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Technological innovation and economic progress in the ancient world: M. I. Finley re-considered¹

By KEVIN GREENE

Moses Finley expressed such a forceful view of Greek and Roman economic stagnation and technological blockage in this journal in 1965 that his article has been cited as the received opinion on the subject ever since.² The main themes of the 1965 article were repeated (in part verbatim) in a seminal book, *The ancient economy*, which was published in 1973, updated in 1985, and reissued as a Penguin paperback in 1992.³ There have, however, been considerable changes in our factual knowledge and interpretation of ancient technology and economics, and the subject remains fundamental to an understanding of the developmental trajectory of ‘progress’ from prehistory to the industrial revolution.

A lively debate on Finley’s intellectual legacy continues in journals of classics or ancient history (and an imminent flood of conference proceedings); however, this article has been written for publication in this journal to reach the same audience that Finley considered important in the 1960s: historians of technology, and economic historians with a wider chronological range than his classical colleagues. Ancient historians are now more interested in Finley for broader historiographical reasons, and see no reason to scrutinize his use of literary and archaeological evidence for interpreting ancient technology. In a sensitive foreword to the latest reissue of *The ancient economy* in 1999, Ian Morris concluded that it ‘stands midway between deterministic, economicistic approaches and postmodern literary explorations’, occupying a position which explains its enduring significance, but added that Finley’s ‘humane vision of the Greek and Roman past will remain at the center of our arguments for the foreseeable future’.⁴ As an archaeologist with a particular interest in both the material and conceptual aspects of the history of technology I am unable to accept this conclusion, and to move on without continuing to challenge Finley’s minimalist interpretations and dismissive attitude

¹ This article was written while I held a Research Fellowship financed by the Leverhulme Trust (1997–8); my research into the context of Roman technological change has also been supported by the Society of Antiquaries of London (Hugh Chapman Memorial Fund). I am also grateful to this journal’s anonymous referees; one in particular provided many constructive suggestions and bibliographical references.

² Finley, ‘Technical innovation and economic progress’.

³ Knowledge of the original 1965 article among classicists was increased by its inclusion in a volume of Finley’s collected papers in 1981 with some bibliographical addenda (*Economy and society in ancient Greece*, pp. 176–95).

⁴ Morris, ‘Foreword’, p. xxxii.

towards archaeological evidence. To do so would reinforce the persistent representation of the Greco-Roman period as a curiously unproductive intermission between the great advances of later prehistory and of the middle ages.

Non-specialists are still likely to encounter Finley's views first because of the high profile of his publications, and may be swayed by his forcefulness and clarity. For example, a 1994 book on medieval technology used his 1965 article as the sole authority for the Roman background to the changes that took place after the end of the empire.⁵ A 1996 overview of world technological development subtitled 'an anthropologist's enquiry into western technology' did little better.⁶ A parallel may be drawn between Finley and V. Gordon Childe, whose 'Neolithic Revolution' has survived in non-specialist works for 60 years because of its attractive presentation in widely read popular books, 30 years after it had been declared neither neolithic nor a revolution by many prehistorians.⁷

This article does not break new ground; it is a synoptic collection of evidence, largely archaeological (most of which Finley did not know about), and a reinterpretation of some texts that he used, and its purpose is to offer a corrective to the continued use of Finley by non-classicists unaware of the progress of the debate about his views.⁸ It will concentrate on the study of technology as far as possible, and attempt to avoid straying too far into a general critique of economic theory. The principal conclusion is that Finley underestimated the spread of technological improvements, especially under the Romans. If the treatment seems rather discursive, it is because instead of adopting a thematic approach, it addresses the points of his 1965 article in the rather idiosyncratic sequence in which Finley presented them.

My considered position is that the classical world offered a remarkable opportunity for technology transfer, especially if a definition of technology is adopted that takes full account of utilization and not simply innovation.⁹ Greek colonization of areas bordering upon the Mediterranean, followed by Roman military conquest of its hinterland, brought an unparalleled geographical tract into a single political unit. The ruler of the Roman empire was both an emperor spending the state's tax revenues on the civil service and the army, and a substantial landowner operating an enormous palace economy, while much of the empire's territory belonged to landowners who drew profits from estates in many provinces. All would have gained from transfers of improved infrastructural, organizational, and mechanical technologies that facilitated the production and distribution of agricultural or industrial goods. The process of transfer was facilitated

⁵ Gies and Gies, *Cathedral, forge, and waterwheel*, pp. 22-37.

⁶ Adams, *Paths of fire*, pp. 42-6.

⁷ Greene, 'V. Gordon Childe'.

⁸ I make no attempt to profit from joining a 'knock-Finley movement', *pace* an anonymous referee who nevertheless provoked a clarification of my aims.

⁹ The best exposition of this definition is Edgerton, 'De l'innovation aux usages'; forms of technology transfer in the Roman period are explored by Greene, 'How was technology transferred?', and Stoll, 'Der Transfer von Technologie'.

by literacy, while a single currency oiled the wheels of long-distance trade, whose profits—even if devoted largely to good living and enhancing social status, rather than productive re-investment—provided at least some motivation for economic progress.¹⁰ This argument concurs entirely with Pleket's magisterial survey of the economy of the European provinces of the Roman empire, which addresses Finley's outlook in exhaustive detail and brings in comparative evidence from medieval and pre-industrial north-western Europe. Pleket's general conclusion is that many aspects of the form and scale of the Roman economy resembled those of north-western Europe in the sixteenth to eighteenth centuries AD, and that the course of development before the great changes of the industrial revolution was a fluctuating horizontal line, rather than an inexorable upward curve.¹¹

I

It is important to place Finley into the tradition of twentieth-century scholarship.¹² Like Rostovtzeff and Childe (but in very different ways) he took an active part in politics and social thought and this inevitably found expression in his academic work. After an initial training in law, Finley worked with exiled German economic historians at Columbia University in the 1930s, and got to know the Hungarian economic anthropologist Karl Polanyi. Rostovtzeff's ground-breaking *Social and economic history of the Roman empire* had been published in 1926, and Tenney Frank was engaged in editing a five-volume *Economic survey of ancient Rome*, following on from a monograph of 1920.¹³ Finley's progression from an interest in Marx to greater sympathy with Weber did nothing to reconcile him to the 'modernizing' outlook of Frank or Rostovtzeff; Polanyi's economic anthropology also reinforced a view in which the role of markets was diminished in favour of socially embedded exchange.¹⁴

The pressures of the McCarthy era forced Finley to move in 1954 to Cambridge, where A.H.M. Jones had been Professor of Ancient History for three years; Finley was to succeed him in 1970. Jones shared an active interest in the ancient economy, based upon an exhaustive knowledge of historical and legal texts, although his main interest increasingly lay in the late Roman period, while Finley's centred upon classical Greece.¹⁵

¹⁰ An accessible model for this process (Hopkins, 'Taxes and trade') is discussed in section VI; Garnsey and Saller supply a more sceptical view with particular clarity (*Roman empire*, pp. 51–63).

¹¹ Pleket, 'Wirtschaft', pp. 142–60; on fluctuations, p. 28. The entire work is argued in detail and accompanied by comprehensive bibliographical support, and, despite its particularly dense written style, deserves to be much more widely known.

¹² This task is facilitated by Shaw and Saller, 'Editors' introduction' to Finley, *Economy and society*, and by Whittaker, 'Moses Finley'.

¹³ Frank, *Economic history of Rome*.

¹⁴ Polanyi et al., eds., *Trade and market*; the approach was applied to early medieval Europe in Hodges, *Dark age economics*, whose introductory chapter explains its theoretical basis particularly well.

¹⁵ Jones's 1953 article 'Inflation under the Roman empire' (published in this journal) is characteristic of his approach.

Jones held a very negative view of the role of trade and industry in the Roman empire in comparison with agriculture, and was emphatic that political and economic power lay only among the very wealthy.¹⁶ Finley shared these views (including a rather puritanical attitude towards trade in luxuries) but reinforced them with a Weberian interpretation that subordinated all economic activity to the pursuit of social status. This led him to hold texts written by the senatorial class in much higher esteem than any forms of material evidence. In the opinion of French scholars reviewing his work in *Annales* in the mid-1990s, this ‘méthode de Finley’ usurped a role that might otherwise have been taken by a broader economic anthropology.¹⁷

Finley remained an influential scholar in Cambridge until his death in 1986, by which time Keith Hopkins had become Professor of Ancient History. Hopkins’s previous academic career had been in sociology, and he maintained an interest in ancient economies throughout the 1980s. Other former students and colleagues contributed to lively Cambridge seminars, a selection of which was published in 1983.¹⁸ Impressive books in the Finley mould published by Duncan-Jones (1974) and Garnsey and Saller (1987) focused entirely upon the Roman empire, probably because it has been the subject of more research (from a socio-economic point of view) than the Greek world, and also because its greater geographical extent provided such a diversity of evidence.¹⁹ Indeed, no individual writer, at Cambridge or elsewhere, has attempted a comprehensive economic overview of the entire classical world since Finley, though period-specific, regional or thematic work has abounded.²⁰ My own book of 1986 presented archaeological evidence relevant to the Roman economy with non-archaeologists in mind, while making a strong claim for a more optimistic view of economic dynamism than Finley had allowed.²¹ Meanwhile, access to ancient texts relevant to the economy has subsequently been improved by a sourcebook compiled by Meijer and Van Nijf.²²

In the 1999 reissue of *The ancient economy* the new foreword by Morris presents a fascinating biographical and theoretical commentary on Finley’s intellectual context, and is the best available discussion of his debt to Weber and the politics of status. Morris describes *The ancient economy* as ‘quintessentially Finleyan’, and notes that it is notoriously difficult to find a sentence or two in his books or articles that sum up his views precisely.²³

¹⁶ e.g. Jones, ‘Ancient empires’, pp. 103–4: ‘I have deliberately ignored industry and trade because I think that their importance was marginal’.

¹⁷ Andreau, ‘Présentation’, p. 947. The ‘Finley/Jones’ position was labelled as a ‘new orthodoxy’ by Keith Hopkins in the early 1980s (‘Introduction’, pp. xi–xiii).

¹⁸ Garnsey, Hopkins, and Whittaker, eds., *Trade in the ancient economy*.

¹⁹ Duncan-Jones, *Economy of the Roman empire*; Garnsey and Saller, *Roman empire*.

²⁰ von Reden has devoted a book to *Exchange in ancient Greece*; examples of regional studies are Safrai, *Economy of Roman Palestine*; Morley, *Metropolis and hinterland* (on the agrarian economy of Rome), Rich and Wallace-Hadrill, eds., *City and country in the ancient world*. Relevant articles appear regularly in *Münstersche Beiträge zur antiken Handelsgeschichte*.

²¹ Greene, *Archaeology of the Roman economy*.

²² Meijer and Von Nijf, *Trade, transport and society*.

²³ Morris, ‘Foreword’, p. xix.

He also observes that Finley's model does nothing to solve the long-standing debate between primitivists and modernists, and cannot be used to place Greece and Rome on a continuum between simple and complex economies, since they were qualitatively different, and do not belong on such a continuum. Although Morris did not comment specifically on the issues of technological innovation or economic progress, his general discussion of critical reactions to Finley's work has important implications for the study of these topics.

Morris characterizes three critical responses to Finley: empiricism, oversocialization, and undersocialization.²⁴ Empiricist critics concentrate on details and factual errors, and 'foreground details at the expense of formal argument and methodological exposition'; such critiques tend to be undertheorized. The second and third forms of criticism originate in attitudes to the work of Polanyi. Critics of oversocialization accuse Finley of taking ancient sources at face value and instead place more emphasis on material evidence to help read 'through' ancient texts to reach the underlying economic structures. Undersocialization criticism, which is related to the 'new cultural history', goes in the opposite direction and not only (like Finley) embeds both conceptual and material aspects of the economy into a larger sociological picture, but also brings discourse itself to the fore: 'Rather than beginning from sociological categories and looking at how they structured ancient literature, the critics claim that we should instead look for how such categories were created and contested in the discursive practices of knowledgeable actors.'²⁵

II

In the light of this shift from concrete to abstract concerns, it is not surprising that the technological dimensions of Finley's 1965 article have received little discussion in subsequent considerations of his concepts. Meanwhile the study of classical technology has undergone a process of proliferation by specialists since its consolidation in the nineteenth century, but there have been no major modern overviews apart from White's *Greek and Roman technology* in 1984, although three useful shorter contributions from the 1990s will be discussed at the end of this article.²⁶ Two of my own papers have attempted to place recent publications and archaeological research on Roman technology into a critical conceptual framework.²⁷ Finally, a wide range of literary evidence—with authoritative commentary—has been made available in a comprehensive sourcebook.²⁸

Finley's 1965 article actually answered a challenge that he had issued six years earlier in a review article (also published in this journal) which

²⁴ Ibid., pp. xxvi–xxx.

²⁵ Ibid., p. xxix.

²⁶ Chevallier, *Sciences et techniques*; Schneider, *Einführung*, Traina, *La tecnica*.

²⁷ Greene, 'Perspectives on Roman technology'; *idem*, 'Technology and innovation in context'.

²⁸ Humphrey et al., *Greek and Roman technology*. One of its editors had previously incorporated a broad discussion of technology into a specialized monograph (Oleson, *Greek and Roman mechanical water-lifting devices*).

considered specialist books by Moritz and Forbes, along with the second volume of the Oxford *History of technology*.²⁹ Finley pronounced Moritz's book excellent, and accepted its conclusion that there had been considerable technical progress in grain processing and bread baking in antiquity. He welcomed Forbes's erudite series of *Studies in ancient technology* less wholeheartedly, for although they *did* attempt to address socio-economic as well as technical aspects, Finley felt that they lacked consistency and accuracy over wider issues.

Thorough condemnation was reserved for the volume directed by Sir Charles Singer—"in large part a demonstration of what is wrong with the present state of affairs"³⁰—which showed that the history of technology and economic history had gone separate ways, and, being unaware of each other, were failing to ask the really important questions. Finley castigated contributors 'who, on both external and internal evidence, have never studied, in a systematic way, the ancient world'; 'and so we have a work by museum-keepers and technicians'.³¹ Avoidance of socio-economic aspects was combined with errors of fact, while jibes about the methods and aims of classicists by some of Singer's specialists went down particularly badly with Finley, who was a stickler for methodological consistency.³² He concluded his review by stating with astonishing confidence that 'the framework is already there, in economic history, and a historian would find no difficulty in fitting the development of technology within it'.³³ At M. M. Postan's suggestion he soon set about this task himself in a lecture to the 1960 conference of the Economic History Society, which, with some amendments resulting from discussion, became the article published in this journal in 1965.

III

It was entirely characteristic of Finley to include in the title of this article the words 'innovation' and 'progress', which would immediately grab the attention of readers by implying a linear, 'Whiggish' view of technology, only to withdraw this comfortable assumption a few pages later by asserting that efficiency, productivity, rationalism, and growth are all very recent concepts.³⁴ It caught out the writer as well as his readers, however, for his article walked a tightrope between an outright rejection of the relevance of such ideas to the ancient world, and a desire nevertheless to ask questions about them. To add to the danger, the chronological contexts of Finley's evidence leapt unpredictably between ancient Greece

²⁹ Finley, 'Technology in the ancient world', reviewing Moritz, *Grain-mills and flour*; Forbes, *Studies in ancient technology*; Singer et al., eds., *History of technology*.

³⁰ *Ibid.*, p. 121.

³¹ *Ibid.*, pp. 123-4.

³² Finley, *Ancient history*.

³³ *Idem*, 'Technology in the ancient world', p. 125.

³⁴ *Idem*, 'Technical innovation', p. 31. An opposite view that makes the most of applying modern economic analysis to the Roman period is von Freyburg's *Kapitalverkehr und Handel*.

and the Roman empire, and he treated the classical world as a unity within which arguments from any part might be generalized to the whole.³⁵

Finley began his article with a conventional list of Graeco-Roman inventions, but followed it with a paradox: there was *more* technical progress than generally acknowledged, in terms of the development of traditional techniques, but *less* in the extent of their application.³⁶ He then addressed four areas of economic activity—food processing, agriculture, mining, and pottery—before turning to concepts and texts. Since his intention was to demonstrate some fundamental failures before seeking an explanation for them, it is important to know whether any changes in the basic evidence have affected his arguments.

Finley's account of the pressing and milling of the three great Mediterranean crops—grapes, olives, and cereals (derived from Moritz and Drachmann)—has been confirmed and expanded. There was indeed continuous progress in grape- and olive-pressing equipment, and fieldwork projects around the Mediterranean have shown that this technology was applied comprehensively throughout the region, particularly in Roman times.³⁷ However, we now know that mechanical grain-mills driven by muscle power or water were common on Roman estates, in towns, and in military contexts throughout the empire.³⁸ This stands in contrast to the ‘sporadic’ use described by Finley that underlay several negative judgements about rationality and labour in the remainder of his article.³⁹

Finley considered agriculture to have been an accumulation of empirical knowledge, and saw no selective breeding, no changes in tools or techniques for ploughing, exploitation, harvesting, or irrigation, although he did acknowledge modifications of land use.⁴⁰ His perception of agriculture as static has been subjected to fundamental criticism in a major book by Sallares on the ecology of new crops in ancient Greece. However, although Sallares believes that very significant developments took place in agriculture in antiquity he attributes them not to technological change or economic development, but to ‘unconscious mutual interactions between human populations and plant populations’.⁴¹ Thus, his important contribution is likely to be overlooked by historians of technology and economics, not least because it is presented in an aggressive manner and moncausal biologically determinist form, but mainly because his definition of technology is so narrow that it cannot encompass the fundamental changes that he has detected and described.⁴²

³⁵ Warnings about this made no impact on the 1985 edition of *The ancient economy*: see for example Carandini in 1981, ‘Sviluppo e crisi’, p. 260.

³⁶ Finley, ‘Technical innovation’, p. 29.

³⁷ Mattingly, ‘Olive presses’.

³⁸ Wikander, *Exploitation of water-power*.

³⁹ Finley, ‘Technical innovation’, pp. 29, 35, 44.

⁴⁰ Ibid., p. 29.

⁴¹ Sallares, *Ecology*, p. 13.

⁴² Ibid.; ‘In the view of agriculture in antiquity adopted here, no important role is assigned to technological progress’, and K. D. White’s approach is ‘an anachronistic assumption, retrojecting distinctive characteristics of a modern world into an interpretation of the past’ (pp. 13–14). Lynn White Jr receives the same treatment on p. 399.

Finley's assertions about the absence of increased productivity or economic rationalism were supported in particular by the use of the *vallus* (a wheeled animal-propelled reaping device). He noted that derivatives of this 'rude ox-powered mechanical reaper' had enjoyed a successful career in nineteenth-century Australia, but regarded it as a failure in the Roman period because it was neither imitated, nor an inspiration for other devices. However, the Roman original was sufficiently successful to enter the texts of Pliny and Palladius, and to appear in several carved scenes from the area between the Seine and the Rhine, where other sculptures include animals and vehicles that suggest progress in harnessing.⁴³

Moreover, there is now plenty of evidence from Gaul for selective breeding, thanks to statistical studies of the dimensions of bones from archaeological sites.⁴⁴ The frequency of iron tools is acknowledged more than their novelty—Finley himself, making a different point later in his article, quoted with approval Rostovtzeff's observation that their introduction into Ptolemaic Egypt had been 'almost tantamount to a revolution'.⁴⁵ Ploughs and sickles—like the *vallus*—show specialization and refinement where suitable contexts existed, especially in temperate regions where Mediterranean 'dry' farming was not applicable.⁴⁶ Finley overlooked transport entirely in 1965, although he touched upon it in his later works; the omission is very surprising considering its significance in later periods of agrarian change.⁴⁷ The image of horses choking against ill-fitting harnesses has had an overwhelming symbolic power, and is one of the most frequently repeated 'factoids' about classical technology—with direct economic implications. Combined with underestimation of the role of water power in classical times, it provided the yardstick by which enthusiastic medievalists measured the progress of the middle ages.⁴⁸ In fact the Roman empire offered opportunities for marketing farm produce in towns and rural fairs equal to (if not better than) those of some later periods, while once again the region of Gaul that has produced evidence for the *vallus* and improved harnessing is endowed with plentiful roads, waterways, and extensive settlements.⁴⁹

At the other end of the Roman empire, in Egypt, a positive image of economic rationalism in farming has been deduced from documentary evidence—in one of the few places where relevant written records have survived.⁵⁰ The treatment of Egypt as a special case because of its early civilization and Hellenization has been completely undermined by writing tablets preserved at Vindolanda, a fort adjacent to Hadrian's Wall.⁵¹ The

⁴³ Raepsaet, 'Les prémisses de la mécanisation agricole'.

⁴⁴ Lepetz, 'L'amélioration des espèces'.

⁴⁵ Finley, 'Technical innovation', p. 36.

⁴⁶ Marcone, *Storia dell'agricoltura*, pp. 45–53; Ferdière, *Les campagnes*, II, pp. 23–34 (ploughs), pp. 41–59 (sickles).

⁴⁷ e.g. Finley, *The ancient economy*, p. 165; Langdon, *Horses, oxen and technological innovation*.

⁴⁸ Amouretti, 'L'attelage'.

⁴⁹ Greene, *Archaeology of the Roman economy*, pp. 116–20; Ferdière, *Les campagnes*.

⁵⁰ Rathbone, *Economic rationalism and rural society*.

⁵¹ Bowman, *Life and letters*; see also Safrai, *Economy of Roman Palestine*, for extensive rabbinical literature that provides circumstantial evidence about everyday economic life.

range and character of the Vindolanda texts around AD 100 (within a generation of the first conquest of northern Britain) bear comparison with those found in Roman Egypt. Many of the documents about the purchase of supplies also enhance an optimistic interpretation of the dynamism of the military economy.

The heavily used term ‘subsistence’ normally associated with peasant farming should not carry the pejorative implication of a lack of engagement with a wider economic world: as Paterson wrote, ‘What is meant by this term is not that the peasants necessarily lived on the margin of subsistence, rather their economic aim was subsistence. The peasant household produced much of what it consumed, and also produced for the market, primarily to buy the food and services needed to subsist.’⁵² Thus, an up-to-date picture of classical farming and food processing requires a significant number of adjustments that result in a more generous view of progress and vitality than Finley allowed. It also emphasizes the importance of material evidence from peripheral provinces in complementing the better-documented central Mediterranean region. Even there, landscape archaeology offers insights into the impressive scale of modifications of land use that Finley acknowledged.⁵³ The conclusion of a single example from central Italy is representative of the nature of what may be observed: ‘Gli agrimensori romani crearono una subdivisione agraria quasi perfetta, che si adatto e aderì in maniera ottimale alle esigenze morfologiche del territorio.’⁵⁴

Turning to mining, Finley claimed that all of the necessary tools and methods used before the introduction of explosives already existed in, or were achieved by, classical Athens; he added that mining was actually carried out to a higher standard than at any time in the following 1,000 years.⁵⁵ This accolade was quickly diluted by suggesting that it is a matter of psychology, rather than technology, to apply high standards of craftsmanship to mines, as well as to temples or public buildings. Finley was clearly not bearing in mind the nineteenth-century tendency to ornament factories and stations, as well as town halls and churches. He extended this infelicitous argument by comparing the finely tooled Athenian mine tunnels to the ‘unmatched beauty’ of Greek coins, declaring them ‘irrelevant in an analysis of technological and economic growth’.⁵⁶ Coinage was itself a significant—and still relatively recent—innovation, and confidence in its use was surely enhanced by good looks. This is certainly supported by the widespread imitation of gold staters of Philip V of Macedon throughout late iron age ‘barbarian’ Europe.⁵⁷ In any case, the neatness of tunnels was the result of the method of tunnelling,

⁵² Paterson, ‘Production and consumption’, pp. 188–9, building on interpretations advanced most clearly by Garnsey: see now *Cities, peasants and food supply*.

⁵³ Finley, ‘Technical innovation’, p. 29.

⁵⁴ ‘The Roman land surveyors created an almost perfect subdivision of the agricultural land, that adapted or conformed to all of the territory’s morphological demands in an optimal manner.’ Marcucci, *La terra*, p. 250.

⁵⁵ Finley, ‘Technical innovation’, p. 30.

⁵⁶ Ibid., p. 31.

⁵⁷ Allen and Nash, *Coins of the ancient Celts*, pp. 1–2, 10–16.

not a matter of aesthetics; the same technique was also employed in underground water conduits where rough walls would create unhelpful turbulence.⁵⁸ Recent studies in France indicate that miners of the medieval and Renaissance periods were not noticeably rougher in their work than their classical predecessors.⁵⁹

Finley was quite wrong to assert that there was a ‘failure of effective invention’ in mine drainage in the north-western provinces of the Roman empire.⁶⁰ Wood was the predominant construction material for Roman mine machinery, just as it was for the equipment featured in Chinese engravings of mining scenes or in the woodcuts illustrating Agricola’s *de re metallica* in the medieval to early modern period. Despite their inherent perishability, remains found in those few Roman mines that have escaped destruction by later exploitation reveal a range of pumps and water-wheels that allowed effective mining some 200 metres below the water table.⁶¹ The supposedly ‘unattested’ chain pump was the machine of choice for deep wells at Pompeii, where the water table was 25 metres below the surface, but in mines it was normal to place simpler water-wheels or Archimedean screws in series, each making a short lift.⁶² Finley did not even mention the *productive* use of water in mining. Carefully constructed leats following contours brought water over long distances to storage dams. It could then be used to erode ore deposits (*ruina montium*), or released in a rush for ‘hushing’ open-cast workings.⁶³ Water also fed ore-washing tables, and even, it is argued by some, ore-crushing stamp-mills.⁶⁴ Domergue commented on Finley’s 1965 opinion in 1993: ‘[Les romains] ont innové en mécanisant les mines, en développant, en améliorant, en rationalisant des techniques existantes, auxquelles ils ont fini par donner un visage original: les mines à ciel ouvert du nord-ouest de l’Espagne le montrents l’évidence.’⁶⁵

Pottery was the last of the four areas of classical technology that Finley used in his opening assault.⁶⁶ He noted that Greek vases had reached artistic heights without innovation, but that changes in taste had led to the disappearance of red-and-black painted vessels, and the replacement of hand-painted decoration by moulded designs. This was, Finley believed, the *only* new technique ever introduced into classical pottery production, and it was adopted not because it was faster or cheaper, but in response to a new fashion. Here too, the ground has shifted; Greek painted vases have lost the iconic status once accorded them by art

⁵⁸ Riera, ed., *Utilitas necessaria*, pp. 195–6.

⁵⁹ Benoit and Braunstein, eds., *Mines, carrières et métallurgie*.

⁶⁰ Finley, ‘Technical innovation’, p. 30.

⁶¹ Domergue, ‘Regard sur les techniques minières’.

⁶² Oleson, ‘Water-lifting devices at Herculaneum and Pompeii’.

⁶³ Domergue, ‘Regard sur les techniques minières’; Greene, *Archaeology of the Roman economy*, pp. 144–8.

⁶⁴ Lewis, *Millstone and hammer*, pp. 106–10.

⁶⁵ ‘[The Romans] innovated by mechanizing mines, and by so developing, improving, and rationalizing existing technology that in the end it gained a novel appearance: this is demonstrated by the opencast mines of north-west Spain.’ *Ibid.*, p. 353.

⁶⁶ Finley, ‘Technical innovation’, p. 31.

historians and collectors, and are now seen as cheaper substitutes for metal vessels preferred by the richest consumers.⁶⁷ An impression of high status resulted from the survival of intact vases in graves, which are still regularly looted for the illegal antiquities market; their gold and silver counterparts were, with few exceptions, melted down long ago. The implication is that the ceramic vessels were produced for a widening market during the period of Greek overseas colonization. If so, the far greater quantity of moulded *terra sigillata* (from Italy and/or Gaul) and Mediterranean red-slip wares manufactured during the Roman empire suggests a genuine mass market.⁶⁸ If production really was *not* faster and cheaper, then the spending power of ordinary people must have risen dramatically, for these wares are found in significant quantities on all but the poorest Roman sites.⁶⁹

IV

After this brief foray into archaeological matters Finley turned to matters of principle that were to be restated even more firmly in *The ancient economy* in 1973 and 1985. He issued a second warning against introducing recent values—efficiency, productivity, rationalism, growth—into classical antiquity, but once again brought one of these concepts (productivity) straight back into consideration.⁷⁰ Wealth, he stated, was unambiguously ‘good’, and associated with large-scale consumption. Why, then, did productivity not advance to increase it? His answer was that without figures, we cannot know whether it did—but the question was nevertheless ‘right’. The sequence of Finley’s thought must be underlined and challenged—a ‘modern’ concept must not be applied to the ancient world, but if it provokes a valid question, it is acceptable to use it to assess the concept that has just been declared inapplicable.

In any case, Finley’s choice of the Pont-du-Gard to demonstrate *non-economic rationalism* was inapt, for recent studies have shown that the citizens of Arles had more than prestige in mind when designing their water supply.⁷¹ The aqueduct system, of which the famous arched structure over the river Gard was only one element, extended for many miles into the hinterland, and was tapped for agricultural irrigation at numerous points. Another of the aqueducts of Arles later fed the famous multiple water-mill complex at Barbegal, the greatest known concentration of mechanical power in the ancient world.⁷² Thus, food production and processing were integral components of the aqueduct system, however much symbolic importance the urban elite might attach to fountains, baths, and clean drinking water.

⁶⁷ Vickers and Gill, *Artful crafts*.

⁶⁸ Bémont and Jacob, eds., *La terre sigillée gallo-romaine*; Hayes, *Handbook of Mediterranean Roman pottery*.

⁶⁹ Greene, *Roman pottery*.

⁷⁰ Finley, ‘Technical innovation’, p. 31.

⁷¹ Fabre et al., *L’aqueduc de Nîmes*.

⁷² Amouretti, ‘Barbegal’.

Finley then diverted the path of his article away from economics and technology to emphasize the rupture between science and practice that had originated with Aristotle and continued through Archimedes.⁷³ Pliny's passion for naming inventors of non-utilitarian arts and crafts supposedly perpetuated this divide, for he was unable to identify the inventors of new machines such as the screw-press. However, this particular lacuna does not seem surprising in a pre-mercantilist era lacking any system of patents. Finley then turned to another fundamental Roman text, *de architectura* by Vitruvius ('the highest example of a do-er not just a know-er'), only to chastise it for containing just one reference to economy of effort (despite the supposed irrelevance of these terms in antiquity). Vitruvius, in contrast to Aristotle, considered *only* practical things, but displayed an equal failure to comment on productivity. This allowed Finley to assert that no ancient author entertained the notion that technology might be advanced by 'sustained, systematic effort'.⁷⁴

Historians of technology who had skimmed impatiently through abstractions on Aristotle were now rewarded by a section on strictly technical matters to accompany the lists of inventions and mechanical principles already provided.⁷⁵ Having noted gaps in the availability of some materials, tools, and processes in the ancient world, Finley took advantage of hindsight to attack those involved in technical matters: 'But what material conditions prevented men who could make very complicated weather-vanes from getting the idea of the wind-mill? Or from linking the lever and the wheel to make a wheel-barrow?'⁷⁶ Finley blamed these failures on the classical mind-set: 'attitudes are the key to the blockage'.⁷⁷ Interpretations and evidence relating to these inventions have changed significantly since 1965, however. Langdon has pointed out that windmills exploited a specialized niche in the medieval economy, and were not an unqualified success.⁷⁸ The wheelbarrow is supremely suited to large flat regions (such as China) where human labour is more plentiful than pack animals or draught oxen, but even so it has been alleged to have originated in ancient Greece.⁷⁹ To castigate the ancient world for its failure to act in any particular way is unproductive, especially when the failure may be one of modern interpretation. As Amouretti observed in the context of the long-lived notion of defective classical harnessing, 'souhaitons que l'heure soit enfin venue ... de quitter le domaine des

⁷³ Finley, 'Technical innovation', pp. 32-3.

⁷⁴ Ibid., p. 35. Finley regularly condemned similar arguments from silence made by others, for example in the second edition of *The ancient economy*, p. 197.

⁷⁵ *Idem*, 'Technical innovation', pp. 29, 32.

⁷⁶ Ibid., p. 35.

⁷⁷ This powerful metaphor recalls Gille's 'systèmes blocqués' (*Histoire des techniques*), whose etymology in French conveys a sense of purposeful siege rather than accidental obstruction.

⁷⁸ Langdon, 'Birth and demise of a medieval windmill'.

⁷⁹ Lewis, 'Origins of the wheelbarrow'. A wall-painting from the port of Ostia shows how a Roman two-wheeled cart might be manoeuvred like a wheelbarrow if its shaft and yokes were manipulated by human hands (Pisano Sartorio, *Mezzi di trasporto e traffico*, p. 52).

idées reçues, il évoque un blocage épistémologique de la réflexion historique sur l'Antiquité, non un blocage technique de l'Antiquité'.⁸⁰

'Above all, what about the water-mill?'⁸¹ This question was particularly perplexing for Finley because it concerned something that *had* been invented, but was apparently not exploited. It formed part of 'the one process, corn-grinding, in which there had been a reasonably continuous history of technical advance . . . Every 'rational' argument suggests quick and widespread adoption'.⁸² Once again Finley invoked a standard of judgement (economic rationalism) whose relevance he had denied a few pages earlier. In any case, the picture has changed dramatically since 1965, for subsequent research has revealed numerous water-mills from Hadrian's Wall to north Africa and to Palestine, and has demonstrated that Italy was not excluded from this phenomenon.⁸³ Hard evidence for industrial implementations remains scarce, although Ausonius's 'solitary and suspect reference' to a stone-cutting machine seems increasingly credible.⁸⁴ There has also been a change in the attitudes of medievalists, some of whom have challenged the basis of the determinist assertions of Lynne White Jr, and questioned the evidence for Jean Gimpel's 'medieval industrial revolution'.⁸⁵

Finley's use of Suetonius as evidence for the absence of water-mills from first-century Rome is an excellent example of how dangerous it can be to trust secondary citations of ancient sources. He selected part of a sentence from a paragraph of outrageous tittle-tattle about the excesses of the emperor Caligula (AD 37–41), written at least 60 years later.⁸⁶ Suetonius simply noted that 'bread was often scarce at Rome' (*panis Romae saepe deficeret*) because mill animals had been commandeered, and the rest of his sentence noted that court cases were lost because carriages had also been taken, and people could not get to court. Rather than proving the absence of water-mills, it indicates thorough animal-powered mechanization of food-production, and intensive use of vehicles for urban transport.⁸⁷ Furthermore, the goods to be transported were not 'Gallic booty' but palace effects to be taken from Rome (to Gaul?) for auction. That this was a practical proposition is a tribute to Roman long-distance goods transport, and should not be used to debunk an emperor who also 'built moles out into the deep and stormy sea, tunnelled rocks of the hardest flint, built up plains to the height of mountains and razed

⁸⁰ 'Let us hope that the time has finally arrived . . . for abandoning received ideas that evoke an epistemological blockage in historical thinking about the ancient world rather than a blockage in ancient technology.' Amouretti, 'L'attelage', p. 229.

⁸¹ Finley, 'Technical innovation', p. 35.

⁸² Ibid.; Finley's knowledge of this subject came from reviewing Moritz's book in this journal in 1959 ('Technology in the ancient world').

⁸³ Wikander, *Exploitation of water-power*; Wilson, 'Water-power in North Africa'; Oleson, 'A Roman water mill on the Crocodilion river near Caesarea'; Johannowsky, 'Canali e fiumi per il trasporto del grano'.

⁸⁴ Wikander, 'Ausonius' saw-mills'; Adam and Varène, 'La scie hydraulique'.

⁸⁵ Holt, 'Medieval technology and historians'.

⁸⁶ *Lives of the Caesars*, 39.1; quotations are from the Loeb translation.

⁸⁷ Water-mills may have become important to the state only when bread began to be dispensed to the citizens of Rome instead of grain: Bell, 'An imperial flour mill on the Janiculum'.

mountains to the level of the plain', in addition to devising a new kind of baths and building luxurious galleys.⁸⁸ Finley's terse quotation was actually plucked from a context that demonstrated how successfully imperial power could command major engineering works, in addition to debauchery: in such a world, who missed wheelbarrows or windmills?

Finley concluded that the failure to exploit water-mills was explained in a poem by Antipater in the first century BC: it simply was not worth liberating slaves or animals from mills on either economic or sentimental grounds.⁸⁹ As has been pointed out elsewhere, there is no simple evolutionary line from rubbing-stones to rotary hand-mills, and then from animal- or slave-powered Pompeian or 'Vitruvian' mills with 90° gearing to fully mechanical water-mills.⁹⁰ As with wine presses and olive-crushing mills, a range of machines was available from a 'technology shelf'; a selection would be made according to the wealth of a food producer or the overall scale of operation. Finley himself observed that Vitruvius included machines in *de architectura* because they could do things that were impossible without them. What possible rationale lay behind the choice made by estate owners other than an economic one? There was little or no prestige to be gained from mills hidden in the *pars rustica* of a villa, well away from the lavishly decorated dining rooms of the *pars urbana*.⁹¹

Italian archaeologists have made much of the phenomenon of intensive agricultural estates based on slave labour, and these are the very places (along with mines) where machines are found in productive contexts.⁹² As on eighteenth-century Caribbean sugar estates, where steam engines were imported from Britain to fulfil specific roles in which they were more effective than human labour, slaves and machines were not mutually exclusive, but parts of the range of choices in farming strategies.⁹³ A degree of economic rationalism may be admitted without disputing Finley's judgement that the overriding aim of farming was to extract profits in order to finance the social and political status of wealthy Romans. Whether or not Cato's or Columella's manuals on farming practices make sense to a modern accountant, their very existence (along with others now lost) underlines the size of the audience for advice on profitable agriculture.⁹⁴

V

Finley's views on investment and capital required his readers to accept his proposition that new machinery was neither invented nor

⁸⁸ *Lives of the Caesars*, 37.3.

⁸⁹ Finley, 'Technical innovation', p. 36.

⁹⁰ Greene, 'How was technology transferred in the Roman empire?'.

⁹¹ *Idem*, *Archaeology of the Roman economy*, pp. 90-1.

⁹² e.g. Carandini, *Schiavi in Italia*.

⁹³ Tann, 'Space, time and innovation characteristics', pp. 160-1.

⁹⁴ Carandini, 'Columella's vineyard and the rationality of the Roman economy'; Pleket, 'Wirtschaft', pp. 95-8.

implemented.⁹⁵ He then argued that failure was not attributable to lack of capital, for the Ptolemies had demonstrated the availability of sufficient capital to transform Egyptian agriculture to increase royal revenues from the third century BC. This success was achieved by means of Greek instruments and processes, but ‘only’ the *sakiyah* (a chain-of-pots pump with 90° gearing) and the screw-pump were ‘genuine innovations’. However, Oleson has shown that the (‘Archimedan’) screw-pump was just one of a family of devices suited to different situations and heights of lift.⁹⁶ These devices—vitally important for extending agriculture through irrigation—were associated with the *Museum* at Alexandria, which Finley compared unfavourably with the Royal Society because it was concerned only with military devices, when not designing ‘toys’, rather than useful things for agriculture, food-processing, or manufacturing. He ignored the importance of water-wheels in the ancestry of the turbine, and the role of the *sakiyah*’s gearing in the ‘Vitruvian’ water-mill. Furthermore, just as Oleson demonstrated the variety and significance of water-lifting devices for irrigation, mines, ships, and baths, Schürmann has explained how the social and religious contexts in which *automata* were deployed helped to cement royal authority.⁹⁷ Many of the mechanical principles explored in constructing such ‘toys’ were also of very immediate relevance in designing and making fine astronomical and medical instruments, as well as large pumps and cranes.

Finley then asked why no investment was directed towards increasing royal revenues, while capital was being ‘made available (and wasted)’ on roads, public buildings, water supply, drainage, and so on, ‘but not for production’. This statement not only ignores the economic impact of spending on construction projects, provision of roads, and water supplies and drains for cities, but again flies in the face of his earlier warning about applying modern values of economic rationalism.⁹⁸ He justified the legitimacy of his question by means of an (unreferenced) mention of a royal factory at Pergamum for the mass production of parchment. It would have been beneficial to have considered brick making, for ample evidence has been available for decades (in the form of name stamps) of senatorial and even imperial backing for the many suppliers who met the huge demand for bricks generated by Rome’s building projects.⁹⁹

‘Wherever one turns in industry and commerce, the picture is the same and always negative: one of failure to take steps to overcome the limits of individual cash resources’.¹⁰⁰ Finley’s explanation for this absence of capital for productive investment was his usual one—the only people with the necessary wealth had already invested it in agriculture. This overlooks the fact that a number of the acknowledged technical advances took place in agriculture, or in industries—such as mining or quarrying—that tended

⁹⁵ Finley, ‘Technical innovation’, pp. 36–7.

⁹⁶ Oleson, *Greek and Roman mechanical water-lifting devices*.

⁹⁷ Schürmann, *Griechische Mechanik und antike Gesellschaft*.

⁹⁸ Finley, ‘Technical innovation’, p. 31.

⁹⁹ Steinby, ‘L’organizzazione produttiva dei laterizi’.

¹⁰⁰ Finley, ‘Technical innovation’, p. 37.

to operate by means of similar systems of leases or indirect management. Both the state and large landowners clearly *did* have sufficient capital to pay for production and transport, even without elaborate credit or other financial instruments. Although dismissed by Finley, the ‘desperate search of the modernisers’ has compiled an ever more convincing list of legal, administrative, and financial mechanisms that enhanced economic activity.¹⁰¹ Their efficacy cannot be denied simply by stating that they failed to approach the levels of the early modern period. Since Finley wrote, markets have been studied extensively, and recent publications have emphasized an increase in their role and frequency during the Roman period.¹⁰² An important dimension of markets in the Roman economy was the role of the emperor as a property owner as well as manipulator of public revenues, which meant that the Roman empire also included a palace/royal economy which functioned in complex symbiosis with market-based mechanisms; likewise, rich senatorial families manipulated an estate-based economy at the same time as they participated very effectively in markets.¹⁰³ Current perceptions of Roman guilds offer another context for economic activity, in addition to their social and patronal functions; Roman epigraphy is full of professional *collegia* (shippers, wine-merchants, *fabri*, and so on).¹⁰⁴

However defined, the lack of a fully mercantile system of commercial guilds, partnerships, or brokers did not prevent Roman agricultural products from being processed by machines, packed in amphorae, shipped great distances in large freighters, and distributed by inland waterways or roads to consumers. The movement of goods was enhanced by state involvement in food distribution, army supplies, and taxes in kind. Likewise, aristocrats who used supplies from their estates to feed their *familia* in urban residences also played a part in cross-subsidizing purely commercial cargoes and reducing unit costs of items that were actually for sale.¹⁰⁵ Finley was strangely quiet about money, as opposed to capital, not only in his 1965 article but in his subsequent books on the economy. In the 1970s it was still argued that coins were restricted to official functions and that secondary uses were largely limited to towns, but the extensive use of coins in everyday transactions is now widely supported by specialists in numismatics.¹⁰⁶ Like literacy, coin use was surprisingly wide and deep in the Roman empire, and both were effective lubricants of the machinery of commerce.¹⁰⁷ They help to explain the extent to which ordinary materials such as pottery penetrated modest rural sites from northern England to the southern fringes of Libya.¹⁰⁸

Finley moved on next to the division of labour, largely because historical

¹⁰¹ See for example Aubert, ‘Workshop managers’.

¹⁰² Frayn, *Markets and fairs*; de Ligt, *Fairs and markets*.

¹⁰³ I owe this point to an anonymous referee; see briefly Pleket, ‘Wirtschaft’, p. 148.

¹⁰⁴ See for example Meiggs, *Roman Ostia*, pp. 311–36.

¹⁰⁵ Whittaker, ‘Trade and the aristocracy’, is of fundamental importance in evaluating this aspect of the economy.

¹⁰⁶ Harl, *Coinage in the Roman economy*; King and Wigg, eds., *Coin finds*.

¹⁰⁷ Bowman and Woolf, eds., *Literacy and power*.

¹⁰⁸ Evans, ‘Roman finds assemblages’; Dore, ‘Pottery and the history of Roman Tripolitania’.

hindsight suggested that it *should* be important. Adam Smith's pin factory received a customary citation, and Schumpeter was invoked to disarm any critics who still thought that something might be made of the sporadic evidence for modes of economic thought in antiquity that appeared to rise above a primitive level. A passage from Xenophon's *Cyropaedia*, written in the fourth century BC, was quoted to establish that, despite appearances, the assembly of shoes from pieces of leather turned out by individual craftsmen was a question of quality, not productivity. Finley did not draw an analogy with the production of moulded pottery, where the wider range of tasks made division of labour unavoidable; it would have brought him up against a truly enormous scale of production. Tens of thousands of table vessels were fired together at La Graufesenque (France) in the mid-first century AD, and, as has been noted above, they reached a very wide range of consumers over a very large area. But Finley had already declared (on Greek evidence) that the transition from painting to moulding had nothing to do with increasing the speed of production or reducing prices. If Xenophon had written 500 years later, and in Gaul, he might have noted that consumers had a choice of styles and forms of tableware from a variety of sources. He did not, of course, and although Finley deplored argument *ex silentio*, it must be pointed out that no literature of any kind survives from second-century Gaul where such observations might have been recorded. Finley's undifferentiated classical world allowed him to set great store by Xenophon's comments on Persia or Sparta in the fourth century BC, and to generalize them across a period of nearly 1,000 years. Would an historian assess the economy of Tudor England by means of a literary allusion to Anglian York?

From labour Finley turned to the rentier mentality of wealthy land-owners, who were supposedly inimical to innovation; this opinion was generalized to the whole period from Homer to Justinian. He supported the view that landowners eschewed economic rationalism by noting that the surviving agronomists' manuals include no analysis or comparisons of alternative methods, and in general 'lacked the spirit of capitalism'.¹⁰⁹ A particular criticism is that they were ignorant about recent developments in presses, mills, reapers, and so on. However, Cato and Varro may have lived too early to have become familiar with them, while Palladius (fourth century AD) *does* refer to such equipment, which had first been described by Vitruvius and Pliny the Elder in the first century AD. Only Columella (also first century AD) presents any problem from this point of view, but his intended audience of intensive farmers in central Italy may not have required, or have been interested in, the Gallic reaper or the water-mill.

Finley was undoubtedly right to stress that industries as well as agriculture operated on a rentier basis, and that traders and manufacturers were in a minority without social status or political or economic influence.¹¹⁰

¹⁰⁹ Finley, 'Technical innovation', p. 40; his apology for this 'very old-fashioned' expression seems less important in the post-Thatcher 1990s than it did in the 1960s.

¹¹⁰ *Ibid.*, p. 40.

Perhaps he placed undue emphasis on this because of views about the industrial revolution that did not fully acknowledge the role of the landed gentry in economic development, alongside smaller-scale workshop owners or traders.¹¹¹

VI

The remainder of Finley's article hammered home points he had already made, in a way that reflects its origin as a lecture. A lively but rather disjointed sequence of references to Greek and Roman texts, and to a variety of modern ideas, leads to a final flourish about the fall of the Roman empire. Entertainment begins with a story about 'unbreakable' glass recounted by Pliny the Elder, Petronius, and Cassius Dio.¹¹² According to Finley, the emperor Tiberius executed its inventor, rather than rewarding him. Finley made much of the fact that none of the ancient writers were 'troubled' by the inventor's desire for a reward, rather than investment capital for production. He then leaped back three centuries to Xenophon's *Cyropaedia* to show that such an idea would threaten over-production because of 'the extremely low level of demand and its inelasticity'.¹¹³ Finley ignored the fact that glass blowing—a near-eastern invention of the first century BC—had spread so rapidly that within a century production had begun in many provinces.¹¹⁴ Like mass-produced pottery, glass vessels are common finds on archaeological sites. In other words, the economic setting of the Roman empire *did* allow new products to succeed, whatever the nature of demand may have been, and irrespective of ways in which distribution might be subsidized by non-market forces.

However, 'unbreakable glass' requires closer contextual analysis. Pliny actually calls it 'pliable' (*ut flexile esset*), and it is mentioned in a chapter on recipes for the smelting of glass from a number of minerals. He had already mentioned that 'some of it is shaped by blowing, some machined on a lathe and some chased like silver'.¹¹⁵ After describing current recipes used in Italy, Gaul, and Spain, he appended the story 'which, however, has for a long period been current through frequent repetition rather than authentic'. In Pliny's account, unlike the versions recounted by Petronius and Dio, the inventor was not executed. As told by Petronius's central character Trimalchio, the glass vessel is indeed unbreakable (*phialam vitream, quae non frangebatur*), and the reason for execution is 'because if his invention were generally known we should treat gold like dirt' (*aurum pro luto haberemus*).¹¹⁶ But Trimalchio introduced the story as an aside from a garbled account of the origins of Corinthian copper alloy, before returning to details of the silverware that he owned. This is

¹¹¹ Honeyman, *Origins of enterprise*.

¹¹² Finley, 'Technical innovation' p. 41; Isidore of Seville should be added.

¹¹³ *Ibid.*, p. 41.

¹¹⁴ Newby and Painter, eds., *Roman glass*.

¹¹⁵ *Nat. Hist.*, 36.56.195; Loeb translation.

¹¹⁶ *Satyricon*, 51; Loeb translation.

reminiscent of Pliny, who saw formable glass as a threat to the value of gold, silver, and copper; it was the inventor's *workshop* that was destroyed in Pliny's version. The 'value-added' element would be affected if glass could be formed to elaborate shapes with little effort, and if damage could be repaired by simple hammering (as described by Petronius).¹¹⁷ Contrary to Finley's statement, Pliny, Petronius, and Dio did *not* state that the inventor sought a reward; in Dio, the man in question was not even an inventor, but simply performed a conjuring trick to repair a 'bruised or shattered'¹¹⁸ crystal goblet. He did this to atone for an earlier transgression when he had repaired a subsiding portico by sensible architectural engineering methods, which somehow incurred the envy of Tiberius.¹¹⁹ Thus, there is little foundation for Finley's interpretation that the inventor's failure to seek venture capital represented the outlook of the entire ancient world; if the story does contain a surprise, it is that it was so easy for a craftsman to gain an imperial audience.¹²⁰ Perhaps the entire story, which echoed down through the medieval and modern periods, should simply be placed into the modern category of 'urban myth'.¹²¹

Finley now extended his interpretation of the tale of unbreakable glass (i.e. the failure of investment in production) into a judgement about the defective nature of markets. 'Xenophon was fundamentally right: it is our modern writers who are wrong when they exaggerate ancient export trade, as they often do, to enormous proportions.'¹²² Finley did admit that inter-regional trade was economically significant—but 'only' in corn, wine, olives, slaves, and luxury goods. Why 'only'? The list seems reasonably impressive, particularly when magnified to the scale of the whole Roman empire rather than Xenophon's Greek city-states. Luxuries need not be frowned upon, if they are part of the mix of profits and costs involved in long-distance transport. Sherratt recently criticized the tendency towards 'calorific prioritisation' in an article that stressed the role of luxuries in stimulating inter-regional trade.¹²³ Furthermore, luxuries were not necessarily separable from ordinary items, even at a production level; the pottery workshops of central Gaul turned out cooking pots for local purchasers as well as table wares for export.¹²⁴ Given that most workers would also have been involved in part-time subsistence farming (as nineteenth-century Pennine lead miners were), the greater the variety of

¹¹⁷ Price has linked these stories to the development of blowing glass into relief-moulds in the first century AD: Newby and Painter, eds., *Roman glass*, p. 64.

¹¹⁸ The Greek terminology is vague about the material from which the vessel was made, and how it was damaged.

¹¹⁹ 57.21. A footnote in the Loeb edition includes details 'missing' from Dio that are related by Pliny and Petronius 'much more sensibly'.

¹²⁰ I owe this point to Prof. Jennifer Price.

¹²¹ Eggert, 'Vitrum flexile', p. 288.

¹²² Finley, 'Technical innovation', p. 41.

¹²³ Sherratt, 'Reviving the grand narrative', p. 14.

¹²⁴ Vertet, 'Lezoux et les ateliers du centre de la Gaule'.

their output of ordinary and luxury items, the more easily they could absorb observed fluctuations in demand.¹²⁵

Despite having reproached contributors to the Oxford *History of technology* for their critical comments about classical scholarship,¹²⁶ Finley then attempted to undermine the growing use of material evidence by classical archaeologists: ‘We are too often the victims of that great curse of archaeology, the indestructibility of pots.’¹²⁷ Actually, ceramics have filled in an enormous amount of detail about production and distribution, particularly in regions where literary evidence is entirely absent. Furthermore, classical pottery frequently bears stamps giving the names of its makers or workshops, not only on pottery designed for use as pots (*terra sigillata*, lamps, mortaria) but also on containers or building materials (amphorae, tiles).¹²⁸ It is no argument to state that pottery seems important only because it survives (so do stone buildings), or that the lack of significance of Greek red-and-black pottery to the *overall* economies of Athens or Corinth reduces its interest. The closure of the world’s largest pottery works (Maling of Newcastle upon Tyne) in 1963 was only one small factor in an economic transition. Its location, products, and distribution of exports tell an important part of the region’s story, because its very existence reflected a broader pattern of population, raw materials, and transport opportunities. Ceramics may be used as proxy evidence for those hundreds of other commodities that do not survive because they were perishable. The curse is, in fact, a blessing: our knowledge of the Roman wine trade disintegrates once clay amphorae began to be superseded by barrels as the main means of conveyance.¹²⁹

Rostovtzeff had used the *terra sigillata* of Italy and Gaul as a source for ideas about economic decentralization and its implications; Finley’s dismissal of pottery indirectly undermined any interpretations based upon it. ‘I mean no offence, but this theory is an anachronistic burlesque of the affluent society’, he commented disingenuously.¹³⁰ Rostovtzeff was, in fact, a pioneer in the development of an ‘archaeologically aware’ economic history, as the copious illustrations in his books of 1926 and 1941 on the Roman and Hellenistic worlds reveal, and he was prepared to use material evidence in the construction of a broad picture of social change.¹³¹ He employed a rather modernizing vocabulary, and in many ways resembled his contemporary V. Gordon Childe, who was engaged in a parallel attempt to extract quasi-historical social information from prehistoric material culture.¹³² As with Childe’s *Dawn of European civilis-*

¹²⁵ Greene, ‘*Terra sigillata: imitations and alternatives*’; Going, ‘Economic “long waves” in the Roman period’.

¹²⁶ Finley, ‘Technology in the ancient world’, p. 124.

¹²⁷ *Idem*, ‘Technical innovation’, p. 41.

¹²⁸ A recent collection of papers on these and other *instrumenta* (Harris, ed., *Inscribed economy*) underlines their potential for serious economic analysis.

¹²⁹ Tchernia, ‘Le tonneau’.

¹³⁰ Finley, ‘Technical innovation’, p. 42.

¹³¹ Rostovtzeff, *Social and economic history of the Roman empire*; *idem*, *Social and economic history of the Hellenistic world*.

¹³² Greene, ‘V. Gordon Childe’.

ation (1928), Rostovtzeff's footnotes were awesome in breadth and depth; it is sad that Finley, who was so keen to encourage the use of models in the study of the past, did not acknowledge his achievements.

Finley was right to observe that manufacture of pottery and other items became diffused, and that an explanation lay in the modest level of technology and capital involved.¹³³ He did not add that many of these acts of diffusion were achieved by the organized establishment of branch workshops rather than independent imitators.¹³⁴ The diffusion came about not because 'population spread away from the Mediterranean', but because indigenous people in the provinces developed a demand for the material trappings introduced by soldiers and merchants. The economic activities associated with that inelegantly titled process, 'Romanization', brought monetization, and the spending power with which to acquire its physical manifestations. Hopkins developed a simple model to show how trade was stimulated by the state's taxation and expenditure, its demands for supplies for garrisons on the frontiers, and conspicuous consumption by wealthy inhabitants of Mediterranean cities.¹³⁵ Intermediate provinces such as Gaul or Africa were forced into the market economy to raise money for paying taxes, and some of their profits came from selling surpluses to the army. Thus, flows of staples, luxuries, and money were developed that encouraged manufacturers to operate in centres such as Lugdunum (Lyons). The 'excessive costs of transportation by land' cited as a factor by Finley were overstated, and largely irrelevant once this inter-regional dynamic had been established.¹³⁶ Private operations accompanied and followed the official establishment of an infrastructure of roads, ports, and urban centres. None of this fits Finley's assertion that 'production for the domestic market and inelasticity of demand were as predominant as Xenophon believed'.

At this point Finley introduced another 'story' taken from Suetonius.¹³⁷ The emperor Vespasian (AD 69-79) rewarded an engineer who could have transported heavy columns to the Capitolium at little expense, but did not take up his offer, saying, according to Finley, 'How will it be possible for me to feed the populace?'¹³⁸ The story sounds best out of context, giving the impression that, like the glass-maker discussed above, the engineer had sought out the emperor, and that their conversation had been reported by Suetonius (who, let us not forget, wrote some 50 years later). The Latin text does not bear this weight, however, and quotation marks are a feature only of translations.

Sections 16-19 of *Vespasian* actually deal with the emperor's reputation for meanness in a balanced fashion. Suetonius presented an image of prudence while the state finances were in straitened circumstances, and

¹³³ Finley, 'Technical innovation', p. 42.

¹³⁴ Aubert, *Business managers in ancient Rome*.

¹³⁵ Hopkins, 'Taxes and trade', see now Andreau, 'L'Italie impérialé'.

¹³⁶ Finley, 'Technical innovation', p. 42. The level of efficiency of land transport is a separate issue: see Raepsaet and Rommelaere, eds., *Brancards et transport attelé*.

¹³⁷ *Vespasian*, 18.

¹³⁸ Finley 'Technical innovation', pp. 42-3.

then countered anecdotes of Vespasian's miserliness with examples of generosity. These included subsidies to impecunious senators, repairs to cities, and encouragement of talents and arts.¹³⁹ Teachers of Greek and Latin rhetoric gained salaries, poets were handsomely rewarded, as was an artist/restorer of statues, while the architectural engineer with his method¹⁴⁰ of moving columns was rewarded *non mediocre*. Section 19 goes on to record artists; having restored the theatre of Marcellus, Vespasian gave large sums of money to a tragic actor, two lyre players, and several others. Finally, he held frequent dinner parties, and gave gifts to men and women on festival days. It is important to note that these parties were sumptuous *ut macellarios adiuvaret*—to benefit the market men. This explains the reason for declining to make use of a method of column transport that required less labour; Vespasian intended that casual labourers should receive wages for public works in the same way that market traders should profit from supplying the imperial kitchens.¹⁴¹ The reason was certainly *not* antipathy to innovation.

VII

Finley moved on to less contested ground in the next section of his article, where he explored the relationship between slavery (one of his most enduring interests) and economic and/or technological stagnation. He rightly pointed out the lack of a direct relationship, noting that machinery was introduced into mining and intensive agriculture, and observing that 'slave labour in antiquity was as good as any'.¹⁴² From this he went on to develop two key points related to the Roman imperial period. First, a shortage of manpower had developed through reductions in the supply of slaves and the 'persistent increase in the parasitical classes'; second, there was no adequate response: 'no one disagrees, that neither technique nor productivity nor economic rationalism made an advance in these final centuries of antiquity'.¹⁴³ Finley explained this in terms of attitudes; the aristocracy retreated to their proto-manorial estates for political reasons (they remained wealthy) while the state, instead of attempting to improve production, simply took 'a bigger bite out of the old pie'. He linked the ancient antipathy to artisans' labour with the effect of slave owning on the spirit of enterprise, citing analogies from nineteenth-century South Africa and North America.¹⁴⁴ The perception of slavery as a normal part of domestic, agricultural, and industrial activities up to the mid-nineteenth century AD does not lend much support to the idea that it had an inevitably negative impact on technology. The

¹³⁹ *ingenia et artes: Vespasian*, 17.

¹⁴⁰ The Latin term *commento* means an idea or plan, not a 'machine' or 'device'.

¹⁴¹ This interpretation diverges from, but in no way invalidates, the idea that urban aristocratic households were supplied by their own estates, and thus side-stepped the market: Whittaker, 'Trade and the aristocracy'.

¹⁴² Finley, 'Technical innovation', p. 43.

¹⁴³ Ibid., p. 44.

¹⁴⁴ Ibid., pp. 44-5.

notion of a positive effect should not be excluded; while Eric Williams overstated the claim that the industrial revolution was made possible by capital formation from the slave trade, the ‘triangular trade’ was an undoubted stimulant to production and shipping.¹⁴⁵ What happened to the economic products of periods of abundant slaves, such as the Roman republic? Even if they were converted into conspicuous consumption, that does not end the enquiry, for the materials of consumption had to be obtained from somewhere.

A fundamental weakness in Finley’s chain of logic is the concept of manpower shortages, both in terms of the availability of slaves and the demographic curve of Graeco-Roman population. It relies upon a model of demographic change that is far from secure. Perhaps in recognition of this, he appended two final paragraphs that clouded the more general economic conclusions. He admitted that there was some technical and economic progress in the ancient world and that (‘obviously’) the range and quality of products and living standards rose (‘at least for the rich’), while urbanization and town life demonstrated that ‘a larger share of the total income was available for non-productive expenditure’.¹⁴⁶ These positive judgements were diluted in a series of rather vague qualifications about population growth and territorial expansion. The remarkable episode of Greek colonization from the Black Sea to the western Mediterranean was ‘merely the consequence of population outstripping the available means’, and ‘represented no real gain to the original Greek settlements’. Like Finley’s earlier comments on the ‘waste’ of capital on major state projects, this judgement ignores positive feedback from public goods such as infrastructural development and transport networks.

Finley’s final paragraph invoked a bleak Malthusian view of population growth, which he saw as a problematic disequilibrium.¹⁴⁷ One solution was to send people out, the other to bring in booty and tribute; both underlined the inability to raise productivity. However, even a cautious interpretation of recent regional fieldwork studies suggests that the productivity of Greek and Roman farming was able to support a far higher population than had ever been imagined,¹⁴⁸ and that supposedly ‘sparsely occupied’ areas—such as Spain and Gaul—were actually more densely populated both before and after their Roman conquests than hitherto thought.¹⁴⁹ Furthermore, the picture of demography is far from uniform across the empire, making judgements even more difficult. Irrespective of this new information, Finley’s worries about an expanding population contradicted his earlier remarks about manpower shortages.¹⁵⁰ From a historiographical point of view, if Finley had been influenced by anthropological studies of surpluses and feasts rather than the dire predictions of

¹⁴⁵ Williams, *Capitalism and slavery*; Daunton, *Progress and poverty*, pp. 374-80.

¹⁴⁶ Finley, ‘Technical innovation’, p. 45.

¹⁴⁷ *Ibid.*

¹⁴⁸ Murray, ‘Ecology and agrarian history’.

¹⁴⁹ Greene, *Archaeology of the Roman economy*, pp. 110-22.

¹⁵⁰ Finley, ‘Technical innovation’, pp. 43-4.

Malthus, he might have taken an altogether more relaxed view of the issue of population.¹⁵¹

Finally, Finley declared that ‘barbarian pressures’ challenged the economy and political organization of the empire in a way that could not be met in the West.¹⁵² Even this seemingly uncontroversial conclusion is open to qualification, however. How far did the loss of the western provinces result from the selfishness of the East and internal strife, and how did the East finance resistance to barbarians for another 1,000 years? Dispassionate studies of ‘barbarians’ reveal mature political entities that had grown prosperous as neighbours of the Roman empire, through trading, raiding, diplomacy, and military service. The wealth of the Goths, for example, encouraged the evolution of social hierarchies and centralized dynastic rule similar to that of Rome.¹⁵³ In contrast to the cherished stereotypes of abject nomadism repeated by classical writers such as Ammianus Marcellinus, the Goths had a productive settled agricultural economy that provided sufficient surpluses for craft specialization, trade in luxuries, and conspicuous consumption by elites. The Ostrogoths around the Black Sea coasts in the fourth century AD lived in villa-like masonry buildings, drank wine, and ate from wheel-thrown tablewares identical to those found inside the Roman empire.¹⁵⁴ Is it any wonder that Germanic peoples sought (or fought for) Roman territory in the face of the Hunnic onslaught, and that (with the exception of Anglo-Saxons) they merged so easily into the language, religion, and rural settlements of the Roman provinces? Such concepts may well have seemed unattractive to Finley, whose heart really lay with the ancient Greeks, rather than their disappointing Roman successors.

VIII

Sufficient evidence has been adduced above to show that a change in emphasis has taken place in the interpretation of the classical economy since Finley placed his stamp upon it in 1965, and repeated the same view in 1973 and 1985.¹⁵⁵ His overall framework has remained intact: gross disparities in wealth, the importance of political power and social status, and the limitations of financial systems, are not in dispute. However, most commentators are more positive about the level and nature of economic activity that took place within this framework. A lack of ‘capitalist spirit’ is not a sign of aversion to growth, but one of caution: in the words of Paterson’s recent pithy summary, ‘The behaviour of the great landowners was perfectly rational, given their goals. In the language of the economist they were “profit-satisficing” and “risk-averse”’.¹⁵⁶ Likewise, the supposed aristocratic objection to involvement in trade ‘is not

¹⁵¹ Murray, ‘Ecology and agrarian history’, pp. 20-1.

¹⁵² *Ibid.*, p. 45.

¹⁵³ Heather, *The Goths*, pp. 130-65.

¹⁵⁴ Kazanski, *Les Goths*, pp. 39-59.

¹⁵⁵ Finley, *Ancient economy*.

¹⁵⁶ Paterson, ‘Production and consumption’, p. 192.

moral or snobbish, but the practical one that such investments were *periculosum et calamitosum*'.¹⁵⁷ Andreau's label 'anti-finleyien'¹⁵⁸ implies no disrespect for Finley's achievements, not least as a supreme provoker of debate: indeed, *The ancient economy*'s French edition received the accolade of a twentieth-anniversary retrospective review in *Annales* in 1995. I have restricted most of my comments to Finley's views about production and trade, whereas Andreau highlighted five dimensions to his approach: economic integration, the market principle, the ancient city, rationalism, and status.¹⁵⁹

However, my complaints about Finley's economic history are modest in comparison with those about his treatment of technology. He did real harm to this subject by consolidating and perpetuating the idea of stagnation, for most historians of technology are explicitly interested in the dynamics of *change*.¹⁶⁰ Thus the classical world was made to look very dull beside prehistory, where a few thousand years produced the Neolithic/Agricultural Revolution, the first metallurgy, the rise of literate civilizations, and, within centuries of the rise of classical Greece, the beginning of iron working. Each of these exciting stages has spawned debate, particularly where they have been linked to social evolution—such as Childe's Urban Revolution, or Lilley's 'iron, the democratic metal'.¹⁶¹ A similar sense of excitement extended to the middle ages, where some detected the beginnings of modern industrial mechanization,¹⁶² or the Renaissance, when scientific and theoretical approaches began to be applied systematically to technical problems.¹⁶³ Unfortunately Usher's pioneering work in the 1920s failed to inspire a counterpart to Lynn White Jr who would (rightly or wrongly) promote classical technology into the centre of debates about historical change.¹⁶⁴

Finley's many economic critics have had little or nothing to say about technology, from Frederiksen in 1975 to Paterson in 1997,¹⁶⁵ while Garnsey and Saller, in their socio-economic account of the Roman world in 1987, made fewer references to technology than Finley himself—and usually added the qualifier 'backward'.¹⁶⁶ Giardina's excellent presentation of Rome in terms of profiles of classes and professions in 1993 included chapters on slaves, traders, and craftsmen, but not architects or engineers.¹⁶⁷

Revisions to the 'blocked' notion of classical technology have not yet extended far beyond those Graeco-Roman specialists who employ a broad contextual approach to their subject. Schneider acknowledged the impact

¹⁵⁷ Ibid., p. 198.

¹⁵⁸ Andreau, 'Présentation', p. 957.

¹⁵⁹ Ibid., p. 949.

¹⁶⁰ e.g. recently Buchanan, *Power of the machine*, pp. 3-20.

¹⁶¹ Childe, *What happened in history*; Lilley, *Men, machines and history*.

¹⁶² White, *Medieval technology*; Gimpel, *Medieval machine*.

¹⁶³ Gille, *Renaissance engineers*; Parsons, *Engineers*.

¹⁶⁴ Cantor, *Inventing the middle ages*, p. 369.

¹⁶⁵ Frederiksen, 'Theory, evidence'; Paterson, 'Production and consumption'.

¹⁶⁶ Garnsey and Saller, *Roman empire*, esp. pp. 52, 197.

¹⁶⁷ Giardina, ed., *Romans*.

in Germany from the mid-1970s of an approach that involved a socially situated contextual interpretation of technology and innovation.¹⁶⁸ He traced the early path of the slavery/stagnation/blockage view from Diels in the 1920s through Ferrero, Rostovtzeff, and Lefebvre de Noëttes to Finley, Pleket, and Lee in the 1970s, and its perpetuation by Gille in the 1980s.¹⁶⁹ However, like Gille, he recognized that searching for the causes of stagnation may lead to neglect of actual achievements; the way forward was to acknowledge the nature of the classical economy (Schneider accepted the broad outlines of the 'Jones-Finley' view), and to explain the real progress that took place in a society based primarily on agriculture, with limited ideas of economic rationalism.

Traina's 1994 overview of conceptual approaches to classical technology goes beyond Schneider's, even drawing upon modern theories of the relativity of knowledge (such as those of Michel Foucault) to challenge the text-bound discipline of Finley (and most of his contemporaries and followers): 'Le tecniche degli antichi erano perlopiù "invisibili" in quanto non erano codificate dalla cultura egemone mediante l'elevazione a dignità letteraria'.¹⁷⁰ He particularly regretted the contradictory perception of classical technology in terms of simultaneous admiration for its achievements but condemnation of its stagnation, and followed it forward into chronological and social contexts untouched by Finley by using unusual late Roman literary sources.¹⁷¹

A third writer of the 1990s, Chevallier, took a broader view combining Roman technology and science, but aligned himself with the view that technology was subordinated to ideals of prestige and status, right through to late antiquity.¹⁷² Chevallier did allow Rome two achievements: the beginnings of industrialization, and the idea that technology could contribute to general well being. He also emphasized that an awareness of progress was well established, especially in Pliny's *Natural history*.¹⁷³ Although he did not cite Finley in his bibliography or discussion, Chevallier held a very similar notion of the subordination of technology to status that is difficult to reconcile with the cumulative effect of his chapters on production and machines, which actually provide better support for the optimistic interpretations of Schneider and Traina.

Assessing the place of technology within the economy (and the rest of Graeco-Roman life) demands a further stage of analysis and interpretation. Each of the major episodes of change defined by historians of technology involved a shift in the use of resources or in the application of power sources. Perhaps the clearest example—and one of the most

¹⁶⁸ Schneider, *Einführung*, pp. 1-2. The inelegantly named 'SHOT' approach is an acronym of the Society for the History of Technology and is not to be confused with SCOT, the social construction of technology; see Fox, 'Methods and themes'.

¹⁶⁹ Ibid., pp. 22-9.

¹⁷⁰ 'The technology of the ancient world was mostly "invisible" in that it was not codified by the cultural hegemony through being elevated to literary dignity.' Traina, *La tecnica*, p. 16.

¹⁷¹ Ibid., pp. 21-63.

¹⁷² Chevallier, *Sciences et techniques*.

¹⁷³ Ibid., pp. 110-12.

recently hypothesized—is the Secondary Products Revolution.¹⁷⁴ It was not the direct effects of the ‘Neolithic Revolution’ that led to the SPR, but further processing of the materials and consumables provided by the initial ‘revolution’, combined with the first use of animal power for ploughing and pulling wheeled vehicles. What is interesting in this example is that the most important effects of technology may be apparent not in the initial phase of change, but in its aftermath. Exactly the same observation could be made about the industrial revolution that (conventionally) began in the mid-eighteenth century, but whose most familiar elements—steam engines, factories, mechanized transport, urban conglomerations, to name but four—are more characteristic of its maturity in the nineteenth century than of its origins. Perhaps the Graeco-Roman period should be seen as the maturing of the European iron age, when the use of iron first proliferated into all spheres of use. For the first time in human history, armies could be equipped with weapons and armour, workshops could be provided with specialized tools; farms could possess sufficient implements to operate effectively in all of their activities of production and processing, while the building trade could construct and maintain buildings on a large but economical scale.

When the classical period is placed into this kind of context the changes of the medieval period seem less dramatic—gradual but effective developments, rather than keys unlocking doors that were impeding progress. Most genuine medieval innovations now appear to be applications and/or intensifications of ideas rooted in antiquity—windmills, reciprocating machinery, cranks, and skeleton-built ships all have clear classical antecedents. The absence of revolutionary change is surprising only to those who consider it to have been a regular feature of human development. Lewis Mumford’s description of everything before the ‘so-called’ industrial revolution as ‘eotechnic’ places the whole subject on to a very different scale of measurement.¹⁷⁵

It must be asked in conclusion whether the Greek and Roman economy and their technological components ‘matter’. The answer must be that they do, as long as writers of overviews of economic or technological history continue to refer back to the prehistoric and/or early historic past. Specialists operating in those periods have a dual obligation to present radical changes in information or interpretation in accessible form, and to take account of the work of broad-minded writers, such as Angresano or Mokyr, who incorporate early periods into their studies in a serious fashion.¹⁷⁶ Such writers provide a valuable intellectual bridge to modern economic or technological history and theory, which can be exploited (like prehistory or anthropology) for tackling problems of classical antiquity. Both disciplines have experienced a similar, if separate, theoretical trajectory.¹⁷⁷

¹⁷⁴ Sherratt, ‘Plough and pastoralism’.

¹⁷⁵ Mumford, *Technics and civilization*.

¹⁷⁶ Angresano, *Comparative economics*, pp. 29–56; Mokyr (on industry and technology), *Lever of riches*, pp. 19–30, 193–208.

¹⁷⁷ Fox, ‘Methods and themes’.

Thus, readers of this journal, approaching the classical period from more recent perspectives, need to rid themselves of the notion that it was any less complex than later centuries, even if the pace of change was not remarkable. Indeed, the steady growth in infrastructure, equipment, and production mirrors the slow rise of Greek states and gradual expansion of the Roman empire over a period of more than five centuries. Could such a phenomenon really have been based upon economic stagnation and technical blockage? It is time to set Finley into his proper historiographical context, admire his achievements, and regret the over-effectiveness of his legendary powers of argument. Meanwhile, research should continue into the fundamentals of classical economics and technology in an informed, wide-ranging contextual manner, constantly reviewing the implications of the latest archaeological discoveries.¹⁷⁸

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¹⁷⁸ The rapid pace of discovery of physical evidence relevant to Roman technology and trade is typified by a set of stonemason's tools found in the wreck of a ship carrying blocks of marble, and an analysis of desiccated remains of food and fodder supplied to a fort deep in the Egyptian desert, reported in volume 11 of *J. Roman Archaeol.* for 1998, which arrived while I was writing this article.

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