

The Malthusian Empire: A Malthusian Model of the Roman Economy

Introduction: Roman ‘oikonomikos’

‘Economics’ is a term of Greek origin, combining *oikos*, meaning ‘a household’, and the semantically complex root *nemos*, used in the sense of ‘regulate, administer, organize’. The first conventionalization of the term economics comes from Xenophon’s *Oikonomikos*, which served as a guide for the gentleman landowner of the ancient Mediterranean world. However, neither Xenophon nor any succeeding Roman author concerned themselves with the maximization of societal material welfare (in modern terms, the maximization of Gross Domestic Product) but rather with proper management of estates and personal wealth.¹ Indeed, where concerned with the marketing of goods, it seemed more a result of common sense rather than systematic economic analysis. For example, Varro’s advice for cultivation of flowers on a farm near the city² indicates an understanding of the profitability of specialized agriculture but not necessarily an understanding of comparative advantage. Given the limited understanding of economic phenomena at the time, it is perhaps not surprising that today the Roman economy is perceived as primitive.

This perception is not new; as economist David Hume observed, “I do not remember a passage in any ancient author where the growth of a city is ascribed to the establishment of a manufacture. The commerce, which is said to flourish, is chiefly the exchange of those commodities for which different soils and climates were suited.”³ The modern classicist Moses Finely blames this primitivism on the lack of economic thought among Romans,⁴ citing a lack of “an economic system that was an enormous conglomeration of independent markets”. To what extent, then, was the Roman Empire the primitive economy described by Finely? The Roman economy was primitive, in large part because it was subject to the Malthusian Constraint.⁵ Despite this, the Roman economy of the high empire (roughly 27 BC to roughly 211 AD) still managed to achieve growth, in part because the early Roman Empire coincided with a remarkable period of climatic stability⁶ but also because Rome,

¹ Xen. *Oec.* 6.4; Columella *Rust.* 1,2

² Varro, *Rust.* 1.46

³ David Hume, *Essays, moral, political & literary*, David Hume, (London: G. Richards, 1903), 415

⁴ Moses Finely, *The Ancient Economy*(Berkeley,1973), 22

⁵ The Malthusian constraint refers to theory of Thomas Malthus that population growth will overwhelm any gains to productivity garnered by changes in technology or other increases in efficiency.

⁶ Büntgen et al., *2500 Years of European Climate Variability and Human Susceptibility*, (Science 331.57, 2011); see Appendix 5 for the time series associated with this piece

whether intended or not, expanded trade and monetization across the Mediterranean world.

A Brief Description of the Malthusian Model

The model presented herein is an expansion on observations contained in Thomas Robert Malthus's work, *An Essay on the Principle of Population*. The observation most central to understanding the Roman economy, is that while subsistence resources grow arithmetically, human populations grow exponentially.⁷ From this "Malthusian model," two implications are derived.⁸ First, that arable land is a constraining variable in long-term growth of not only population but of output and consumption.⁹ Second, Malthus's variable z , which represents total factor productivity (TFP)¹⁰, drives shifts in the equilibrium in this model. Importantly, TFP includes a wide range of influences of the production function¹¹ including climate, trade, and most importantly technology; it was the inability of Rome to influence this variable z that defined the primitiveness of its economy.

A Malthusian Specification for the Roman Economy

From the Malthusian perspective (in contrast to Finely's), it is the lack of economic and technological understanding that forms the basis for the primitiveness of the Roman economy. Specifically, with regards to agriculture, Roman policy promoted oligopoly power resulting in the stagnation of agriculture production.

The Romans took the view that agriculture was the most socially acceptable means of accumulating wealth. Cicero noted, "of all the occupations by which gain is secured, none is better than agriculture, none more profitable, none more delightful, none more becoming to a free man."¹² Yet from the Malthusian model, it is recognized that if land is constant over time, it is highly susceptible to oligopolistic competition.¹³ Pliny the Elder argued that this policy was the ruin of Italy, noting "[I]f truth be told

⁷ Thomas Malthus, *An Essay on the Principle of Population*, (London, 1826), 25-26

⁸ Appendix 1 for the expanded model derived from Malthus' Essay

⁹ Output is an abstract concept describing the aggregated quantity of goods and services produced in a given time period. Consumption is the aggregation of consumer spending on goods and services.

¹⁰ Total Factor Productivity (TFP) measures the impact on output not caused by traditionally measured inputs.

¹¹ A production function is some function $f(K, \dots, Z)$ which determines a firm's level of production

¹² Cic. *Rosc. Am.* 75

¹³ Hal Varian, *Intermediate Microeconomics*, (W.W. Norton & Company, New York 2006), 480 i.e. The Malthusian constraint produces larger agricultural units with market power.

large estates have been the ruin of Italy and are now the ruin of the provinces too. Six owners possessed half the province of Africa when the *princeps* had them killed.”¹⁴ Pliny argues thusly because, following the advice of Virgil¹⁵, he correctly believed that large estates (*Latifundia*) were less efficient. Given the shift toward the production of specialized staples that occurred under oligopolists¹⁶ his conclusion is highly credible.

There was a consensus among Roman observers that the most profitable crop available to a landowner was grape vines. Cato places it at the top of his list of profitable crops,¹⁷ Columella, using crop yields and pricing, demonstrates very large profits from grape vines,¹⁸ and Pliny goes so far as to argue that the practice is even more profitable than trade with the Far East.¹⁹ However, the problem with such specialized production is that Italian Peninsula itself produced little of its own wheat. Indeed, conventional estimates of wheat yields, based on seed production, are 1:4 for Roman Italy compared to 1:10 for Egypt, a near three-fold difference in yield per seed ratios.²⁰ A Malthusian interpretation of these conditions implies that the Malthusian constraint could only be withstood insofar as harvests were good and Egypt remained a viable exporter.²¹ It is revealing that Domitian’s edict forbidding the planting of further vines came only “when a bumper vintage followed a poor grain harvest.”²² Moreover, this type of specialization would make Italy, and those regions which were more climatically isolated, more susceptible to climate shocks. On the other hand, the very reason these shocks caused such economic havoc was in large part due to population changes within the Empire.

The Malthusian model predicts that population will grow faster than productive resources and then stabilize following mass starvation and war or what Malthus terms

¹⁴ Plin. *HN* 18.7

¹⁵ Verg. *G.* I. 268, ff.

¹⁶ Under Oligopoly, the consumer surplus (difference between maximum price the consumer is willing to pay and the actual price) is going to be necessarily smaller than under more competitive systems. Ergo, the system is less efficient on the whole.

¹⁷ Cato *Agr.* 1.7

¹⁸ Columella *Rust.* 3.3

¹⁹ Plin. *HN* 14.47-52

²⁰ Rathbone, 308 from Bowman et al., *Quantifying the Roman Economy* (Oxford, 2009)

²¹ Rome however taxed Egypt in wheat so this was not as significant a problem for the Roman economy. J. Rowlandson, “Money Use among the Peasantry of Ptolemaic and Roman Egypt” in *Money and its uses in the Ancient Greek World* (Oxford, 2001), 147

²² Suet. *Dom.* 7

“preventive checks”²³ on population. Our best estimate for the population of the Roman Empire at its zenith under the Aurelians is 50 to 60 million people (roughly the population of the UK today).²⁴ Of this figure, roughly 20% (10-12 million)²⁵ lived in urban areas with Rome as the largest with a population of about 1 million, followed by Carthage and Alexandria at 500,000 each.²⁶ However, the extent of population growth from the late Republic to the Empire would appear enormous as the number of Roman citizens grew from 318,823 in 131 BCE to 4,063,000 in 28 CE.²⁷ It is clear that the Emperors did not understand that they faced a “Malthusian constraint” under any terms; indeed, the Emperors fostered population growth through the use of *alimenta* – loans to encourage an increase in birth rate. Pliny notes, in his *Pangyric*, that Trajan’s benefactions for the support of children were designed as a source of future demographic increase and consequent prosperity.²⁸ The reason for this thinking reflects the prosperity of Augustus’ reign, which occurred during a time of extensive demographic growth; the Romans of Trajan’s age saw a correlation between these two events. Yet, in all likelihood, this policy aggravated circumstances when the temperature began to cool in the reign of Marcus Aurelius.²⁹

On Industry, Climate, and Growth in Roman Empire

Despite its Malthusian nature, the Roman economy in the early Empire was almost certainly more productive than in those periods which immediately followed it. Indeed, though industrial production was probably not a major component of the Roman economy, ice core samples taken in Greenland suggest that lead and silver smelting under Rome caused pollution levels which would not be matched until the Industrial Revolution.³⁰ As previously discussed, increased productivity in the Malthusian

²³ Malthus 8

²⁴ Julius Beloch, *Historische Beiträge Zur Bevölkerungslehre* (Leipzig, 1886), 507; For population of UK, 2011 UK Census, (Office of National Statistics, 2011)

²⁵ Neville Morley, *Metropolis and Hinterland: The City of Rome and the Italian Economy, 200 B.C.-A.D. 200* (Cambridge, 1996), 174-83

²⁶ Collin Wells, *The Roman Empire* (Harvard, 1992), 195

²⁷ Livy *Per.* 59 for 131 BCE; *Res Gestae* 8 for 28CE (from Robert Shrek, *The Roman Empire: Augustus to Hadrian* (Cambridge 1988) 26)

²⁸ Plin. *Pan.* 28.5; on average, around 10% of towns in Italy were involved in this program, which is sizeable for the ancient world, according to the sample given by the table in Appendix 3

²⁹ Büntgen et al. 2011

³⁰ Hong et al. «Greenland Ice Evidence of Hemispheric Lead Pollution Two Millennia ago by Greek and Roman Civilizations.»(*Science* 26,1994), 1842; See Appendix 4 for the associated data and graphs. These clearly

model occurs with increases in TFP. However, in the case of the Roman Empire, these increases were more by accident than by design. For example, it is possible to increase productivity through more efficient technologies. Yet, a passage from Suetonius on Vespasian is revealing: “An engineer offered to haul some huge columns up to the capitol at moderate expense by a simple mechanical contrivance, but Vespasian declined his services: ‘I must always ensure,’ he said, ‘that the working class earn enough money to buy themselves food.’”³¹ In other words, this example suggests that one of the primary reasons why the Roman economy did not become more productive is that the Romans themselves either did not take an interest in productivity increasing technologies or were somehow politically constrained. The same concept can be applied to agriculture as well.

In talking about land under the Malthusian model, the primary question for the purpose of TFP relates to the actually yields per unit of input. Due to the expanse of the Empire, the yields from land would vary depending on the region. However, on aggregate, while technical development in agriculture wasn’t uncommon in the Empire, innovations remained rare.³² For example, whereas in one passage Pliny describes the use of a kind of threshing machine in Gaul, earlier in the same book Pliny quotes Cato in saying that land must lie fallow for two years.³³ Thus, while there were potential advances in harvesting, the Roman landed gentry in general still followed farming techniques limiting the land yield and were set in their agricultural methods.³⁴ This tendency would serve them poorly as the climate began to change in the mid-2nd century.³⁵

The primary reason for the phenomenal growth of the Roman economy before 180 CE was the warming which occurred during this period. Researchers at Eidgenössische Technische Hochschule in Zürich have shown, using the growth of tree rings in oak trees in Germany, that from roughly 50 BCE to 120 CE temperature anomalies were consistently above average.³⁶ These higher temperatures shifted TFP upward, meaning higher yields for agriculture. However, around 120 CE the climate began to cool and TFP decreased,

show a sizeable peak in pollution in the era corresponding to the High Roman Empire.

³¹ Suet. *Vesp.* 18

³² K. White, *Greek and Roman Technology* (Ithaca, 1984) p.58; Margaritis 171 from John Oleson, *The Oxford Handbook of Engineering and Technology in the Classical World* (Oxford, 2008)

³³ Plin. *HN* 18.72; 18.3

³⁴ See Sherk 199 for a Roman farmer’s almanac which rigidly describes planting conditions

³⁵ Büntgen et al. 2011

³⁶ *Ibid.* 578 See Appendix 5 for the time series associated with this argument.

leading to a massive subsistence crisis.³⁷ Such crises typically occur in two stages.³⁸ First, the climatic shock leads to a series of bad harvests which weaken the human immune system. This consequence can be seen in the work of Philostratus, who noted that, after several successive bad harvests in the 2nd century CE, the poor were reduced to surviving on vetches and “whatever else they could get.”³⁹ Second, this weakened state leads to greater susceptibility to plague, in turn leading to an increase in the death rate. Indeed, Galen notes that as a result of poor nutrition, many peasants became severely ill after bad harvests.⁴⁰ This pattern continued until the population declined sufficiently to arrive at the new equilibrium around the middle of the 3rd century. Roman failure to augment agricultural productivity allowed for attainment of the Malthusian constraint. Yet Rome was still able to temporarily achieve growth thanks to trade and the exceptional monetization of the Empire.

On Roman Trade and Money

As noted previously, agriculture in Italy had become heavily oligopolistic and specialized, which meant that much of the wheat for Rome and other major cities had to be imported from abroad. If we take the number of shipwrecks by century as a metric for early trade, we find that, as compared to succeeding centuries, the last two centuries BCE and the first two centuries CE of the Roman Empire exhibit exceptionally higher levels of trade throughout the Mediterranean.⁴¹ In economics, trade is viewed as a form of productivity increasing technology (*i.e.*, it has the same effect as increasing z). Unfortunately, trade did little to alleviate the Malthusian crisis when it came for the Empire.

There are two key reasons for this. First, despite the specialization of agriculture in Italy, foodstuffs were still produced locally in most of the Empire. An archeological study by Cavallo *et al.* indicates that Roman legions on the Rhine traded scarcely at all with the locals, instead importing most of their foodstuffs.⁴² Second, imports of grain to Italy, which

³⁷ Ibid. 578

³⁸ Dionysus Stathakopoulos, *Famine and Pestilence in the Late Roman and Early Byzantine Empire: A Systematic Survey of Subsistence Crises and Epidemics* (Burlington VT, 2004), 36 for a more detailed description

³⁹ Philostr. *VA* 1.15

⁴⁰ Gal. *Nat. Fac.* 1.1-7 (See Appendix 6 for a more in depth description of this shock)

⁴¹ Wilson 220 from Bowman *et al.* 2009; See Appendix 7 for a graph of the number shipwrecks by century which clearly shows a spike in the number of shipwrecks corresponding to the High Roman Empire.

⁴² Cavallo *et al.*, 75 from Stallibrass *et al.*, *Feeding the Roman Army* (Oxbow, 2008); see Appendix 8 for full description of the study which clearly shows that military settlements primarily used less common grains for that region like wheat and barley avoiding more common native grains like rye.

came from Africa for eight months of the year and Egypt for four months of the year⁴³, were shipped by private individuals.⁴⁴ This meant that, while the Emperors did employ a number of schemes to try and encourage grain merchants,⁴⁵ during the subsistence crises of the second and third centuries it likely would have been unprofitable to finance such voyages. Reported interest rates on such voyages were 20% per voyage,⁴⁶ well above the legal maxima. With the additional risks associated with a subsistence crisis this rate likely would have increased even more. Indeed, during times of economic contraction, those businessmen who would ordinarily grant loans for shipping were supplanted by elites and professional money lenders who were less willing to take on such risk.⁴⁷ However, the Romans also exacerbated this unwillingness to trade due to the imperial practice of seigniorage.

To their credit, Roman economic agents did understand the concept of pricing. More precisely, they understood that the price of an object is related to its relative scarcity.⁴⁸ What this suggests is that at least some citizens would be aware when the Roman currency was being debased as the need for military expenditures increased (which accounted for over 50% of government expenditure).⁴⁹ The acquisition of precious metals, which were required to back the monetary system of the Empire, was traditionally done through conquest (see citation below). As a result, the Romans never endeavored to develop exploration techniques for new sources of precious metals and instead availed themselves of ores uncovered by surface mining.⁵⁰ When the subsistence crisis (as Malthus points out) forced barbarians onto Roman lands,⁵¹ the military needed to be paid to deal with these invasions, even if there was not sufficient precious metal to back the currency. Simply put, in times of crisis, the government minted new coins with less precious metal in order to pay the troops. This debasement of coinage would have a drastic consequence in an Empire as widely monetized as Rome's.

Trade is only efficient when conducted through some medium of exchange. This is because, unlike exchanges in kind, using a medium of exchange (like coinage)

⁴³ Joseph. *BJ* 2.383-5

⁴⁴ William Harris, *Rome's Imperial Economy*, (Oxford, 2011), 162

⁴⁵ Suet. *Aug.* 41-42; Gaius, *Institutes* 1.32c

⁴⁶ Sidney Homer, *A History of Interest Rates* (New Brunswick NJ, 1977), 49

⁴⁷ Bowman et al. 2011 11:782

⁴⁸ Tac. *Ann.* 15.42 where Tacitus notes that gold and jewels had lost value due to their commonness; Tac. *Agr.* 19

⁴⁹ Richard Duncan-Jones, *Money and Government in the Roman Empire* (Cambridge, 1994), 45

⁵⁰ T. Rickard, *Man and Metals* (Cambridge, 1974), 402; For techniques see *HN* 33.21

⁵¹ Malthus 12

eliminates the double coincidence of wants.⁵² Hopkins has demonstrated, using a sample of 90,000 coins from various eras and places, the economy of the Empire was indeed widely monetized.⁵³ However, any medium of exchange functions only insofar as the population believes the medium has value and will retain its value. That seigniorage was destroying Roman monetization can be seen by precious metal content in the coins of different emperors: the mean silver weight of the denarii minted in Rome decline dramatically from the reign of Nero onwards and most dramatically under the Severans.⁵⁴ Another measure which more directly reflects the devaluation of Roman currency is the fact that Egyptian coin hoards from the Empire's zenith and afterward are typically composed of coins minted from Nero's reign or before.⁵⁵ This suggests that the monetization of the Empire enabled trade and expansion during times of prosperity but subsequently crippled trade during the subsistence crises of the later Empire.

Conclusion: The Malthusian Empire

Despite the fact that the Roman Empire was more productive than the economies that succeeded it, it remained subject to the Malthusian constraint; the Empire only achieved 'growth' due to a favorable climatic period and its remarkably monetized economy which promoted trade. However, the Roman economy did not fail to develop because of its primitiveness, in contrast to Finely's argument. Rather, the Roman economy was primitive as a result of a lack of economic understanding that might have permitted it to escape the Malthusian trap. This review also highlights one of the flaws found in empirical economic studies: the Romans did have ideas about how to promote prosperity, as the *alimenta* demonstrates but that the policy was based on correlation instead of causation. As Albert Einstein once said "It is quite wrong to try founding a theory on observable magnitudes... It is theory which decides what we should observe." In other words, the fundamental problem of the Roman economy was a lack of thought but rather

⁵² In other words, if everyone accepts a certain coinage then one can exchange one's goods for coins and then buy what one needs. However, if exchange is in kind, then one has to find another person who has the goods one wants and who wants to buy one's own produce. Stephen Williamson, *Macroeconomics* (Boston, 2008), 564

⁵³ Keith Hopkins, "Taxes and Trade in the Roman Empire (200 B.C.-A.D. 400)," *The Journal of Roman Studies* 1980, 112-116

⁵⁴ Richard Duncan Jones, *The Economy of the Roman Empire* (Cambridge, 1982), 374; See Appendix 9 for the graphs and table which clearly show a decline in the mean weight both of the overall coin and the silver included.theChristiansen

⁵⁵ Erik Christiansen, *Coinage in Roman Egypt* (Aarhus, 2004), 198; See Appendix 10 for a table of all hoards. These clearly show that the overall number of hoards increase over time and that those of Nero's reign (which had a higher gold content) were increasingly hoarded over time.

a lack of method for scientifically determining how to address economic problems.

Theodore Naff

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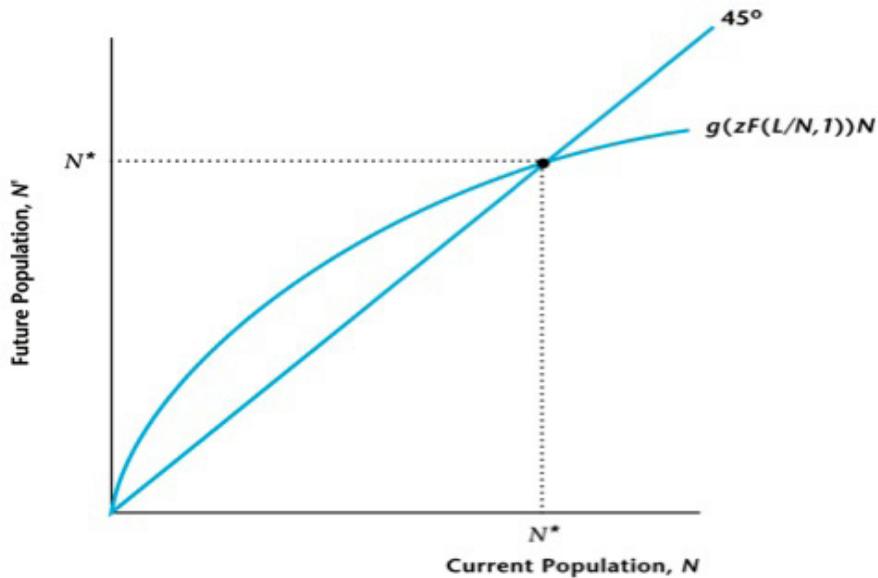
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Appendix 1: The Malthusian Model

We can examine Malthus' observations in a dynamic model where output (Y) is produced using the factors of land (L) which is held constant and labor (N) which can adjust. This will take the functional form $Y = zF(L, N)$. Additionally, assume that population growth depends on the quantity of consumption per worker, or $N^{\wedge}/N = g(C/N)$ where N^{\wedge} is future population, g is an increasing function, and C is aggregate consumption (which will equal Y in the long run since all goods will be consumed). Steady state in this model is the point when $N = N^{\wedge}$ (i.e. it is the point when LR population equals today's population). The key property of this is that even production technology and increases in the quantity of land will not affect the long run standard of living but it can have effects of on what the steady state will be. Such changes in total factor productivity (z) shift our production curve upwards thus increasing the possible population that the land can sustain.



From Williamson (2008) p.192

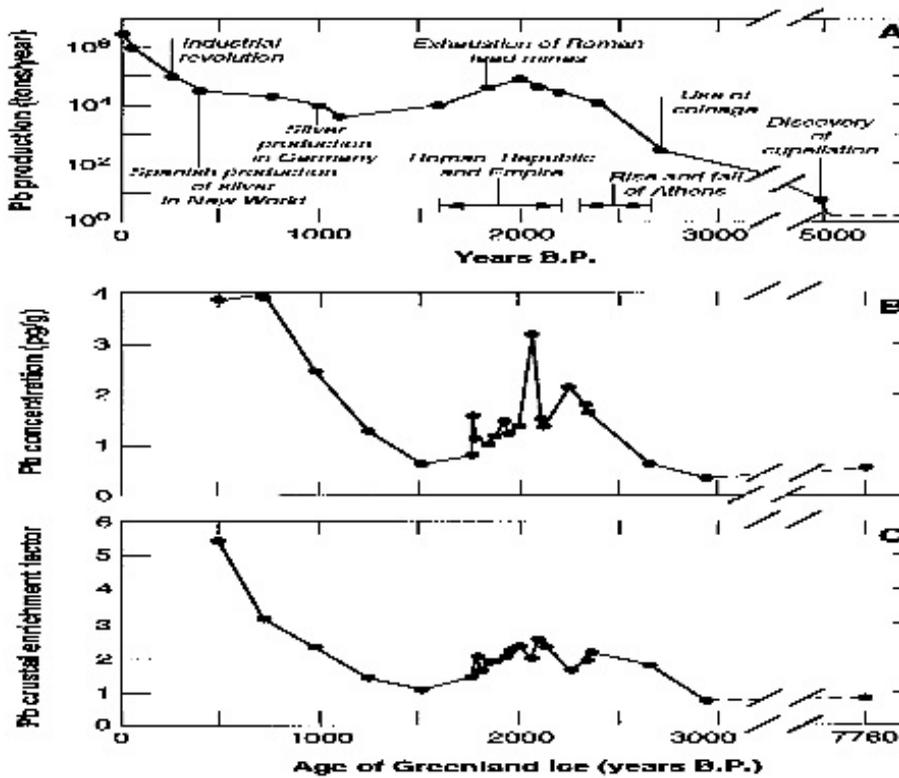
Appendix 2: Extent of Alimenta

Appendix 2: Extent of Alimenta

	Towns by region	Towns with state alimenta	alimenta as % of all towns in regio	Area of regiones in km squared	Average area per town in km squared	Inscriptions (CIL)
Regio I	86	13	15.1	15500	180	8523
Regio II	76	4	5.3	25000	329	2512
Regio III	24	3	12.5	27500	1146	551
Regio IV	43	9	20.9	18000	419	2895
Regio V	23	2	8.7	6500	283	951
Regio VI	49	8	16.3	10000	204	2835
Regio VII	49	6	12.2	31000	633	4624
Regio VIII	26	2	7.7	19500	750	1525
Regio IX	17	1	5.9	14000	824	474
Regio X	25	2	8	51000	2040	5858
Regio XI	12			32000	2667	2159
Average	39.09091	5	11.26	22727.27	861.3636	2991.545
Total	430	50		250000		32907

From Duncan-Jones (1982) p.339

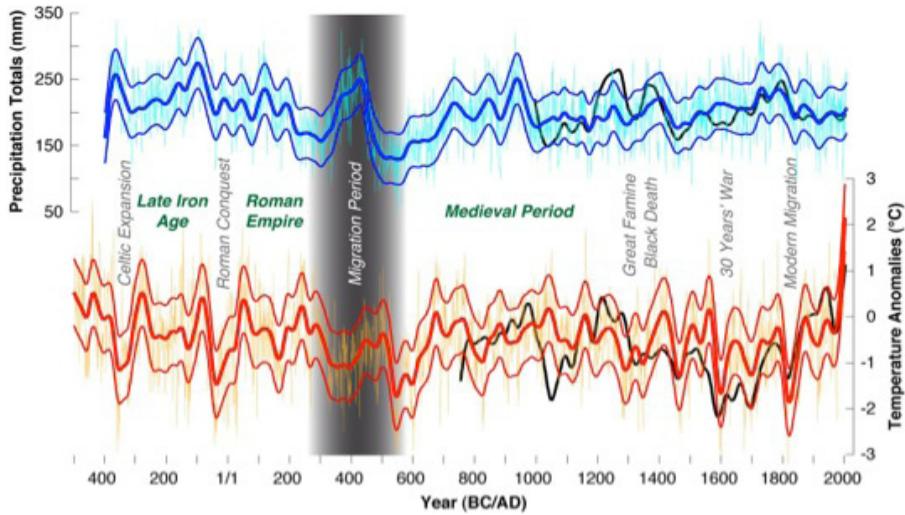
Appendix 3: Greenland Ice Evidence



Depth (m)	Age (years ago)	Measured Pb concentration (pg/g)		
		2nd layer	3rd layer	Inner core
129.25	470	4.77	3.99	3.90
349.25	1520	1.79	0.65	0.66
399.3	1775	1.06	1.07	1.17
510.95	2360	13	1.64	1.64
1286.45	7760	0.57	0.56	0.55

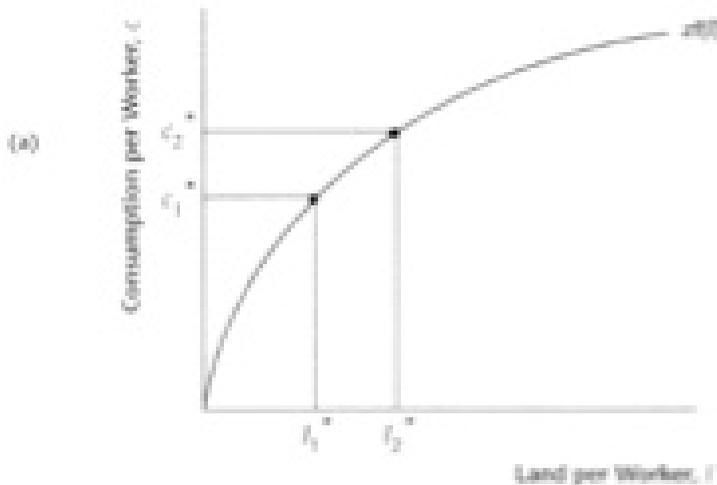
From Hong et al. (1994)

Appendix 4: Temperature Anomalies in Europe

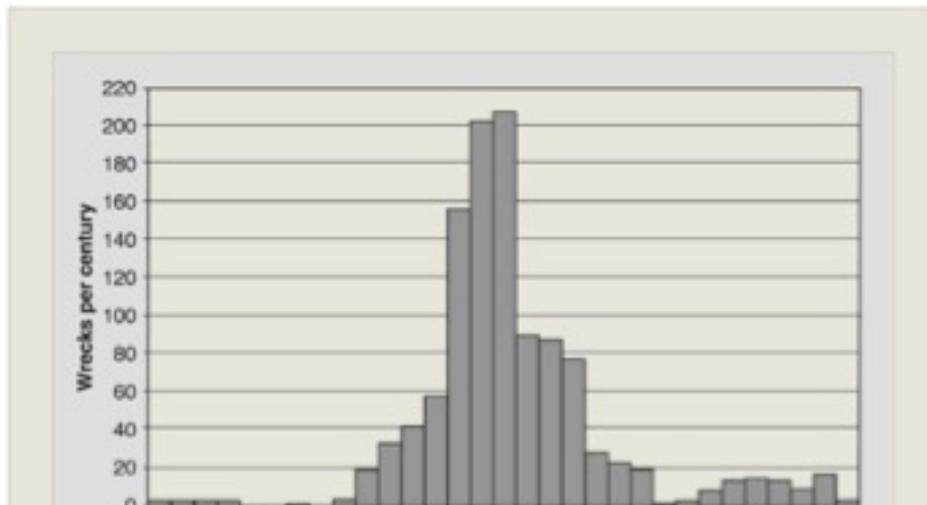


From by Büntgen et al. (2011)

Appendix 5: Subsistence Shocks in the Malthusian Model



Appendix 6: Shipwrecks by Century in the Ancient World



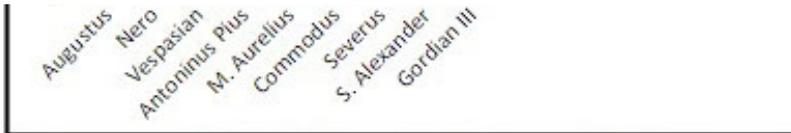
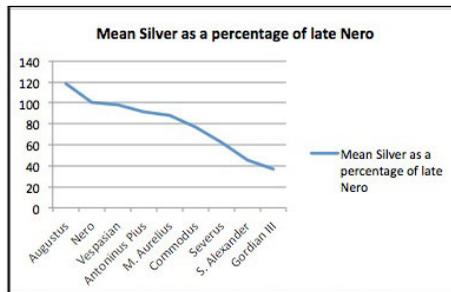
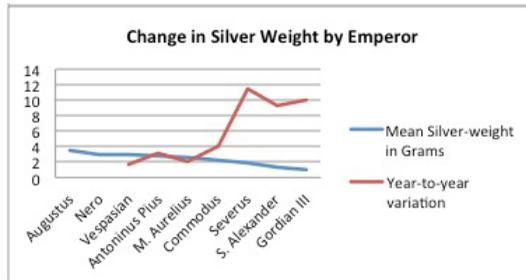
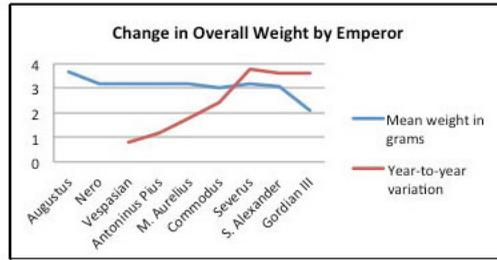
From Wilson p.223 in Bowman et al. (2009)

Appendix 7: Food Supply to the Roman Army in the Rhine Delta

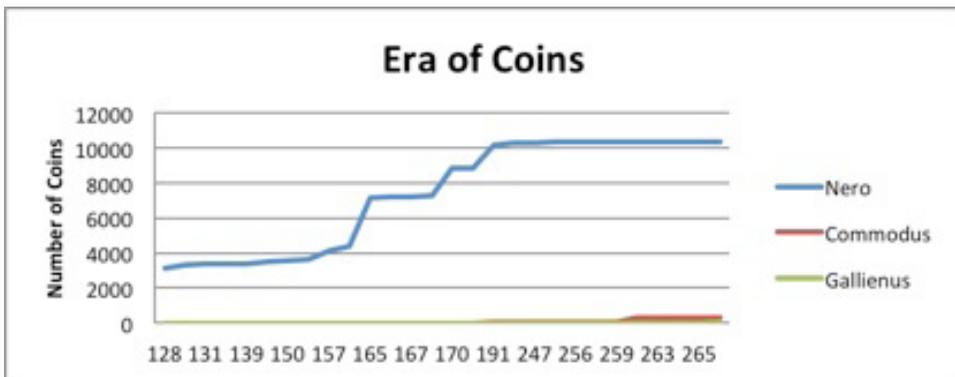
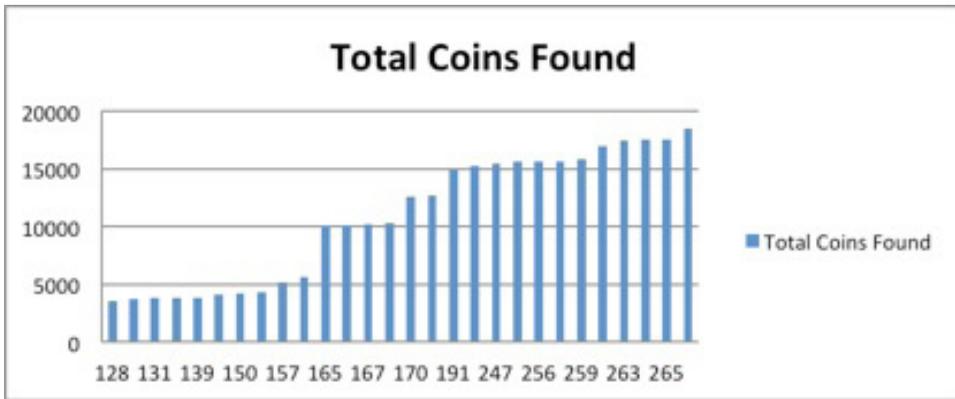
<i>Settlement type</i>	<i>Period 2 A.D. 40 – A.D. 70</i>			<i>Period 3 A.D. 70 – A.D. 140</i>		
	<i>Military</i>	<i>Rural (south of the Rhine)</i>	<i>Rural (north of the Rhine)</i>	<i>Military</i>	<i>Rural (south of the Rhine)</i>	<i>Rural (north of the Rhine)</i>
<i>Number of sites</i>	4	7	3	4	8	2
Cereals						
Hulled barley	4	7	3	3	7	2
Millet	1	4	-	-	3	1
Oats	2	5	1	-	4	2
Rye	2	-	-	-	1	-
Bread wheat	2	-	-	2	(1)	-
Emmer wheat	4	7	-	4	5	2
Spelt wheat	3	-	-	4	(1)	-
Pulses						
Celtic bean	2	3	-	1	4	-
Vegetables and kitchen herbs	3	1*	-	3	5	-
Exotic foodstuffs	4	-	-	1	1	-

From Stallibrass et al. (2008) p.75

Appendix 8: On the Silver content of Denarii



Appendix 9: All Hoards



From Christiansen (2004) p.197