at the most congested point would have elevated aggregate agricultural productivity, thus resulting in an economically meaningful outcome", that is, "a quantitative increase in productivity and hence per capita GDP".[43] It seems unlikely that milling capacity had ever constituted a bottleneck in cereal production. Secondly, we have no way of telling how the distribution of water-mills in the Roman empire of the third century CE compares to the situation in England in 1086 when the Domesday Book reported no fewer than 6,082 water-mills at a time when the country was inhabited by perhaps two million people and the urbanization rate

[39] See the balanced account in Howgego 1995: 121-135 and the more strained argument in Strobel 2002.
[40] For the sophistication of Roman credit money, see now Harris 2006 and 2008. For China, see von Glahn 1996: 49-51.
[41] Wilson n.d. I use the term "feeble" because neither the overall sample size nor the differences between 5 archaeologically attested water-mills from the first century CE, 11 from the second century, 12 from third century, and 8 from the fourth century CE are particularly striking.
[42] Wilson 2002: 9-15. See now also Brun 2006; Wikander 2008: 141-152.
[43] Zelener 2006: 313.

stood at a few percent.[44] According to one estimate these installations provided 30 percent of England's total energy needs.[45] In order to match this density, some 200,000 water-mills would have had to operate in the Roman empire as a whole. If that had not been the case – how would we know?[46] –, would that mean that weakly urbanized and monetized eleventh-century England was technologically and economically more advanced than the Roman world? And thirdly, we might wonder why – if true – Roman water-mill construction peaked in the second and third centuries CE and how this might be related to different models of economic growth. For example, in as much as water-mills replaced animal-powered mills, this substitution could have reflected increasing competition for land between humans and animals caused by population pressure. In that case, productivity gains from the application of water power might have been absorbed by demographic growth. Alternatively, the spread of water-mills could just as well have been precipitated by different factors. Roman historians have little hope of addressing this issue in any meaningful way: after all, John Langdon's recent study of the milling economy of late medieval England, which is vastly better known than its Roman counterpart, struggles to make sense of chronological variation in the number of water-mills and ultimately proves unable to link it decisively to a particular variable, such as economic performance or demographic developments.[47]

It is similarly difficult to relate changes in crop cultivation and livestock breeding techniques to competing models of economic growth.[48] Productivity increases in farming may be a sign of intensification, driven by and in turn sustaining population growth,[49] just as the appearance of larger domesticated animals might equally well reflect per capita increases in consumption or represent a response to increasing competition for scarce land without attendant net increases in per capita consumption. What may have been the single most important innovation in the sphere of labor organization, the expansion of chattel slavery, was primarily concentrated in the late republican period and moreover limited to select core regions: if this process had indeed raised mean productivity, it would have done so prior to the early monarchical period, which would be consonant with the notion of a more general abatement of intensive growth at that time.

Consideration of features that can reasonably be expected to have promoted economic development or reflected this process, such as monetization, financial institutions, legal facilitation of commerce, market integration, and the emergence of the *societas*, is of great interest in its own right.[50] However, it cannot help us address the problem of how to choose between different models of change: thus, the notion that a particular configuration of institutional characteristics *might* have protected Roman

[44] Munro 2003. This comparandum was already invoked by Marc Bloch back in 1935.
[45] Langdon 1986: 20.
[46] Cf. Brun 2006: 121-122.
[47] Langdon 2004: 28-31. Cf. similarly Munro 2003.
[48] Geoffrey Kron has studied signs of progress and sophistication in great detail: see esp. Kron 2000, 2002, 2008. In principle, progress in farming would have had the most impact on overall GDP because of the dominance of this sector: cf. Zelener 2006: 304.
[49] E.g., Zelener 2006: 315-316, with reference to the Roman case.
[50] I draw here largely on the list of features discussed by Silver 2007: 200-220. On monetization, see Duncan-Jones 1994: 167-170, with Jongman 2003: 187; on finance, see Temin 2004; Harris 2006 and 2008; on integration, Temin 2001; on the *societas*, see Malmendier 2002. For the economic import of institutions in general, see most recently Lo Cascio 2006; Frier and Kehoe 2007; Kehoe 2007; De Ligt 2007.

economic development from Malthusian pressures is precisely what we would need to establish but must not assume a priori. Suffice it to note that the fact that early modern Europe experienced great advances in all these areas did not insulate it from the adverse consequences of demographic growth and resource depletion (see the penultimate section below).

Income proxies of economic growth

In principle, serial data on incomes might serve as a proxy of economic development. In practice, we face two major problems. One is that economic change and wages need not be closely related in time, although they tend to be in the long term. I will return to this issue in the following section. The other is that pertinent documentary evidence from the Roman period is extremely scarce and largely limited to the papyrological record from Egypt.[51] My own survey of mean daily wages of unskilled rural laborers, expressed in wheat, from the early Hellenistic period to the High Middle Ages identified long-term income stability interrupted by a single significant rise in real wages (Fig.5).

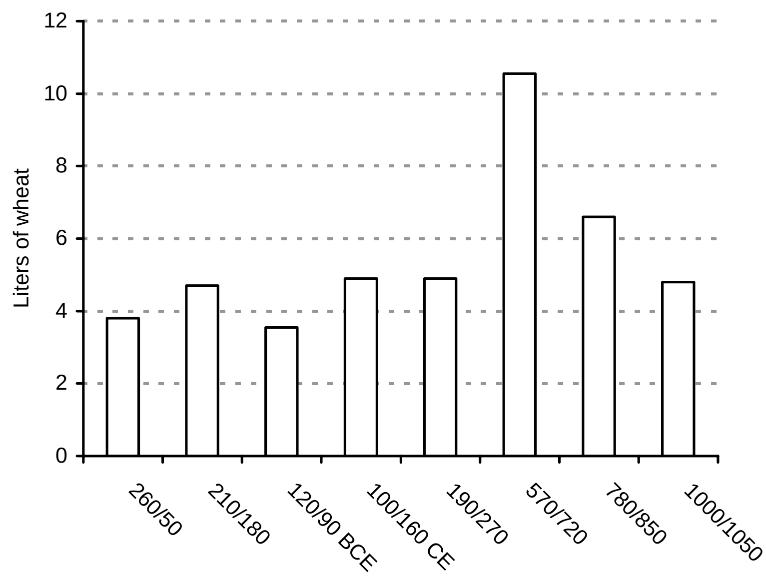

Fig.5 Daily wheat wages for unskilled rural labor in Egypt, 260 BCE – 1050 CE
(in liters of wheat)
Source: Scheidel forthcoming

[51] The main surveys are Maresch 1996 (Ptolemaic period); Drexhage 1991 (early Roman period); Johnston and West 1949, with Morelli 1996 (late Roman period). Ashtor 1969 covers the medieval evidence.

The secular trendline of approximately 4 to 5 liters of wheat per day is consistent with comparative evidence from a number of other early Afroeurasian economies reaching back to Mesopotamia 4,000 years ago: most of the reported daily wheat wages fall in a range from 3.5 to 6.5 liters.[52] In Egypt itself there is no sign of an increase in real incomes for this category of workers between the Hellenistic and the Roman periods. Moreover, the Egyptian wheat wages are roughly the same as the daily wage cap of 4.7 liters of wheat equivalent for an unskilled worker ordained by the tetrarchic price edict of 301 CE.[53] However, while this might be taken as indicative of a lack of significant per capita growth in this period, these data do not conclusively show that average incomes did not rise in Roman Egypt. Given the expansion of urbanism in this period, it is possible that income growth did occur but was concentrated in urban labor markets.[54] This, after all, would be the most plausible proximate cause of urbanization. Unfortunately, the available sources do not allow us to test this hypothesis. All we can say with some measure of confidence is that the Roman period did not deliver noticeably higher real incomes to rural wage laborers. It appears that wheat wages greatly increased only once when a series of epidemics known as the 'Justinianic Plague' ravaged much of Europe and the Middle East.[55] In addition, as I argued on a previous occasion, the so-called 'Antonine Plague' of the late second century CE may have bestowed more modest real income benefits on Egyptian workers.[56] These observations underscore the relevance of Malthusian scenarios for our understading of premodern economies: both at the end of antiquity and in the late Middle Ages, at the time of the Black Death, massive population losses were required for real incomes to rise across the board. It is true that these demographic contractions must have reduced total gross GDP and that changes in real wages in one segment of the labor market need not track changes in mean real wages or per capita GDP: changes in occupational structure and income distribution may account for divergent movements.[57] This means that as already noted, we cannot rule out the possibility that intensive growth that was not associated with demographic contraction may have occurred in Roman Egypt as long as it was limited to relatively privileged segments of the population and did not affect poorer workers. We will encounter an example of this type of development in the next section.

An independent wage series is available for the Roman army. The nominal annual base pay for a legionary soldier amounted to 225 *denarii* around 50 BCE and to 300 *denarii* until 197 CE, an increase by one-third over the course of a quarter of a millennium (not counting donatives or discharge bonuses). Owing to intervening currency debasement, gold wages rose less during this period, by about 20 percent if soldiers' wages are expressed in newly minted *aurei*, while silver wages fell by about 27

[52] Scheidel forthcoming: table 4.
[53] See the analysis by Allen 2007, with the revision in Scheidel forthcoming: n.15. Cf. also Temin 2006: 45-46 for similar wheat wages in Rome and Roman Egypt.
[54] For levels of urbanization in Roman Egypt, see Tacoma 2006: 21-68. For the causes, see now Monson 2008.
[55] See Fig.4, with Scheidel forthcoming; and cf. also Findlay and Lundahl 2006.
[56] Scheidel 2002: the price of wine and olives fell relative to wages, as did rents and land prices. But the scale of this effect – which is itself contested: cf. Bagnall 2002 – is dwarfed by the rise in real incomes after the mid-sixth century CE.
[57] E.g., Pamuk 2007: 296, and in the following section below.

percent.[58] We are unable to relate these changes to price trends, which remain essentially unknown outside Egypt. However, it is unlikely that inflation was completely absent: after the *quadrans* (1/4 *as*) had replaced the *sextans* (1/6 *as*) as the smallest denomination of the Roman currency system by *c*.90 BCE, both the *quadrans* and *semis* (1/2 *as*) disappeared after the 150s CE. Similarly, some low-end denominations of eastern provincial coinages ceased to be minted at various times between Augustus and Trajan. Nominal prices in Roman Egypt may have risen in the first half of the first century CE and doubled between the 160s and 190s CE. All this suggests both gradual and accelerating inflationary devaluation.[59]

If the recorded wages had sustained military forces drawn from a stable pool of recruits, it would be tempting to interpret this as a sign of stagnation of real incomes or even possible to speculate about real-term losses in the long run. However, any economic inferences from these data are undermined by the displacement of military recruitment from the core to the periphery that unfolded in this period: if the evidence of soldiers' tombstones is to be trusted, legionary recruits from Italy, whilst initially dominant, were gradually replaced by those from provincial areas.[60] This raises the possibility that due to inflation and/or real income growth in Italy, military service became less attractive to its population and provincials from lower-wage regions filled the gap. In that case, the shift in recruitment together with the apparent stagnation of military real wages might simply reflect differentiation between more and less developed parts of the empire and the emergence of an integrated military labor market that enabled the state to keep down real wages by shifting recruitment to lower-income areas. It merits attention that these developments do not necessarily denote ongoing civilian income growth (and thus, perhaps, intensive economic growth) in Italy during the early monarchical period: if this region had been disproportionately affected by price increases caused by nonreciprocal asset inflows – as suggested by the economist Hans-Ulrich von Freyberg –, the peripherization of military service might very well have been a function of this process alone.[61] All this casts grave doubt on the utility of the military wage data even as rough proxies of economic growth.

In theory, it would be feasible relate increases in the imperial budget to per capita output growth if we had reliable information about changes in the nominal budget, in population size, and in the effective tax rate, as well as about the rate of inflation. While this is an equation that consists entirely of 'known unknowns', this approach nevertheless

[58] See Duncan-Jones 1994: 216-7 for rates of coin debasement. In practice, soldiers received much of their pay in kind, and probably also in older coin.

[59] Disappearance of denominations: Howgego 1995: 122. For Egypt, see Rathbone 1997.

[60] See Campbell 2002: 26, summarizing Giovanni Forni's results.

[61] Freyberg 1989: 146-148. All we know for sure is that prices in the city of Rome were exceptionally high: see Duncan-Jones 1982: 345-346. Maddison 2007: 47-53 posits significant differences in per capita GDP between Italy and the provinces. Incidentally, the high nominal price of slaves in Roman Italy may have been a function of this process, driving up slave prices elsewhere and causing slaves to be concentrated in Italy. Hopkins 1978: 162 has argued that Roman demand was behind the rising cost of unconditional manumission of slaves recorded in Delphi during the last two centuries BCE; but cf. Duncan-Jones 1984 for some doubts. It is tempting to deduce from this development high real (rather than nominal) wages for free workers in Roman Italy, as maintained by Jongman 2007: 602, but we cannot be sure whether we are dealing with high real rather than nominal wages and whether those slaves whose manumissions were epigraphically recorded were particularly skilled or otherwise privileged: there is nothing to suggest that they were the equivalent of "typical adult male workers" (ibid). Cf. already Scheidel 2007: 335 n.51.

offers controls on modern guesswork regarding the *potential* scale of Roman intensive growth. This limited but important purpose is served by a simple matrix of variables that is designed to illustrate the logical implications for the rate of per capita growth of certain assumptions about each variable. This matrix is anchored in two empirical observations about the size of the imperial legionary forces and their base pay. The number of legions (28) was the same in 1 and 150 CE while base pay had risen by one-third, which means that overall (regular) expenditure had likewise risen by (approximately) the same proportion. Based on this information, the conjectural matrix in Table 1 manipulates four variables both separately and concurrently – population size (1), the effective per capita tax rate (2), the mean annual rate of inflation (3), and the mean annual rate of per capita economic growth (4) – in order to simulate changes in the size of the military budget (5), overall state revenue (6), and the share of military spending in total state revenue (7). I employ a set of what I consider to be conservative assumptions: I assume that the imperial population grew by about one-third in this period; I allow for an effective per capita tax rate that either remained constant or rose by 20 percent; I operate with mean annual rates of inflation of zero and 0.1 per cent (for a modest increase by one-sixth over 150 years); I envision rates of intensive growth of zero, 0.1, and 0.2 per cent; and I assume that total military spending either developed proportionately to that of the legions (for a nominal increase by one-third) or that expenditure on auxiliary and other military forces equaled legionary spending in 1 CE but due to manpower increases had grown by one-third by 150 CE on top of the one-third raise in wages. Population size, the effective tax rate, and the total military budget are all standardized at 100 for 1 CE.[62] The share of military spending in 1 CE is set at three-quarters of total state revenue, which is necessarily arbitrary but does not affect the logic of the matrix: any percentage is merely a placeholder used to illustrate changes in the share of the military budget. Any remotely plausible proportion would serve the same function in the same way.[63]

Table 1 Matrix of determinants of Roman state revenue and the share of military expenditure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
YEAR	POP	TAX	INF	GRO	MIL	REV	MIL SHARE
1	100	100	-	-	100	133	75
150	133	100	0	0	133	177	75
	133	100	0	0	156	177	88
	133	120	0	0	133	212	63
	133	120	0	0	156	212	74
	133	100	0.1	0	133	206	65
	133	100	0.1	0	156	206	76

[62] For population growth, I follow Frier 2000: 811-814; see above, n.25. Duncan-Jones 1994: 46 guesses that Vespasian raised tax revenue by 20 percent. It seems likely a priori that the maturing census system increased the tax take, especially in the western provinces. For inflation, see above.
[63] Duncan-Jones 1994: 45 puts military spending at 75 percent around 150 CE; I use this share for 1 CE: see in the text below, and n.64.

133	120	0.1	0	133	246	54
133	120	0.1	0	156	246	63
133	100	0	0.1	133	206	65
133	100	0	0.1	156	206	76
133	120	0	0.1	133	247	54
133	120	0	0.1	156	247	63
133	100	0.1	0.1	133	239	56
133	100	0.1	0.1	156	239	65
133	120	0.1	0.1	133	287	46
133	120	0.1	0.1	156	287	54
133	100	0	0.2	133	239	56
133	100	0	0.2	156	239	65
133	120	0	0.2	133	287	46
133	120	0	0.2	156	287	54
133	120	0.1	0.2	133	333	40
133	120	0.1	0.2	156	333	47

This matrix shows that between 1 and 150 CE, under conservative assumptions – a population increase of one-third, a tax rate increase of one-fifth, inflation of one-sixth –, the share of military spending in total state revenue would have dropped from three-quarters to around one-half of the budget if annual intensive economic growth had averaged 0.1 percent. A higher intensive growth growth rate of, say, 0.2 percent would have depressed military spending below one-half, indicating an amount of slack in the system that seems hard to reconcile with the apparent cost of modest troop enlargments in the late second century CE and the currency debasement triggered by increases in military base pay in the early third century CE. At the same time, even in the absence of any intensive economic growth, the military share could easily have fallen from three-quarters to around 60 percent of the budget. Moreover, it merits attention that the starting assumption of a military budget of 75 percent of total revenue is considered too high by some: alternatively, a rate of two-thirds has been proposed for the late first century CE.[64] With a lower starting rate, higher economic growth would depress military spending even further than indicated in my matrix, to perhaps closer to one-third of total revenue, which would push down military spending to levels encountered in maturing European nation states which had already assumed funding obligations that were absent from most earlier states.[65]

The main point of this exercise is to show that unless we prefer what seem to me unrealistic assumptions – such as zero inflation over 150 years, or very little population growth, or a constant effective tax rate –, the scope for intensive economic growth is quite limited unless we are prepared to believe in a dramatic shift from military to civilian spending priorities during this period, a notion which seems inconsistent with the strain later expansions of the military sector put on the system. While some re-weighting in favor of non-military spending may well have occurred during this period of overall stability, this matrix makes it hard to posit intensive growth of closer to 0.2 than to 0.1 (or indeed 0) percent per year, let alone a higher rate. This tentative conclusion allows us to

[64] Wolters 1999: 223.
[65] Cf., e.g., Tilly 1992: 124 for comparanda.

consider the mean annual rate of intensive economic growth of (at least) 0.2 per cent in the Netherlands between 1580 and 1820 an implausibly high upper limit for the Roman imperial economy as a whole: in that period, the Netherlands boasted the fastest-growing economy in Europe and experienced transformations that had no parallel in the Roman world.[66] We can therefore safely rule out the possibility that "Rome experienced intervals as long as a century during which per capita income grew by as much as 0.5 percent per year", at least if this claim is meant to apply to the empire as a whole or any large part thereof.[67] Thus, it lends a measure of support to guesstimates of around 0.05 or 0.1 percent p.a. proposed in recent scholarship on a priori grounds.[68] However, I must stress that this matrix cannot tell us whether there was intensive economic growth at all but merely indicates (1) that if it did occur, it was likely to be modest, and (2) that its occurrence is not essential to a credible scenario of state revenue growth and distribution.

Growth and income

The study of intensive economic growth in the Roman period acquires meaning only if it can be related to the question of the development of real incomes, which are a critical determinant of well-being.[69] In order to assess the performance of the Roman economy we would need to know three things: how gross GDP changed over time; how per capita GDP changed over time; and how the distribution of income changed over time. Comparative evidence shows that these issues are related in complicated ways. Angus Maddison estimates that between 1500 and 1820, gross GDP in western Europe increased by 262 percent whereas average per capita GDP rose only 56 percent during the same period.[70] Nothwithstanding the highly conjectural character of these figures, there can be no doubt that the bulk of economic growth was a function of population growth: more output was much more likely to generate more people rather than more income per person. Nonetheless, while an aggregate rate of 50 to 60 percent intensive growth over 320 years must seem paltry by modern standards – equivalent to China's growth over the last five years –, it nevertheless represents a considerable achievement that might be expected to have lifted living standards across the board. This, however, was not the case: the average rate of per capita growth conceals growing income differentiation. Thus, recent work by the modern economic historians Robert Allen, Jan-Luiten van Zanden and others has conclusively demonstrated that real wages for unskilled laborers dropped

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[66] See Saller 2002: 258 tab.12.1 (0.2 percent); but cf. Maddison 2007: 383 for a higher mean of 0.28 percent. De Vries and van der Woude 1997 reveal the exceptional character of the early modern Dutch economy.

[67] *Contra* Silver 2007: 207. Relatively rapid growth may have occurred in late Republican Italy when tribute started flowing in (see Scheidel 2007b and in the following section) but no comparable stimulus ever reached the empire as a whole.

[68] For likely rates of growth on that scale, see Morris, Scheidel and Saller 2007: 5-6, 11. Maddison 2007: 383 conjectures a western European annual mean of *c.*0.14 percent from 1500 to 1820, roughly the same as from 1000 to 1820 CE. Cf. also Silver 2007: 199.

[69] Other factors come into play, such as education and health, as emphasized by the UN's Human Development Index. While this is well beyond the scope of this paper it is a promising subject even for ancient historians and deserves more attention: see Scheidel 2006: 54-59.

[70] Maddison 2007: 379, 382.

throughout this period, except in the precociously advanced economies of England and the Netherlands (Fig.6).[71]

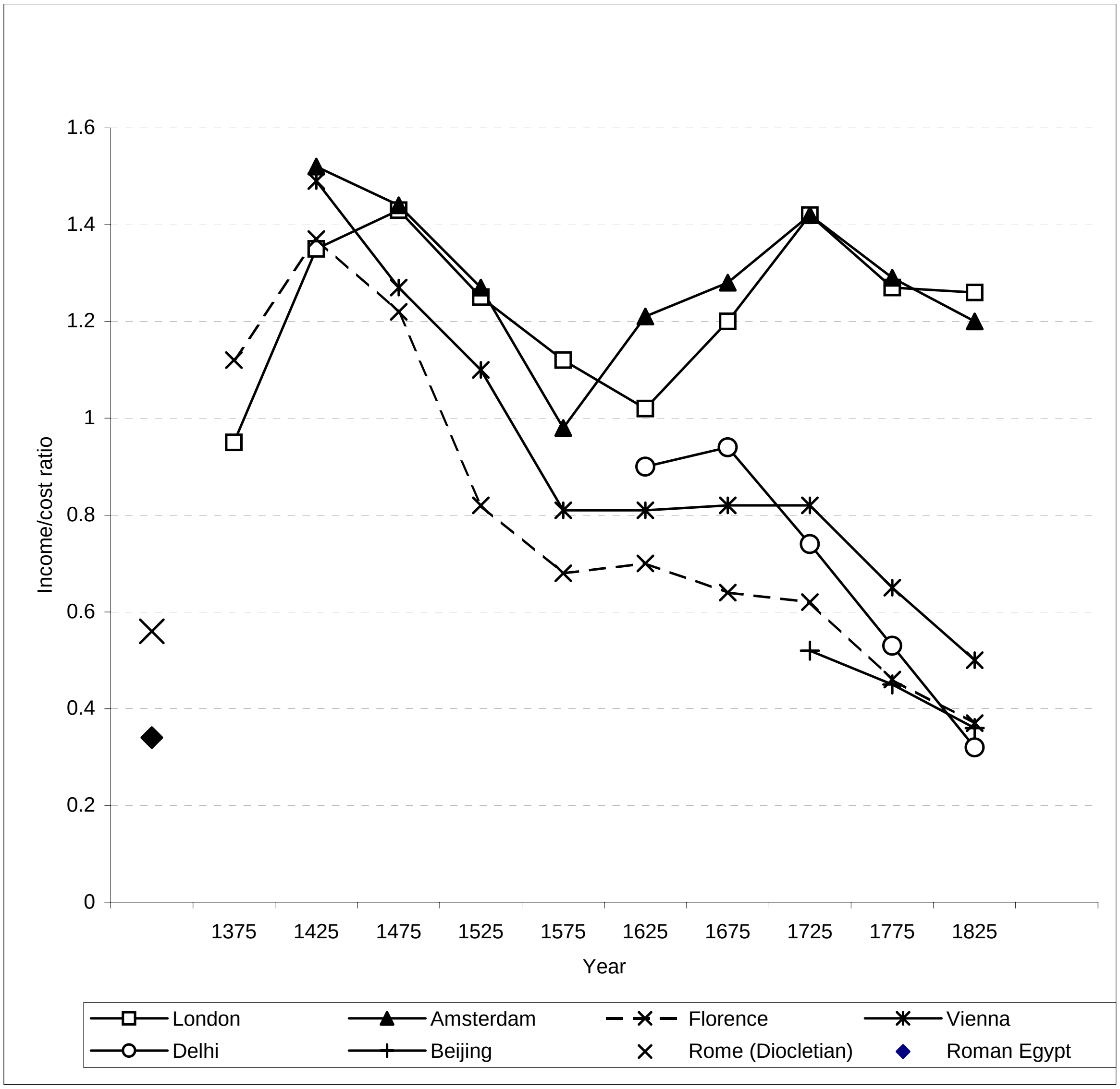

Fig.6 "Respectability ratio" for unskilled wage laborers (laborer's income divided by cost of "respectable" consumption basket for a family)
Source: Allen 2007; Scheidel forthcoming

In the early modern European case, real incomes for workers slid from a peak induced by the scarcity of labor in the wake of the Black Death until they reached levels

[71] See esp. van Zanden 1999; Allen 2001, 2005, 2007; Allen et al. 2005. Real wages may be expressed as wheat wages (van Zanden) or in the form of consumption ratios that relate an adult male worker's income to the cost of a standardized basket of consumer goods for his family (Allen).

that are comparable to those in contemporary Delhi and Beijing as well as those found in Roman Egypt and implied by the Roman price edict of 301 CE. What matters here is that this slide coincided with some 50 to 60 percent per capita economic growth within the same period, suggesting that inequality increased faster than average real incomes. A recent study consequently documented substantial increases in inequality indicated by changes in the relative cost of living of high- and low-income groups in England, France, and (less so) the Netherlands.[72]

How can we tell whether anything comparable happened in the Roman empire? Imagine that long after a nuclear holocaust or devastating asteroid impact, future archaeologists set out to measure 'economic growth' in early modern Europe. All relevant statistics have been lost but stratigraphy allows them to draw direct comparisons between conditions in 1500 and 1800. How would they interpret the record? Faced with ample evidence of innovation and expansion, such as more and larger cities, more advanced technology, bigger ships, more writing, new crops, more metal and more consumer goods of any kind, they would undoubtedly conclude that very considerable 'growth' had occurred in this period and that Europe in 1800 was an unprecedently prosperous place. Yet without the help of statistical data, would they be able to discern the massive difference between the rates of gross and real growth, let alone the concomitant increase in inequality and the worsening immiseration of manual laborers? In the real world, Roman archaeologists encounter similar signs of innovation and expansion: more and larger cities, more advanced technology, bigger ships, more writing, new crops, more metal and more consumer goods of any kind. Yet without the statistics available to historians of early modern Europe, how can they hope to disentangle the key variables that matter so much to our understanding of the early modern period? And without this disentanglement, how can they hope to define the nature of Roman economic development?

I have introduced early modern data and this counterfactual scenario to address the inevitable 'commonsensical' objection that it would simply be perverse to doubt Roman growth and prosperity given the abundance of evidence for innovation and expansion. This comparison shows that this abundance is insufficient for our purposes. At the very least, we must accept that the Roman imperial record appears by no means incompatible with the development that unfolded in early modern Europe. Proliferating cities clad in marble with their aqueducts and statues and honorific inscriptions might conceivably be the most visible manifestation of a system that funneled a growing share of growing resources to urban elites and their retainers. Trade may have been boosted in the first instance by the combination of state demand for tax and private consumption by the same elites that managed this extractive structure, as Keith Hopkins, Chris Wickham, and Peter Bang have argued in different ways.[73] Assorted subelite groups from craftsmen to merchants and engineers would have thrived along the way, though perhaps disproportionately less so, while many others, like the rural wage laborers or the men attracted by army wages discussed in the previous section, were left behind. This scenario is readily consistent with the plausible notion that inequality in the overall distribution of

[72] Hoffman, Jacks, Levin and Lindert 2005: esp. 161-163.
[73] Hopkins 1980, 1995/96; Wickham 2005; Bang 2002, 2007.

assets increased throughout the Roman period.[74] It would also mesh well with a fundamentally Malthusian model in which income gains are not merely unevenly distributed but increasingly (and not merely steadily) absorbed by a growing population.

A more optimistic reading of the same evidence might hold that all or most inhabitants of the Roman empire benefited, at least for a while, even if some may have done so more than others, and I certainly do not wish to maintain that the pessimistic version is correct, because that is not my point. What I would like to know is how we would know whether or not something akin to the early modern European scenario applied to the Roman empire. To my mind, this question is the greatest challenge archaeologists face in their desire to assess the nature of Roman economic growth. It is a question that cannot be addressed by counting shipwrecks or measuring pollution levels or even the acreage of towns. This is not to say that there is no hope: different methods may allow us to probe more deeply. Given the common correlation between body height and well-being, anthropometry promises greater insight into changes in the level and distribution of real income. For example, Geoffrey Kron's finding that Italian males between 500 BCE and 500 CE appear to have been taller than until quite recently is certainly suggestive: however, a more recent study for Roman central Italy discovered a significantly lower mean, and in any case better chronological resolution is required to identify patterns and trends in these data.[75] In this respect, Nikola Köpke and Jörg Baten's (over?-)ambitious time series of mean body heights in different parts of Europe is of much greater relevance (Fig.7).

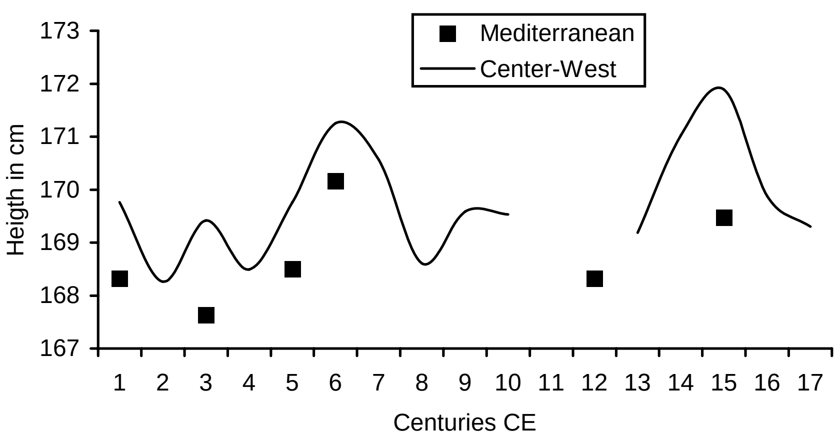

Fig.7 Mean body height in Mediterranean and Central/Western Europe (regression analysis)
Source: Köpke and Baten 2005: 77 fig.3.

[74] See esp. Jongman 2006: 247-250. Given the landowning elites' involvement in fiscal extraction, this was an endogenous process. For overall constraints on subelite income growth, see Friesen 2004; Friesen and Scheidel forthcoming.

[75] Kron 2005, who provides only a single average of 168.3cm for males in Roman Italy for this 1,000-year period (n=927). Contrast Giannecchini and Moggi-Cecchi 2008: 290, for a male mean of 164.4cm in Roman central Italy (n=283), as well as Capasso 2001: 926, for a mean of 163.8cm for males (n=55) from Herculaneum. Jongman 2007b: 194 fig.7 shows the need for better chronological resolution.

In the present context, it is particularly striking that while the Roman monarchical period witnessed stagnation, increases in body height in both the Mediterranean and Central/Western Europe coincided with episodes of demographic contraction. Recent regional surveys of body height from the original center to the outer periphery of the empire likewise point to improvements in the post-Roman period. Thus, in a sample of 1,021 skeletons from 74 sites in central Italy body height was greater both in the Iron Age (166.6cm for 220 males, 154.3cm for 181 females) and in the Middle Ages (166.9cm for 187 males, 154.5cm for 150 females) than in the Roman period (164.4cm for 153 males, 152.1cm for 130 males). 1,867 specimens from 61 sites in Britain reveal increases in mean body height of 5.7cm for males (n=773) and 4.4cm for females (n=557) between the Roman and early medieval periods.[76] All these observations would strongly support a Malthusian scenario in which Roman intensive economic growth, to the extent that it occurred after the beginning of the Common Era, failed widely to disseminate gains in well-being and only substantial population losses generated palpable benefits.[77] This reading would also mesh with evidence of rising real wages after the late antique and late medieval pandemics whose timing matches increases in body height.[78] However, these long-term comparisons need to be put on a much more solid evidentiary basis in order to support such wide-ranging conclusions.[79] In addition, sufficiently wide-ranging skeletal isotope analysis of changes in diet may eventually provide a further proxy index of variation in income and well-being.[80]

The case for unsustainable growth

Progress in the study of Roman economic growth will critically depend on the expansion of the range of proxy data and on the adoption of a more explicitly comparative perspective. Until this approach delivers tangible new results, any attempt to choose between scenarios of sustainable growth chocked off by exogenous shocks and a one-off growth spurt absorbed by population growth remains exceedingly hazardous and cannot yield more than conjectures that are simply meant to encourage further argument. With this caveat firmly in mind, I conclude this paper by trying to test (if this is not too grand a term here) these alternatives against putatively relevant data.

The model of one-off growth curtailed by Malthusian pressures logically entails a series of predictions that are susceptible to empirical falsification. It predicts that in the

[76] Giannecchini and Moggi-Cecchi 2008: 290 (Italy); Stephan 2008 (Britain).

[77] Köpke and Baten's mean of around 168cm for the Roman Mediterranean is the same as Kron's mean for Roman Italy, which might suggest that while this level was not reached in Italy during the generations prior prior to the mid-twentieth century, it need not have been exceptionally high in the very long run even if it does not inflate actual Roman body height. We also need to make sure to compare like with like, i.e. skeletons and skeletons rather than skeletons and modern statistics. Moreover, the contrast between means of 163.8cm (Capasso 2001: 926) and 169.1cm (Bisel 1988) reported for the same sample of Herculaneam men highlights the degree of inconsistency in existing anthropometric studies.

[78] See above, at Fig.7.

[79] Some of their samples are small and generally disparate. Cf. Jongman 2007b: 194 n.31.

[80] See MacKinnon 2007 for a rich survey of skeletal analysis in classical archaeology.

Roman period – say, between 200 BCE and 400 CE – expansion was stronger in the western than in the eastern half of the Mediterranean; that the coastal regions of the western Mediterranean experienced growth earlier than more remote regions; and that economic growth in the western Mediterranean coastal regions was concentrated in the last few centuries BCE and had already abated or even ceased during the period of ecumenical peace under the monarchy and in any case prior to the Antonine Plague of the 160s CE (the earliest candidate for a significant exogenous shock, to be followed by others in the third century CE). Conversely, a scenario of sustainable growth would imply ongoing growth in both the eastern and western halves of the Mediterranean, at least at diminishing but consistently positive rates, until the arrival of exogenous shocks in the late second and third centuries CE.

As the discussion in the preceding section will have made abundantly clear, testing these models requires a priori assumptions about the representative character and overall pertinence of certain types of proxy data. If, for the sake of argument, we incline towards a 'strong' reading of the archaeological data as defined above, the evidence strongly favors the first of these two models. Thus, the notion of one-off growth is consistent with the fact that the most recent survey of datable shipwrecks from the eastern Mediterranean finds that wrecks from the last three centuries BCE (n=57) are almost twice as numerous as those from the first three centuries CE (n=32), suggesting that growth stalled even earlier in the East.[81] Conversely, Parker's sample of precisely dated shipwrecks from the western Mediterranean contains similar numbers for the last two centuries BCE (n=164) and the first two centuries CE (n=177), indicating a later expansion that may have originated in the East.[82] More generally, the shipwreck data display negative net growth after 1 CE, as do the lead pollution data, reflecting – on a 'strong' reading – the end of expansion close to the beginning of the monarchical period. Western Mediterranean fish-salting capacity stagnated after the mid-first century CE whereas it expanded in highly peripheral Brittany in the second century CE, consonant with the notion of centrifugally staggered growth.[83] Body height, in so far as the currently available data are representative, fail to show increases comparable to those experienced during demographic contractions, and may even have fallen during the early and middle monarchical periods.[84] For what they are worth, all of these indicators are uniformly consistent with a Malthusian model of one-off unsustainable growth but fail to agree with rival interpretations.

In this scenario, in the coastal western Mediterranean and especially in Italy, (intensive) economic growth was primarily concentrated during the last two centuries BCE. This kind of expansion might be regarded as a catch-up process that stemmed from the incorporation of that region into the more developed economic system of the Hellenistic eastern Mediterranean and the Near East. At the risk of undue anachronism, it is worth pointing out that similar patterns could still be observed in the much more recent past, most notably in East and South-East Asia where globalization resulted in rapid

[81] Strauss 2008.

[82] Parker 1992: 551 fig.5. He also notes that the largest shipwrecks tend to be concentrated in the late Republican period: ibid. 26. For general impressions of the difference in scale of economic expansion in East and West, compare Harris 2007 and Leveau 2007 with Alcock 2007.

[83] Wilson in press: figs.10-11. Nobody will want to draw conclusions from this kind of sample: the point is merely to show what kind of evidence is required to test the hypotheses.

[84] See Köpke and Baten 2005 and Jongman 2007b: 194 as discussed above.

catch-up growth, for instance in Japan (twice, after the Meiji Restoration and after World War II) and now in China. Although Roman integration was driven by different factors (imperialism versus market forces), the overall shape of the process may have been similar. The most fundamental difference lies in the fact that in a modern economy, with its heavy reliance on human capital and, most notably, the Demographic Transition that decoupled population growth from output growth, this kind of growth will slow once the short-term gains of globalization have emerged but sustainable growth will continue at appropriately lower levels. In a pre-transition environment, by contrast, incorporation into a more mature system may well deliver benefits in per capita terms but will eventually encounter the countervailing force of population growth driven by rising real incomes.[85]

This model is consonant with what we observe in the Hellenistic and Roman periods. For the first time in history, Roman conquests merged the political-military systems of the eastern and western Mediterranean, arguably with profound consequences for economic integration and the dissemination of capital and technology. The violence and dislocation – in the form of war and mass enslavement – that attended this process constrained population growth and mobilized free-floating resources, thereby generating growth and income gains, most of all among the core beneficiaries of this process in Italy proper. As I have argued in more detail elsewhere, in Italy in the late republican period, the combination of checks on free population growth through war and emigration (warding off Malthusian pressure), the inflow of capital and slaves (indicative of high real wages), the externalization of the cost of war by conducting much of it in the provinces, and the distribution of the fruits of various forms of expropriation among commoners can be expected to have sustained income growth that was potentially substantial necessarily unsustainable in the long run.[86] Perhaps counterintuitively, the ecumenical peace of the Augustan and post-Augustan period removed some of these incentives and relaxed constraints on natural population growth, shifting the ratio of people and resources. In more peripheral areas, by contrast, the abatement of unpredictable predation, the regularization of fiscal extraction, and the diffusion of technology and human capital may have been conducive to intensive economic growth in addition to extensive growth reflected in demographic expansion. In some areas at least – and here we would need better resolution of standardized proxy indices – this development need not yet have abated by the time exogenous shocks intervened: this, however, is not necessary for the Malthusian 'one-off' model to apply. What matters is that growth ceased in the core areas, thereby predicting similar if delayed outcomes in the periphery.[87] In keeping with a prominent strand of research in the field of Roman History, this model assigns critical importance to the state, with its tributary mode of

[85] There is no indication of anything comparable to the Demographic Transition in the general Roman population: see Frier 1994; Caldwell 2004.
[86] Scheidel 2007. On the demographic cost of war and slavery, see Brunt 1987; Rosenstein 2004; Scheidel 2005. For mobility in general see Scheidel 2004a.
[87] Harris 1993: 29 asked, "Is there any good way of periodizing the specifically economic history of the Roman Empire between Augustus and Trajan?" My point here is that there is no such thing as an economic history of the Roman empire, only of zones of development whose asynchronicity requires regionalizing periodization.

surplus mobilization that ultimately underwrote urbanization, monetization, and exchange and ensured a baseline level of stability (though not ongoing growth) into late antiquity.[88]

To return one more time to the issue of technological change – in the narrow, mechanical sense –, the notion of unsustainable one-off growth driven by diffusion is also consistent with the observation that most innovations of the Roman period originated in the Hellenistic East, such as water-lifting devices, water-mills, military machinery, and glass-blowing, as well as others that could have been commercially exploited but were not, most famously the steam engine and perhaps also the wind-mill.[89] This repeated diffusion from a more to less developed area where new technology was applied and refined but failed to be matched by comparable original innovation neatly illustrates the principle of a one-off transfer. The comparative scarcity of similarly influential innovations after the last three centuries BCE even in the East underlines the lack of ongoing technological progress which alone could have generated sustained intensive economic growth in the face of demographic expansion. In a case like this, what did not happen is as important as what did happen. The sheer size and duration of the Roman empire suggests that in order to match the Hellenistic contribution to technological progress it would have had to have generated inventions on an even more impressive scale than the East had: yet precisely the opposite was the case. This speaks loudly of a critical weakness of the Roman economy, one that made sustainable growth a priori less likely and curtailed the economy's capacity to cope with rising population: progress in the accumulation of human capital was discontinuous and therefore insufficient in the long term.[90]

Whatever the merits of this scenario of one-off unsustainable growth and Malthusian pressure, it provides a coherent working hypothesis against which to arraign new empirical data and alternative scenarios. Moreover, it places the Roman period organically in a series of 'pulsations' or 'secular cycles' of growth and demographic constraints separated by crisis in the western Mediterranean and beyond: the Roman period, when population growth eventually caught up with economic real growth after a lengthy period of prosperity and inequality increased, followed by the disintegration of this system in late antiquity and thereafter, with population loss due to instability and plague; a second major cycle of medieval growth resulting in growing population pressure in the thirteenth and early fourteenth centuries that was again resolved by crisis, this time by the Black Death; and a third cycle of growth, pushing population density to unprecedented levels whilst gradually but steadily eroding the income gains enabled by the preceding contraction, with outliers such as the Netherlands and England running to stay in place and, in the latter case, finally breaking free from this Malthusian strait-jacket.[91]

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[88] See above, n.73. Cf. also the obverse argument that the state was the main achievement of the Roman economy: Jongman 2002: 45-47.

[89] See the convenient survey by Schneider 1991: 187-207, and more specifically Wilson 2002: 7-10 and Wikander 2008: 141-142 (water-lifting devices and and water-mill); Cuomo 2007: 41-76 (military technology); Bresson 2006 (steam engine); Drachmann 1961, with Wikander 2008: 153 (wind mill).

[90] See Saller 2007 for human capital and economic performance.

[91] For the concept of secular cycles, see now Turchin and Nefedov forthcoming. For the basic outline, see Grigg 1980. On the economic repercussions of the late antique demographic contraction, see Findlay and Lundahl 2006; on the Black Death, see most recently Pamuk 2007.

It is important to be precise about the purpose of this paper, which is to make a series of simple points. The economic relevance of many proxies is doubtful. However, if we reject them our ability to track change is much diminished. If we do accept the proxies as indicators of growth, which requires a measure of a priori reasoning, we also need to be prepared to follow them where they lead us. In that case, we cannot easily argue for substantial growth in the Mediterranean during the early monarchical period but must look for the most dynamic development in the preceding centuries, both in its eastern and western halves. If we wished to maintain that these proxies are nevertheless consistent with continuing growth, we would de facto question their capacity to track economic change at all. Moreover, if we follow the proxies, we must face up to unsettling questions about the driving forces of economic growth. If ecumenical peace after 30 BCE did not sustain economic growth in the core areas of the region, other factors must have been more significant but weakened in ostensibly favorable circumstances. Unsustainable growth is a hallmark of the Malthusian scenario. This does not mean that this model is correct but at the very least that it ought to be a – in my view, *the* – frontrunner in explaining the nature of Roman economic development. If we take this scenario seriously we also have to ponder side effects such as rising inequality and the example of early modern Europe. And if we do all this we may well come to the conclusion that by the early monarchical period, the Mediterranean economy was already straining against its limits and growth was increasingly confined to its continental hinterlands. Maybe Gibbon wasn't right after all.[92]

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[92] *Contra* Jongman 2007b: esp. 199. The reference is to Edward Gibbon's famous claim in chapter 3 of *The History of the Decline and Fall of the Roman Empire* that "If a man were called to fix the period in the history of the world, during which the condition of the human race was most happy and prosperous, he would, without hesitation, name that which elapsed from the death of Domitian to the accession of Commodus."

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