

Ancient and Pre-Modern Economies

GDP in the Roman Empire and Early Modern Europe

Elio Lo Cascio & Paolo Malanima

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Estimates of per capita and aggregate GDP in the early Roman Empire are presented, discussed and tested. Then a comparison is proposed between these estimates and GDP in late medieval and early modern European economies. The result is that Roman per capita GDP two thousand years ago was the same as that of other pre-modern agrarian economies before modern growth. Pre-modern product per capita in ancient Mediterranean civilisations underwent cycles of rise and decline within a narrow range. A long-term progressive path from Antiquity to the eve of modernisation is not confirmed by the available evidence.

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Elio Lo Cascio

elocasc@tin.it

Paolo Malanima

malanima@issm.cnr.it

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Were the ancient Greeks and Romans richer or poorer than medieval and early modern European inhabitants? Was the productive capacity of the ancient Euro-Mediterranean economies comparable to that of the late Middle Ages and early Modern European civilizations? How far was ancient per capita GDP from that of our modern advanced societies?

Some 40 years after the famous work by Finley (1973) on the ancient economy, historians of the ancient Greek and Roman world share a very diverse perspective and stress the rising trend of product, aggregate and per capita, both in the classical Greek economy of the 8th- 4th century BC and in the Roman civilization during the last centuries of the Republic and the first of the Principate (Scheidel, Morris, Saller (eds.) 2007). Today, ancient economies are seen much more modern than they were some decades ago. A central question of interest lies, however, in the comparison between the economic performance of these ancient economies and those of late medieval and early modern Europe. To this question we still lack an answer. We do not know how far the productive capacity of these ancient economies was from the medieval, early modern and modern economies and we do not know if modern growth was preceded by a slow rising path of several centuries or even millennia or by an overall stability with cycles of growth and decay. It is apparent that the answer to this problem can suggest different views of pre-modern economic history and the path towards modernization.

A central problem when dealing with a vast area, such as the Roman Empire (2,750,000 km² at the death of Augustus and 3,800,000 km² in the late 2nd century AD), is the great variety of regional economic conditions. Differences in prices and wages were considerable at that time. It may be noted that if we use basic data referring to Italy, in our GDP reconstructions, the results we attain are different from those reached whenever we refer to Egypt or other Eastern provinces. In this paper, we will deal only marginally with the economic differences among regions. We will focus, instead, on the differences among the estimates for the entire early Roman Empire, over the long period between the death of Augustus and the An-

tonine Plague in 160-180 AD.¹ Given the scarcity of primary data, scholars are forced to use quantitative information spanning this very long period.

In the following analysis, we will start by presenting the figures put forward by different scholars over the last decades and discuss their methods. Later we will analyse the problem of the comparability between data concerning the early Roman Empire on the one hand and those relating to Europe in the late Middle Ages and early Modern Age on the other. Despite the primary interest of this topic, it has been only touched upon by scholars.

1. Diverse estimates

In the following Table 1, the diverse results put forward by different scholars during the years 1980-2009 are summarized (in columns 1, 2). In the third column the estimates are reported in sesterces (HS). In columns 4 and 5, per head GDP is multiplied by two different estimates of the population of the Empire, 40 and 100 million. These represent the lowest and highest limits of a range that the scholars of the Roman world would consider as plausible for the long period under examination, spanning a century and half after the death of Augustus in 14 AD. Actually the lowest estimate has been proposed by Mc Evedy and Jones (1978: 21 and passim) – about 40-46 million –, Frier (2000: 812, 814)– 45.5 million in AD 14 (rising to 61.4 in AD 164)-- and Maddison (2007: 35) --44 million --. That of 100 million is the likely highest margin of the range (Beloch 1899, attributed specifically to the age of Caracalla). In columns 6, 7, 8, 9, aggregate GDP is presented in tons of silver and gold. The weight of the sesterce in gold was 0.08 grams (actually, with three decimals, 0.077 grams, since a gold libra – more or less 325 grams -- was coined in the Augustan age into 42 aurei, equal to 4,200 sesterces). The ratio gold-silver being at that time 12.5, a sesterce equaled 1 gram of silver (actually 0.97, although we round off our figures to 1).

Table 1. Estimates of per capita and aggregate GDP in the early Roman Empire per author, in sesterces and tons of silver and gold.

1	2	3	4	5	6	7	8	9
authors	year	HS Per c. GDP	HS 40 million (000.000)	HS 100 million (000.000)	Silver 40 million (tons)	Silver 100 million (tons)	Gold 40 million (tons)	Gold 100 million (tons)
Temin	2006	166	6,640	16,600	6,640	16,600	531	1,328
Bang	2008	230	9,200	23,000	9,200	23,000	736	1,840
Hopkins	1995-96	250	10,000	25,000	10,000	25,000	800	2,000
Scheidel-Friesen	2009	260	10,400	26,000	10,400	26,000	832	2,080
Goldsmith	1984	380	15,200	38,000	15,200	38,000	1,216	3,040

Note: in columns 4-9, we compute the aggregate values in sesterces, silver and gold with two different estimates of the population (40 and 100 million). Calculations in columns 4-9 are ours, and not provided by the authors in their contributions.

¹ On the topic see Lo Cascio (ed.), *La peste antonina* (forthcoming).

The estimate by Hopkins is based on Hopkins 1995-96 (republished in Hopkins 2002). Hopkins puts (p. 199) minimum subsistence at HS 165 per capita. Then he suggests (p. 210, footnote 44) the addition of 50 per cent to reach per capita GDP (then $HS\ 165 \cdot 1.50 = 247.5$). We round off the result to HS 250. The same procedure is followed by Bang, who puts the aggregate GDP for a population of 60 million at 13,700 million sesterces and therefore computes per capita GDP at 230 sesterces (p. 91).

We can see that the per capita estimate by R. A. Goldsmith (1984) is 130 per cent higher than that by P. Temin (2006), at least in nominal terms (we will see later that in real terms the difference is much lower) and 45-65 per cent higher than that of the other authors. Data proposed by Hopkins, Bang and Scheidel-Friesen stay between 230 and 260 sesterces per capita, in a range that is lower than 15 per cent between maximum and minimum. The estimate by Goldsmith has been recently accepted by Maddison (2007).

Because of our uncertainties about population level and the notable difference between the lower and higher demographic estimates, the range of the aggregate product is much wider than that per capita. Gross output of the Empire is in fact 5.7 times higher in the estimate by Goldsmith than in that by Temin, taking the range between the lowest estimate of GDP per head (Temin 2006) for a population of 40 million and the highest estimate for GDP (Goldsmith 1984), with a population of 100 million.

2. A similar method

While the results are diverse, the methods followed by these scholars are similar. The starting point is the average wheat consumption per capita during one year multiplied by the price of wheat. To this basic consumption in value several additions are made in order to include other forms of consumption and finally state expenses and investments. Since the authors of these estimates refer to the Roman Empire, a distinction between national and domestic product is not necessary. We can assume that they coincide. The distinction between national and domestic estimates would become important should we choose to evaluate the product of particular regions within the Empire. National product was certainly higher in Italy than domestic product because of the taxation of provincial populations and investments made outside Italy by rich Italian families. A flow of foreign revenues that reached Italy was employed there. For other regions national income could be correspondingly lower than domestic income.

Since A. Maddison tried, in 2007, to improve on Goldsmith's estimate, which is the most accurate and complete, we will summarize Maddison's calculations referring to 14 AD, that is, at the death of Augustus. The approach in both cases is from the demand side, since output per head is calculated on the basis of demand for consumption, investment and public expense. The result attained by Maddison for the Roman Empire is the same as that by Goldsmith, with a slight difference in the share of government expense, investment and expenditure on consumption other than food.

The estimate by Goldsmith is based on both wheat consumption, assumed to be about 250 kg per person per year (about 1,500 Calories per

day), confirmed by recent research on consumption in the early Roman Empire (Jongman 2007: 599) and a wheat price of 3 sesterces per *modius* (6.75 kg); that is approximately 0.444 sesterces per kg in the 1st century AD.²

We know that an average wheat price relative to some decades is hardly representative in pre-modern agrarian economies, given the wide yearly deviations. In medieval and early modern European series of wheat prices annual deviations from the trend of 50 per cent were far from exceptional. While for Italy we have scanty figures on the price of wheat in the early Empire, for Egypt more detailed information is available and we see that wheat prices double or even treble over a few years (Duncan-Jones 1990: 146, and Table pp. 151 ff.; see also Drexhage 1991 and Rathbone 1997: 190-98; Lo Cascio 2009: 253 Table 1). Variability was a feature of the agrarian price history until a recent epoch. However, according to Goldsmith, his own estimate could be “approximately valid from the late first century BC to the mid-second century AD”, and the price of 3 sesterces per *modius* of wheat could also be assumed as a long-term average (Goldsmith 1984: 263).

The price of 3 sesterces per *modius* throughout the whole Empire is nothing but an assumption; plausible but not certain. We know, in fact, that in Egypt, wheat prices were lower, and in some areas much lower (Duncan Jones 1990: 143-57 and Table II, p. 152), and that, naturally, they were much higher in the city of Rome. The price of 3 sesterces per *modius* was also the basis of Hopkins’ estimate of Roman GDP (1980). P. Temin (2006), taking the much lower Egyptian prices, and assuming moreover a lower wheat consumption of 175 kg per person per year, reaches an estimate of per head income which is less than half the estimate proposed both by Goldsmith and Maddison as seen in the previous Table 1. Temin compares the estimates by Goldsmith and Hopkins, stating that “Goldsmith’s approach is more satisfactory than Hopkins’, that is, more in touch with modern economic theory and observations”, but adding that “Goldsmith’s numbers, however, are not as good as his methods”. In the end he suggests an estimate of per capita income closer to that proposed originally by Hopkins. In any case, it must be remembered that Hopkins’ original estimate referred to the *minimum* per capita expenditure (in terms of the annual consumption of wheat or measured in wheat). In the latest version of his calculations (Hopkins 1995-96), he devised a rough multiplier of 1.5 in order to estimate the actual expenditure from the minimum per capita expenditure for wheat. More recently Bang (2008) followed the same method.

3. The procedure

Goldsmith calculated per capita GDP by adding to the estimate of wheat consumption the share of other cereals, that of other food, of other consumption and finally the share of government and investment. Maddison follows the first three estimates of Goldsmith, but lowers the share of other

² A slightly lower weight for the *modius*, 6.55 kg. is given by Bang (2008), p. XV and passim.

consumption (from 39 to 34 per cent of the total per capita income) and raises the share of government and investment, in the 5th column of Table 2, from 8 to 13 percent and adding 45 percent more to the single value of wheat consumption. All these percentages are based on the likely share of these items of demand in pre-modern economies or in contemporary backward countries.

Table 2. The estimate by Maddison (based on Goldsmith) of per capita GDP of the Roman Empire in 14 AD, from the demand side, in sesterces (HS).

		HS	Shares as to y=1	Shares as to w=1
<i>w</i>	Wheat	112	0.29	1.00
<i>c</i>	Other cereals	18	0.05	0.16
<i>f</i>	Other food	70	0.18	0.63
<i>o</i>	Other consumption	130	0.34	1.16
<i>g+i</i>	Government & Investment	50	0.13	0.45
<i>y</i>	TOTAL	380	1.00	3.39

Note: in the last column on the right the figures represent the shares as to wheat consumption. E.g. 0.16 refers to other cereals divided by wheat consumption (18:112=0.16).

A compact presentation of Goldsmith's and Maddison's estimates can be expressed through the following equation:

$$y = w(1 + c + f + o + g + i)$$

where *y*, *c*, *f*, *o*, *g*, *i*, reported in the first column of Table 2, refer to the items of the second column and represent proportions as regards per capita product as a whole (in the 4th column) and wheat (*w*)(in the last column). As can be seen, the calculation depends on the value assigned to wheat consumption (*w*), which is the only known parameter; or rather the only parameter to which we can assign a plausible value. Replacing the letters in the equation with figures (5th column of Table 2), following Maddison, we obtain:

$$380 = 112 \cdot (1 + 0.16 + 0.63 + 1.16 + 0.45)$$

Per capita GDP, 380 sesterces, is then 3.4 times (the sum of the figures in brackets) the yearly wheat consumption per person (380/112).

Maddison improves upon the previous estimate by Goldsmith by trying to specify per capita product in Italy and in other regions of the Empire. Per capita GDP was higher in Italy than in the rest of the Empire. The Italian population, equal to 18 percent of the population of the Empire, enjoyed 26 percent of total output. The result, both in sesterces and kg of wheat, is reported in Table 3.

Table 3. Per capita GDP by Maddison in the whole Empire and Italy in sesterces and kg of wheat; share of population living in Italy and the rest of the Empire; share of GDP in Italy and the rest of the Empire.

	Per c. product (HS)	GDP per c. wheat (kg)	Index GDP per c. Empire=1	Population (index)	GDP (index)
Empire	380	856	1.00	1.00	1.00
Italy	534	1,203	1.41	0.18	0.26
Rest of Empire	351	791	0.92	0.82	0.76

Source: Maddison 2007.

Note: according to Maddison the total population of the Empire in 14 A.D. was 44 million and the Italian population (including the islands) 8 million.

The same procedure from the consumption side is followed by Scheidel and Friesen (2009). Following Temin, they assume, however, as the starting point, lower per capita wheat consumption: 175 kg. They also provide calculations with the lower wheat prices of 2, 2.5 and 3 HS per *modius* (2009: Table 2). The result they reach is about HS 260 per head or HS 13-20 billion for the whole Empire (according to different prices of wheat), with its 70 million inhabitants.

Given the scarcity of primary data, there are few ways of verifying these estimates of per capita and aggregate GDP. Three tests are tried in the following section:

1. a comparison with an estimate from the income side;
2. a comparison with the monetary mass;
3. a comparison with state budget.

4. Testing the data

Whenever possible, a demand-side approach at estimating GDP can be usefully complemented by an income-side approach. According to Goldsmith, the income-side approach confirms that from the demand-side. When taking an average labour compensation of 3.5 sesterces per day and an average number of 225 working days per year, together with assumptions on the dependency ratio and on the share of non-labour incomes, the result tallies with the demand-side computation. According to Goldsmith, "average annual income per member of the labour force may have been close to HS 800 using an average labour income of HS 3½ to allow for the higher wage of skilled workers as well as for the generally imputed lower wages of women, children and slaves, and an average work year of 225 days, with a rather wide margin of uncertainty" (Goldsmith 1984: 269).

Information on wages is, in fact, scanty and, as Temin remarks in his reconstruction, the level assumed by Goldsmith may appear to be too high (2006: 46). On the other hand, the assumption of the working time of 225 days per year is quite debatable. We do not know how many days workers in the distant past actually worked. Assuming a working year of 150 days, also plausible, yearly labour compensation diminishes to 525 sesterces, which is 35 per cent less than the yearly average proposed by Goldsmith. On the other hand, a participation rate of 40 per cent, assumed by Goldsmith (1984: 271), and accepted by Scheidel and Friesen (2009: 71, Table 3) is the same as that in many Western economies today. Participation rate

was high in past agrarian societies; higher than today. What did change considerably was working time; people working more when wage rates were low and less when wage rates were high. Unfortunately we know very little about working time.³

Furthermore, we must increase the calculation based on wage to take into account “rents, interests, indirect taxes” (Goldsmith 1984: 269). To Goldsmith a 20 per cent increase seems justified. The average income per recipient of monetary or imputed income then reaches HS 1000. In this case, however, labour income represents 80 per cent of the total average income, which is quite a high share (although in pre-modern economies labour could represent a higher share of income than in modern economies, where labour is often assumed equal to 50-70 per cent of total income) (Barro, Sala-i-Martin 1995: chap. 10). We see that few, apparently marginal, adjustments in wage per worker or labour time or participation rate or percentage of labour on total income can result in significant changes in the average level.

A second way to check the estimates of GDP is that of evaluating their consistency with estimates of money supply and monetary stock recently built by some scholars – above all by Duncan-Jones (1994: 170; and more recently by De la Hoz Montoya 2008) – including the importance of credit (Lo Cascio 2003: 8; Lo Cascio 2010). The estimate by Duncan-Jones of 20 billion sesterces refers to the mid-second century and is far higher than that proposed by Goldsmith for the Augustan age (6-8 billion, that is 6-8,000 tons of silver); but low, as we will see in section 6, when compared to that of early modern Europe after the arrival of the American gold and silver. According to Goldsmith, this last figure of 6-8 billion sesterces “would imply ratios of three-tenths to four-tenths of total and of three-fifths to four-fifths of monetized national product and velocities of circulation of 2.5 for total and of 1.5 to 2.5 for monetized national product” (Goldsmith 1987: 41).

The estimate by Duncan-Jones must be deflated in order to take into account the probable increase in the monetary stock between the Augustan age and the mid-second century. Even so, it can only be justified if we assume either that the economy was much more monetized than that of late medieval Europe, or that the velocity of circulation of money was much lower than in European pre-industrial economies (Jongman 2003), or even that GDP was significantly higher than estimated by Goldsmith: and this may, of course, derive from the fact that either the population of the Empire was much higher or per capita GDP was higher. In this case, even the already high estimate by Goldsmith, with the assumption of the highest estimate for the population of the Empire (100 million inhabitants) would appear too low. We would venture to say that of these three possible explanations, each of which is not necessarily exclusive, the last one is the most plausible. In this case the Roman economy would appear less singular in comparison to pre-industrial European economies. These comparisons between money supply and previous estimates of GDP would suggest the highest, by Goldsmith, to be more reliable. Those by Hopkins, Scheidel-

³ See the comments in Malanima (forthcoming).

Friesen and Bang, however, would be compatible with the lowest estimates of the monetary mass (HS 6-8 billion) only by assuming the highest level – 100 million — for the population of the Empire.

A third test is that of comparing output with estimates of the state budget. Current estimates from the point of view of expenditure, particularly those by Duncan-Jones, referring to 150 and 215 AD, seem to be very conservative (Duncan-Jones 1994: 45, Table 3.7). They either do not take into account many items of expenditure or assume too low a value for them. Thus the cost of the army most certainly should be increased (there is much more than just the expenditure for army pay in military expenditure), as should the expenditure on public works and infrastructure. In addition the expenses supported by the municipalities must be taken into account. Total expenditures at the time of Augustus have been estimated HS 600 million (MacMullen 1985; Frank 1933-40: 4, 7) and 825 million (Hopkins 1980: 120). Assuming the lower value, the percentage of GDP in the estimate by Goldsmith, is hardly more than 3. The percentage is higher in the case of the lower calculations of GDP reaching 7-8 per cent (Bang 2008).

Table 4. Percentage of state expense on GDP according to two different estimates of population and two different estimates of state expenditure and army expenditure in the early Roman Empire (with the same per capita GDP of HS 380).

	A	B	C	D	E	F	G
	Per c.	Population	GDP	Expenditure	Expense	Taxation	Taxation
	GDP	(000,000)	HS	(=state	for army	on GDP	on GDP
	HS		(000,000)	income)	HS (000,000)	(D1/C1	(D1/C2 and
				HS (000,000)		and D2/C2 (%)	D2/C1 (%)
1	380	40	15.200	682	493	4.49	1.79
2	380	100	38.000	833	554	2.19	5.48

Source: Duncan-Jones (1994, p. 36, Table 3.3, p. 45, Table 3.7).

Note: data in G refer to the range between the lowest estimate for taxation (in D1) and the highest estimate of aggregate GDP (in C2) and the highest estimate for taxation (in D2) and the lowest estimate for GDP (in C1).

In Table 4 we report two different estimates of state budget in the early Roman Empire by Duncan-Jones and their percentage of GDP according to the high estimate by Goldsmith of per capita GDP with two different estimates of population. Looking at column G, an intermediary percentage of about 4 per cent of State expense (made equal to state revenue) on gross output seems quite plausible.

It seems, however, that both estimates of State revenue should also be raised. We need only mention an extremely significant example (Hopkins 2009: 190). A papyrus of the Vienna collection, published twenty years ago, known as the Muziris Papyrus, provided us with information, whose importance would be difficult to underestimate, on the nature and volume of trade between Rome and India in the mid-second century (Rathbone 2000). The document reports the cargo of a seemingly small ship, devoted to the transport of goods from the port of Muziris, on the southern coast of India on the Indian Ocean, to Berenice on the coast of the Red Sea. The imports

in question had to pay the custom due of 25 per cent. Now, the value of the goods transported, calculated for the payment of the tax, is 1,154 talents and 2,852 drachmas, amounting to 6,926,852 sesterces. The custom due paid on this cargo alone therefore amounted to 2,308,950 sesterces. It was noted recently by A. Wilson (Wilson forthcoming; cfr. Wilson 2009, 217, n. 6) that a hundred ships loaded with goods of equal value, a credible estimate of the annual traffic between the coast of the Red Sea and India, would have yielded to the state a sum corresponding to one third of that required to pay the annual expenditure for the army as calculated by Duncan-Jones (see column E of previous Table 4). We must therefore assume that either the revenues of the imperial state were dramatically higher than so far calculated or that the incidence of taxes on foreign trade was disproportionately high and that the incidence of land tax was much too low. The result would be that the tax burden on the majority of the inhabitants of the Empire was very slight (even taking into account the legal exemptions of some areas or individual towns from the most important taxes, such as the land tax and the poll tax, and even taking into account a large proportion of evasion), or that the size of the economy as a whole was much greater than the evaluation made so far: not only far greater than Temin's estimation (2006) or Hopkins' (1980), but also greater than those made by Goldsmith (1984) and Scheidel and Friesen (2009). The first two alternatives are not so convincing. The Egyptian evidence, revisited recently by A. Bowman (forthcoming), suggests that the level of taxation in the Principate must have been higher than commonly thought; even though it is difficult to believe that the weight of the public sector on the GDP could have been more than 10 per cent. A third alternative exists: the size of the imperial economy was greater than recently estimated. But even in this case we can not say whether and to what extent this greater size was the outcome of a higher population or a higher per capita GDP.

5. Roman and pre-modern economies

These estimates of GDP would certainly be much more useful to the economic historian and economist if they would enable to establish comparisons between them and those recently proposed by several historians for following epochs. In other terms: was the Roman economy more or less developed in comparison with those of medieval and early modern Europe, for which more reliable quantitative information is available? According to Temin the level of GDP per head in the Roman world was closer to that of Ruanda or Uganda today (2006: 43), that is \$ 700-800 (Maddison 2001: 602-03).

In Table 5, we report a series of data on per capita GDP presented by A. Maddison for Western Europe. While few historians would consider these data as wholly reliable, many would agree on the long-term trend they show. According to Maddison, a progressive path characterized the long evolution of the economy from antiquity to the eve of the Industrial Revolution, although the rate of growth was very low and imperceptible to coeval observers. Per capita GDP in the Roman Empire was higher than

that around the year 1000. In the eight centuries from 1000 to 1820, per capita GDP trebled. In any case ancient average income was half that on the eve of the Industrial Revolution.

Table 5. Levels of per capita GDP in Western Europe from 1 to 1870 according to A. Maddison (Geary-Khamis 1990 International Dollars PPP).

	Per c. GDP	Index
1	576	1.35
1000	427	1.00
1500	771	1.81
1600	889	2.08
1700	997	2.33
1820	1,202	2.81
1870	1,960	4.59
1913	3,457	8.10
1950	4,578	10.72
2001	19,912	46.63

Source: Maddison (2007), pp. 70 and 382.

On the other hand, other scholars, a minority however, maintain that in past advanced agricultural civilizations before the Industrial Revolution, differences in per head GDP were indeed marginal. According to them, the range of variation in GDP per capita was modest in the 5-7,000 years before modern growth and did not follow a rising path at all (Clark 2007). Cycles of growth did indeed occur, but around an overall long-term stability. Great agrarian civilizations developed, but productive capacity, measured by per capita GDP, did not exceed the range from the 700 international 1990 dollars used by Maddison in the previous Table and 1,400 at best. Growth, in past agrarian civilizations, meant then an imperceptible rise from 1 to 2, often followed by a fall from 2 to 1. The entire cycle could last 3-5 centuries.

When trying to compare Roman per capita GDP and data proposed for the following epochs a difficulty arises from the methods themselves used in the existing estimates. In fact, all attempts made so far to assess per capita GDP in the Roman Empire run the risk of being based on circular reasoning. The authors of the estimates derive the shares of any item composing GDP per head from the better-known figures relating to the following agrarian economies. In other words, if we start the exercise of estimating Roman GDP per head from the actual consumption of wheat in pre-modern economies and to this figure we add a share for the consumption of other cereals, a share for non-agricultural consumption, a share for investment and state expense, and if all these shares are chosen in the light of pre-modern European economies, why should we, in the end, come up against a different level of real per capita GDP? We believe that the procedure used in the estimates previously discussed is the only one that can be used at the present state of our knowledge. We also believe that these estimates are able to single out a realistically reliable range of values. We disagree, however, on the important result of these estimates: that is, on the conclu-

sion that the average income in the early Roman Empire was lower or much lower than in early modern Europe.

6. The conclusions by Goldsmith and Maddison

Both Goldsmith and Maddison try a comparison of per capita GDP in the early Roman Empire and pre-modern Europe through a conversion of Roman GDP into silver and wheat.

It is not easy to make a comparison in precious metal between GDP in the ancient world and early modern Europe as the difference in the availability of gold and silver was so substantial (Lo Cascio, Malanima 2009). As we have seen, the Roman monetary mass was 20,000 tons of silver in the mid-second century AD, according to the higher estimate which is far from certain. As regards pre-modern Europe, there is agreement on a monetary mass of 47,426 tons of silver (gold included, converted into silver) in 1809 (Braudel, Spooner 1967 and Day 1987). About monetary reserves in 1500 scholars disagree. The range between the lowest estimate of only 1,000 tons of silver (including gold converted into silver according to the ratio of the time between the value of gold and that of silver) (Day 1987: 60) and the highest, 40,000-60,000 tons of silver plus 5,000 tons of gold (Boyer-Xambeu, Deleplace, Gillard 1986: 137) is too wide to be useful. Braudel and Spooner discussed the problem in 1967, but were unable to specify monetary reserves in precious metal in 1500 (Braudel, Spooner 1967). However, we know (and in this case the approximation of our knowledge is far more satisfactory) that between 1550 and 1600, 7,100 tons of silver arrived in Seville, plus 95 tons of gold (Boyer-Xambeu, Deleplace, Gillard 1986). Between 1550 and 1650, 16,000 tons of silver were unloaded in Seville⁴, which according to the higher estimate by Duncan-Jones is not far from the total money reserve in the Roman Empire at the middle of the second century..

Since the margins of uncertainty about the precious metal are so wide, a better possibility is that of comparing the price of wheat in precious metal in Roman antiquity and late Middle Age-early Modern Europe. The price of 3 HS per *modius* implies a price per kg of wheat of 0.444 HS in the 1st century AD. Since the weight of a sesterce in silver is approximately 1 gram, then wheat price in silver is 0.444 grams per kg, while lower prices of 2.5 and 2 HS per *modius* correspond to 0.37 and 0.30 grams per kg. In the *Edictum de pretiis* by the Emperor Diocletian in 301 AD, a kg of wheat was evaluated 0.394 gr. of silver (Allen 2009) and so not far from the the 1st century AD evaluation. A comparison of wheat prices in 15th and early 16th century Europe, and particularly in Italy and England, shows that, once converted into silver, the price was close to the level of the 1st century AD. Things changed with the Price Revolution and the importation of precious metals from America. In the 17th century, taking the average of 100 years of wheat prices in England and Italy, the result was in both cases higher than

⁴ These data on importation of precious metals from America are the same suggested by Braudel and in the afore cited works.

1 gram of silver per kg of wheat.⁵ Both in Naples and Strasbourg the average was 0.800-0.900 gr of silver in the 18th century (Allen 2009: Table 2). The conclusion by both Goldsmith and Maddison that in silver, per capita GDP in the Roman Empire was half that of late 17th century England cannot but depend on the different relative price of precious metals and market goods. We cannot accept their conclusions.

The problem of comparing Roman income in units of wheat with that of England was rapidly solved by Goldsmith by taking “three wheat price quotations for 1686-90”, not reported in his article (Goldsmith 1984: 281 (footnote 82)). On this basis, the conclusion by Goldsmith was that “the wheat equivalent of annual national product per head in the early Roman empire of about 125 modii at a price of HS 3 or close to 850 kg was in the order of one-half the level of England and Wales in 1688” (Goldsmith 1984: 281). Therefore, in 1688 English GDP per head could buy about 1,700 kg of wheat, which is twice that of the ancient Roman Empire.

Maddison has chosen to express the 1688 English per capita income in wheat by means of the prices recorded by the same Gregory King (Maddison 2007: 62). In fact for the year 1688 King provided an estimate of English cereal production and the prices of the four main cereals: not only wheat, the price of which was 6.43 pounds per metric ton, but also rye, barley and oats. According to King’s calculations, at that time wheat represented 24 percent of the English cereal output in weight and 31 percent in value. Naturally the prices of rye (4.92 pounds per metric ton), barley (4.74), and oats (4.23) were lower than that of wheat. Minor crops always have a lower price compared to wheat. Maddison chose to express the English product per head utilizing the weighted average price of the four cereals: 4.93 pounds per metric ton. The result of the ratio between income (9.958 pounds) and cereal price (0.00493 pounds per kg) is 2,019. The average Englishman could buy 2,019 kgs of wheat in 1688, while the average ancient Roman could buy only 855 and the average Italian 1,200. The result of Maddison is that the Roman Empire per capita GDP (expressed in wheat) was 42 percent of that of late 17th century England. In Italy, in the centre of the Empire, it equalled 59 percent.

As can be seen, Maddison utilizes cereal prices in his calculations and not wheat prices and, since prices of minor cereals are lower than those of wheat, an average income has a higher purchasing power. The ratio between 9.958 pounds and the wheat price per kg (0.00643 pounds) reported by King is, in fact, 1,548 and not 2,019, i.e. the result obtained when the average price of the four main cereals is used. Utilizing this ratio of per capita product to wheat price in 1688, the difference between the Roman world and early modern England diminishes: per capita product of the Empire and Italy rises respectively to 55 percent and 78 percent of that of England.

One may ask, however, why we should use the prices from King’s calculations when English price history is well documented and many dif-

⁵ We utilized English and Italian wheat prices reported in Malanima (2009), chap. 6 and chap. 4, Figure 12.

ferent series of prices exist; some of them recently revised. Why, furthermore, has only the wheat price of 1688 been chosen? The Roman price of 3 HS per *modius* is nothing but the approximate price relating to a long period of time. During the half century spanning 1650-1700, the wheat price was at its lowest level in 1654 and 1688 when it approximately equalled that of the years of lowest prices in the 17th century: 1601, 1602, 1603, 1619 and 1620. If wheat prices are taken from three recent series, the averages for the period 1680-1700 in pounds per ton of wheat are the following:⁶

1	9.25
2	7.75
3	7.96

Below are the results in kg obtained by dividing 9.958 pounds by the previous three values (in kg) in order to reach an estimate of English product per capita in wheat units:

1	1,076
2	1,285
3	1,244

The result is that per capita GDP in 1688 England was the same as that of Roman Italy (1,200 kg) or even lower and that in the rest of the Empire it equalled about 60-70 percent of this value; which seems plausible. Italy was far more advanced than other European regions and a 30-40 percent difference between the peninsula and the Empire as a whole is reasonable. Since Italy drew tributes and taxes from the provinces, as previously mentioned, and the average disposable income per capita (571 HS) was, according to Maddison, 7 percent higher than per capita GDP (534 HS), on which the comparison with England is based, it may even be contended that Italian per capita GNP was higher than per capita GDP in 17th century England.

7. Per capita GDP in sesterces, wheat and dollars

Annual per capita GDP in central and northern Italy, during the centuries between 1350 and 1750, equalled about 1,000 kg of wheat, whose price was 1,500 international 1990 dollars (Malanima forthcoming for GDP and www.paolomalanima.it for wheat price).⁷ The price of 1 kg of wheat was \$ 1.5 (always 1990 international Geary-Khamis dollars PPP). Accord-

⁶ Data in the series we utilized are in bushels, which is the capacity measure used in England equivalent to 36.3677 litres and corresponding to 28.09 kg, in the case of wheat. In the following table data have been converted into pounds per kg. The series of wheat prices utilized here are the following: 1. Munro (2004) reports prices per 1.25 bushel; 2. Clark (2004), pp. 41-124; 3. Thirsk (ed.) (1985), p. 864, table XVI.

⁷ In order to compute the price of a kg of wheat in dollars, we need to have series of per capita GDP both at current prices and in 1990 dollars. At the moment these series are available only for Italy.

ing to the estimate by Broadberry, Campbell, Klein, Overton, Van Leeuwen (2010) per capita GDP in England in 1700 was \$ 1,568. Dividing this estimate in value by the previous estimate in wheat, the result is 1.2-1.5, and thus not far from the Italian estimate based on a much longer period.⁸ If we multiply Roman per capita GDP converted into wheat by \$ 1.5, the results are those in the fourth column of Table 6. In the same Table, we report the estimates of GDP per capita for the early Empire in sesterces and kg of wheat.

Table 6. Estimates of per capita and aggregate GDP in the early Roman Empire per author, in sesterces, wheat and Geary-Khamis International 1990 dollars PPP.

Author	1	2	3	4	5
	Per c. HS	Wheat kg	\$ intern. 1990 PPP	Index (line 2, col. 4=100)	
1 Temin	166	615	923	119	
2 Bang	230	518	777	100	
3 Hopkins	250	563	845	109	
4 Scheidel-Friesen	260	620	930	120	
5 Goldsmith	380	856	1,284	165	

Note: figures in sesterces have been converted into wheat on the basis of the price of 0.444 sesterces per kg (HS 3 per *modius*), with the exception of the estimates: 1) by Temin (2006: 47), who assumes a lower price per kg of wheat: 0.27 sesterces per kg (we use this price in line 1); and; 2) that of Scheidel-Friesen, p. 74 and p. 91 (who, in Table 2 of their article, p. 68, report the wheat equivalent of their estimate, 620 kg, although they also suggest – p. 62 – that the output of the Roman Empire in wheat equivalent approached 50 million tons for a population of 70 million, and then 714 kg per capita). We take the first of these two estimates.

For a comparison with the following levels of GDP in the same 1990 dollars, we remember that, in the estimate by Maddison for 1820, per head GDP in Western Europe was \$ 1,243. As previously mentioned, since the procedure followed to obtain the estimate of GDP per head in the early Roman Empire is based on likely shares of GDP in pre-modern European economies, the result cannot but be similar to the level of pre-modern European economies. The too low level of pre-modern GDP in Maddison's calculation has already been remarked (Federico 2002).

The average of the empire on the whole hides the internal differences among regions. In highly urbanized regions, such as, primarily Italy, followed by Greece, the coasts of Turkey, Syria, Palestine and northern Egypt (Pounds 1969) the level of per capita GDP was certainly higher than in the regions of Europe beyond the Alps. If we follow Maddison and agree that per capita GDP in Italy was generally 40 percent higher than that of the empire as a whole, then the result in 1990 international dollars is between

⁸ Foldvari, van Leeuwen (2010), suggest a much lower price in dollars of a kg of wheat (dollars 1.17 per litre and then about \$ 0.90 per kg).

1,300 and 1,800 and thus the same as in the late Middle Ages and Early Modern epoch (Malanima forthcoming).⁹

8. The poverty line

Rounding off the figures, the estimates presented in Table 6 range between 800 (or 900 if we exclude the estimates by Bang and Hopkins) and 1,300 international 1990 dollars. It is useful to compare these values to the poverty line in the period we are dealing with. Sometimes, in fact, the poverty line is used as a yardstick to single out incomes in past societies. According to B. Milanovic (2006: 468), average income in past agrarian economies can be assumed as “a little more than twice the subsistence minimum”. Scheidel and Friesen conclude their analysis of output in the Roman Empire (and before discussing the theme of distribution) with the following words: “Maddison put (generic) annual minimum subsistence at \$ 400 per capita”. If, in the Roman Empire, subsistence was 390 kg of wheat equivalent, this means that Roman per capita GDP (at c. 680 kg) was around \$ 700. Alternative estimates of the subsistence minimum advocated by other scholars tend to fall into the \$ 350-400 range. At \$ 350, Roman per capita would drop to around \$ 610” (2009: 74). If, again, we convert wheat equivalent per capita GDP according to the previous price of \$ 1.5 per kg our results are as follows: the subsistence line is \$ 585 (390 • 1.5); per capita GDP, equal, in this passage, to 680 kg of wheat, is \$ 1,020 (680 • 1.5). If, by contrast, as suggested in another passage of their article, the wheat equivalent of per capita GDP is kg 714, then the more plausible result in 1990 dollars PPP is 1,071 (714 • 1.5) (as shown in the note to Table 6), which is close to the average GDP in 1820 Western Europe: \$ 1,243, as already recalled.

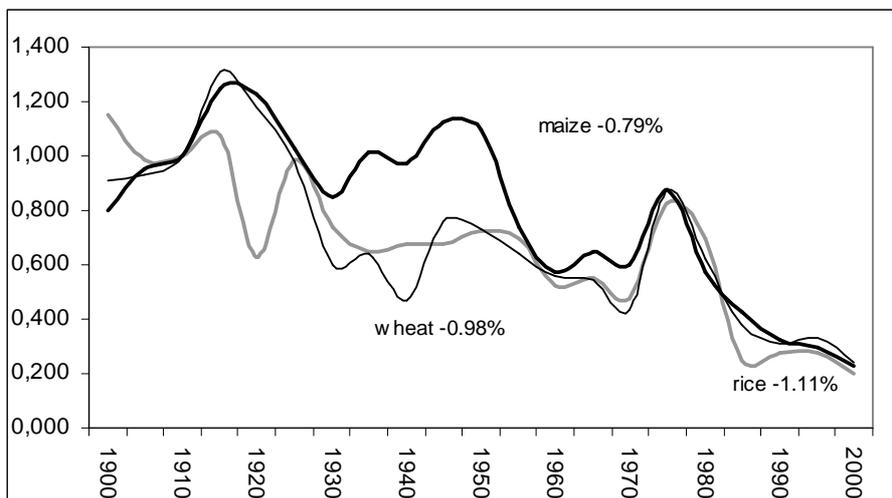
W. Harris has computed the poverty line taking the price of HS 2 per *modius* (and then HS 0.27 per kg), and a yearly consumption of cereals of HS 74 (Harris forthcoming). Assuming therefore that HS 74 represented two-thirds of the total cost of living, Harris reached the result of HS 111 per year as a likely line of subsistence (supported also by Jongman 2007: 600: HS 115). As a comparison, the *alimenta* rates varied in Italy between 120 and 240 HS (Prell 1997: 187). Then the figure of HS 111 could be even lower than it actually was. If we convert this figure into wheat (kg), as we did previously in Table 6, the result is 411 kg (111/0.27). If, in order to reach the equivalent in international dollars we again multiply by \$ 1.5, the result is \$ 617 (409 • 1.5). We thus find a result higher than the 1 dollar per-day accepted until a few years ago as the poverty line. Assuming that in past agrarian civilisations not everybody was on the border of the poverty line and that inequality existed and therefore a share of the population enjoyed an income higher and often much higher than bare subsistence, we easily reach a figure twice that of the poverty line, hence around \$ 1,200-1,300, as in the estimate by Goldsmith and developed by Maddison; the one we deem to be more realistic.

⁹ In this calculation we use the estimate by Temin, Scheidel-Friesen and Goldsmith.

The higher level of our estimates in dollars of per capita GDP in ancient Roman civilisation and for the poverty line depends on the fact that food and ordinary goods diminished relatively in price in comparison with the consumer price index over the last two centuries. The basket of the poor has become cheaper and cheaper. During modern growth many new goods took the place of those used before. Wheat began to be replaced by maize and potatoes, the prices of which were half that of wheat for the same caloric content. Olive oil -- very expensive in past economies-- began to be replaced by much cheaper fats such as margarine; and wine by a variety of beverages, whose prices were much lower for the same energy content. Wool, linen or hemp were replaced by artificial fibres. Firewood was the only fuel available in past societies, but it was replaced by a variety of fuels (fossil fuels), whose prices, for the same calories, have never been so cheap in the history of mankind as in the last two centuries. The basket of the poor is not always composed of the same goods.

In any case, even if the basket of the poor were composed of the same primary goods, these have been subject to an amazing relative decline. In the Figure 1 below, the curves refer to the relative prices on the international markets of three supports to basic subsistence: wheat, maize and rice. We see that the curves of the relative international prices of wheat, maize and rice declined respectively by 0.98 per cent per year, 0.79 and 1.11, in the last century. Their relative prices at the end of the 20th century were one-fifth of what they were at the beginning.

Figure 1. Relative prices of wheat, maize and rice in international markets from 1900 until 2000 and rates of yearly decline (%).



Sources: Commodity Price Indices: 1900-84 compiled from World Bank data by Grilli and Yang (1988); data for 1985-2000 compiled from World Bank data by S. Pfaffenzeller, University of Nottingham.

The diagram is an illustration of the core of the so-called Prebisch-Singer thesis, proposed in the 1950s, on the deterioration of the terms of

trade for primary commodity exporters as one of the main trends in international trade and as the main cause of the rising inequality among economies. We see that a sudden fall occurred after the First and Second World Wars and again in the 1980s (Ocampo, Parra 2003). This is the reason why today it is possible to survive with 400 dollars while it was not so in past agrarian civilisations. If average incomes in past agrarian economies are assumed to be “a little more than twice the subsistence minimum” (Milanovic 2006: 468), as supposed by B. Milanovic and other scholars, and this minimum is assumed to be about 400 PPP international dollars, then the result of something more than 800 PPP dollars as the yearly average income in past agrarian civilisations is plausible. If, by contrast, and more correctly in our opinion, this minimum is assumed to be around 650-700 dollars, then the average product of 1,300-1,400 becomes much more plausible.

We can therefore conclude that, before modern growth, the price of certain basic items relative to the consumer price index was higher than it is today, owing on the one hand to remarkable increases in labour productivity in modern times and, on the other, to the introduction of cheaper substitute goods in the basket of the poor. In relative terms, during the 19th and 20th centuries, the poverty line was not stationary, but curved downwards.

Conclusion

It is hard indeed to “quantify” an economy when basic data is almost completely lacking. Since the 1980s, however, historians and economists have been able to suggest a synthetic view of the Roman economy through the reconstruction of GDP. When the result is expressed in wheat (as in Table 6) the range of the proposed real values hovers between 100 and 165. A 65 percent difference between the highest and the lowest value is not so wide; especially if we look at the poverty of the basic data and the ensuing uncertainty of the conclusions.

The important problem of the comparability between ancient and modern levels of GDP has only been marginally addressed by historians of the Roman world. The prevailing opinion is, however, that per capita GDP in the early Roman Empire was half or less than that of the following late medieval and early modern economies; although, we must add, a simple reflection on the basic method utilized by historians would have to suggest that this conclusion is at odds with the way followed in their statistical reconstructions. Our discussion of the problem strongly suggests that a real difference in the level of average income between the early Roman Empire and the following European pre-modern economies did not exist at all. An estimate of per head GDP of about 1,300 dollars fits much better than the other ones the evidence regarding the following European economies before modern growth. Consequently, for the late medieval and early modern European inhabitants, per capita GDP in ancient Euro-Mediterranean Roman Empire was 15-20 times lower than that of the Western Europeans at the beginning of the 3rd millennium.

In our opinion the conclusion is important for its “methodological” consequences. If we accept the viewpoint supported by many scholars, that Roman per capita GDP was half that of late medieval-early modern economies then we face a slowly rising path from the Antiquity to Modernity, such as that drawn by Maddison in quantitative terms and by most historians in a more narrative way. On discovering that per capita GDP in the early Roman Empire was similar to that of the subsequent agrarian civilizations we are forced to alter this view. The first case presents us with long-term progress, but if we accept the view supported by a minority of scholars, that is, the second, we are presented with a long period of stability with cycles. This is the view that the previous discussion seems to support.

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