Big History: The Role of Universal Darwinism, Collective Learning, & the Rise of Complexity in the *Longue Durée*

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Universal history, while investigating the particular, never loses sight of the complete whole on which it is working.[1]

– Leopold von Ranke, arch-empiricist and pioneer of modern source-based history

[1] Leopold von Ranke, cited from *The Varieties of History: From Voltaire to the Present*, ed. Fritz Stern, (Cleveland: World Publishing Company, 1956), 61-62.

Summary: This thesis demonstrates how the *annaliste* school's search for broad trends over a few centuries can be connected to Big History's search for broad trends over 13.8 billion years. The rise of complexity through Universal Darwinism is linked to the *annaliste* idea of population cycles by the idea of 'collective learning' – which is itself part of the Darwinian process of cultural evolution. On this basis, the macro and micro trends of history are connected. At one end, *annaliste* population cycles influenced the events of conventional history 5000 to 250 years ago by profoundly influencing the rise and decline of living standards, population numbers, elite incomes, and sociopolitical instability. The Big History concept of collective learning explains both why those population cycles occurred in agrarian civilisations and why there was a transition to the Industrial Revolution, since accumulation of knowledge raised the carrying capacity of the human population, and thus the number of potential innovators. I also examine periods when severe population decline caused accumulated knowledge and the carrying capacity to decline. The carrying capacity has a profound influence on all stages of human history.

This work extends the chronology of human history back to 200,000 years of hunter-gatherers and 2 million years of hominine evolution, in which collective learning also played a role in population growth. Collective learning is itself a form of 'cultural evolution', which is in turn a manifestation of the 'Darwinian algorithm'. The latter is a process of random variation and non-random selection that raises the free energy rate density or complexity of certain areas of the Universe: from culture, to biology, to chemicals and minerals, to stellar elements, and the theoretical formation of multiple universes. A portion of this thesis is given over to the role of the Darwinian algorithm in these processes and also to showing how the grand narrative of Big History and even the events of human history are part of the broadest trend of 'rising complexity' in the Universe.

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Introduction

I. Central Arguments & Structure

This work will attempt to reinvigorate and extend the French *annaliste* concept of the *longue durée* from the few centuries covered by historians like Fernand Braudel and Emmanuel Le Roy Ladurie to the full sweep of the grand narrative of 13.8 billion years explored by the interdisciplinary genre of history known as 'Big History'. It will employ and attempt to unite three broad theories: the Darwinian algorithm (a process of random variation and non-random selection found in many physical processes), collective learning (the ability of a species to accumulate more knowledge with each generation than is lost by the next), and demographic-structural theory (how population cycles relate to the rise or decline of sociopolitical instability) to explain some of the broad trends in the agrarian era (c.10,000 to 250 years ago), the rise in numbers and complexity of the human societies from their origin in the Middle and Upper Palaeolithic (c.250,000 to 10,000 years ago), and how rising human populations link to the rise of complexity in the Universe. Random variation and non-random selection within cosmology and biology produce more complex structures, from stars to life-forms, and collective learning and human population dynamics fuel a form cultural evolution that produces even greater levels of complexity. All are part of the trend of rising complexity in the Universe from the Big Bang to the present.

I will apply a Big History analysis to the fruits of ecology, archaeology, evolutionary biology, geology, and cosmology. In doing so I hope to identify some long term trends that govern history: the role of demography and the resultant sociopolitical instability in the ebb and flow of states and empires, the long term rise in the carrying capacity of human populations and growth in human numbers over 250,000 years, and how population relates to cultural evolution and the broad sweep of the Darwinian algorithm. The finding of this work is that all of these processes are the manifestation of the same trend: the impulse toward random variation, non-random selection, and the rise of complexity. United by forms of evolution at all stages, there is a broad trend of development from the Big Bang to modern day, involving studies from all disciplines, in a way that *annalistes* like Ladurie and Braudel foresaw a long time ago. In this sense, Big History and the grand narrative of 13.8 billion years constitute the *plus longue durée* –the longest duration in very much the superlative sense – and it ties directly to the phenomena of population dynamics that *annalistes* had once identified and their perception of the underlying unity between the sciences and humanities.

The overarching theme of this work is the rise of complexity in the Universe aided by a Darwinian algorithm of random variation and non-random selection, from the cosmological, geological, to biological levels, and across the long sweep human history. The level of complexity rises with the increase in the number of viable selection paths, and cultural evolution has reached unprecedented heights of both variation and complexity. While some matter and energy in the Universe will always remain in systems that are relatively simple, like the preponderance of hydrogen atoms or most organic life being bacterial, an increase in the number of variations in a Darwinian algorithm increases the probability that some matter and energy will fill a physical niche that is more complex. Sometimes this process can open even further levels of complexity and variation. And in many physical processes, there is an almost countless amount of variation being generated. Thus the Darwinian algorithm is engaged in a constant and ubiquitous rolling of the dice in our Universe. Occasionally the blind gambit raises the level of complexity, especially when we arrive at biological systems or even a species that is capable of accumulating more cultural innovations with each generation than is lost by the next (collective learning). Cultural innovations are any idea, methodology, technology, belief, or attitude. Unlike with DNA in biological evolution, millions of cultural innovations can be produced within one generation. This leads to a faster rise of complexity and has interesting historical and philosophical ramifications for the future of humanity, since the next rise of complexity in our Universe is likely to be due to animate rather than inanimate forces. It also has implications for the projected 'end' of our Universe and the death of the matter that currently sustains such complex systems. In the meantime, there is much to unite the broader trends of human history to the grand narrative of 13.8 billion years.

I will first proceed with an examination of the theory:

i) An examination of the quest for unifying themes in the works produced in the genre of Big History.

ii) A survey of the many works on the Darwinian algorithm (a process of random variation and non-random selection).

iii) An explanation of the relationship between the Darwinian algorithm and the increase of complexity in the Universe (measured by 'free energy rate density' or the concentration of energy as it flows through space and time).

iv) An exploration how this relates to the traditional historiography of population cycles and Le Roy Ladurie's exploration of the *longue durée*.

There are certain indications that an algorithm of random variation and non-random selection can be found in many disciplines, from Big Bang cosmology, to stellar evolution, to the study of the increase in the number of minerals in geology, to evolutionary biology, and even the increase of intricacy in human culture. The Darwinian algorithm in culture governs much of human history by raising the carrying capacity, although not uniformly, which is why the agrarian period suffered phases of rise and decline that impacted historical events, and which were explored by Ladurie nearly half a century ago.

After a detailed outline of the theories, I will:

i) Employ findings from the sciences to explore the Darwinian algorithm in stellar and geological evolution.

ii) Explore the role of the algorithm in the origin and evolution of life from the perspective of rising free energy rate density (the amount of free energy flowing through a certain amount of mass in a certain amount of time).

iii) Link the algorithm to the rise and fall of population dynamics in human and non-human history.

iv) Explore the origin in the Palaeolithic of collective learning (or, for sake of repetition, the accumulation of more learning and innovation with each generation than is lost by the next).

v) Explain what was behind the rise of the agrarian s-curves that dominated so much of the traditional *longue durée.*

After arriving at the agrarian era, I will use more conventional historical analysis to explore some of the long term trends of population dynamics, collective learning, and cultural evolution play a long-term role in the historical events of human history by:

i) Describing the Tasmanian Effect, or a period in history where the population falls so low and connectivity between groups is so strained that collective learning actually declines. I will explore four such cases: one in Tasmania, one in Oceania, one in Africa, and one in the post-Roman West. The finding of this section is that collective learning is highly dependent on numbers and connectivity, and when these variables are reduced technology either disappears or is simplified. The longer term impact of a Tasmanian Effect is that it lowers the carrying capacity for a population, reducing the pace of accumulation of knowledge and setting the process of collective learning back.

ii) Surveying the impact of the sluggish rise of the carrying capacity in the agrarian period, and how multiple phases of rise and decline impacted historical events and the rise and fall of empires. I will briefly survey the cases of medieval and early modern England, late medieval and early modern Russia, and Rome in the Republic and Principate. Then I will explore more in-depth studies of the Roman Dominate and Ladurie's stomping ground of medieval and early modern France. The finding of this section is that periods of population strain often provoke sociopolitical instability, a wave of natural population decline, followed by a period of manmade population decline that drives numbers down even further and keeps that population low for decades, whereas a conventional non-human s-curve would see the population rebound much more rapidly. This is a phenomenon that is closely related to the sluggish pace of collective learning in the agrarian period, which ensured that the carrying capacity did not rise fast enough to keep pace with population growth.

iii) Exploring several breakthroughs in the agrarian period that actually enhanced collective learning by either raising the agricultural carrying capacity of human populations or improving the connectivity between them. These were the direct result of an evolutionary process in culture and served to raise the free energy rate density (seen by some as a metric for complexity) both in specific technologies and in human society in general.

My concluding chapter concerns two explosions of the carrying capacity due to collective learning, one in Song China and one in pre-Industrial Europe. This brings us up to the present and a new phase of the *plus longue durée* and an unprecedented level of complexity (free energy rate density) in at least one small corner of the Universe. However, the exploration of the modern era and the Anthropocene, or an era where humans have become the dominant force in the biosphere, constitutes an entire study in itself and no shoddy and short treatments will be made here. Allusions will be made to what brought it about, while in-depth study will wait for a future work.

The broad chronology of this study might be troubling to some historians, who are accustomed to fill a study of a few years, or even days, with a treasure trove of detail. Nevertheless I intend to show in this dissertation that it is possible to use a broad chronology to investigate broad patterns and trends. The amount of detail an answer requires depends upon the nature of the question. For our purposes the question is how does the *annaliste* examination of broad historical trends in the agrarian era extend to the grand narrative of 13.8 billion years that is told to us by the natural sciences?

II. Big History & Reviving the Spirit of the Longue Durée

In a paper dating back to 1958, one of the foremost members of the *Annales* school of history, Fernand Braudel, coined the term '*longue durée*' and decried how academic disciplines were busy defining their aims, methods, and superiorities, by drawing boundaries between each other. Braudel recognised that 'each source encroaches on its neighbours, all the while believing it is staying in its own domain.'[2] He deemed history the most flexible of all academic disciplines and said it could make use of all that the other disciplines convey and can reflect them back again. Braudel encouraged the utmost interdisciplinary work in the examination of the cyclical movements of the short *durée* and the even longer term, the *longue durée*, which was the culmination of those cycles. 'Science, technology, political institutions,

[2] Fernand Braudel, 'History and the Social Sciences: The Longue Durée' *Annales. Histoire, Sciences Sociales* 13.4 (1958), 13: 726.

conceptual changes, civilisations,' Braudel said, 'all have their own rhythms of life and growth, and the new history of conjunctures will be complete only when it has made up a whole orchestra of them all.'[3] This is something that Big History in the past few decades, by employing experts from cosmology, geology, biology, and the social sciences, has endeavoured to do.

Around the same time, in 1955, a young graduate student, Le Roy Ladurie began conducting his investigation of the *compoix* of Languedoc (registered land surveys dating back to the fourteenth century) in southern France. Originally he found that the model of sixteenth and seventeenth century accumulation of rural land by the wealthy elite reinforced the classic argument that the Early Modern period gave rise to the first capitalists in the transition from the medieval period to the modern one. But later Ladurie went deeper into the countryside and mountain districts, and found that this trend only held near the cities. A much more interesting set of trends manifested themselves across all of rural Languedoc.[4] These trends could be divided into phases. Some phases saw the number of landowners grow in number as the average size of landholdings shrank, denoting overpopulation and rampant subdivision. Other phases saw average landholdings increase in size and the number of landholders decline, as prosperity reigned in a period of under-population. Ladurie identified overcrowding prior to the Black Death, sparse populations after the pandemic, and subdivision beginning again after 1500 AD. His work, *The Peasants of Languedoc*, focused on this demographic cycle between 1450 and 1730 AD. Ladurie found that this period maintained a certain 'continuum' of successive phases of growth and decline and that 'these phases, taken together in chronological sequence (lift-off, rise, maturity, and decline) imply a unity and serve to

[3] Braudel, 'The Longue Durée', 730.
[4] Emmanuel Le Roy Ladurie, *The Peasants of Languedoc*, (trans. John Day. Urbana: University of Illinois Press, 1976), 3-4.

describe a major, organised, secular rural fluctuation spanning eight generations.'[5] Ladurie had successfully identified an ecological population cycle (or s-curve) in an agrarian civilisation.

Ladurie recognised that it was only a microcosm of a set of cycles that happened elsewhere in what Big History calls the agrarian era (c.10,000-250 years ago). He also recognised that the fluctuations of rise and decline occurred even though in the long term the population remained fairly stable in France as a whole, at around 20 million people, between 1300 and 1700 AD, hence his often misunderstood phrase *histoire immobile*, despite the numerous violent upswings and downturns.[6] 1300-1700 was a period where the agricultural carrying capacity remained fairly stable in France, before the population took off due to the agricultural innovations in the eighteenth century. Ladurie called Early Modern France a society 'without a motor' that developed slowly in comparison to the industrial world.[7]

Where he got it slightly wrong is that the motor was indeed there and quietly running, and that his snapshot of 1300-1700 was in fact bordered on either side by periods of innovation where the carrying capacity was indeed raised. In fact, as this work will demonstrate, the carrying capacity had been rising throughout the agrarian era – just not fast enough to cope with the explosive growth of populations. Ladurie also encouraged the notion of interdisciplinary work in history, saying: 'As historians we are the rear guard of the *avant-garde*. We leave it to researchers in more sophisticated disciplines to embark upon the really dangerous missions. They are the pioneers... we historians draw very largely on the wealth created by established branches of quantitative science such as demography... [W]e have shamelessly pillaged – though we do try to give as good a return as possible – the resources of

[5] Ladurie, *Peasants of Languedoc*, 289.
[6] Emmanuel Le Roy Ladurie, 'History that Stands Still' in Emmanuel Le Roy Ladurie (ed) *The Mind and Method of the Historian*, trans. Sian Reynolds and Ben Reynolds, (Brighton: Harvester Press, 1981), 1-27.
[7] Ladurie, 'History that Stands Still', 3.

demography, to which we have given a historical dimension.'[8] He also recognised that France served as a window to the world, and an example of how his case study was replicated in many other regions in many other time periods.[9]

This thesis will argue that Ladurie was correct, and needed only to push back the scope of the chronology to see just how connected all these trends really were. Periods of population growth and decline happened at intervals of centuries in many agrarian civilisations between 10,000 and 250 years ago. This trend itself was governed by an even broader rise of the carrying capacity and population numbers that resulted from our species' unique ability to accumulate and pass on a vast amount of knowledge from generation to generation: collective learning. The groundswell of human population growth and innovation had been proceeding since the Palaeolithic. This generation of variations of ideas, the selection of productive ones and the disappearance of inefficient ones, gradually raised the carrying capacity and the ability of human beings to harness the energy of their environments. Collective learning itself was the result of random variation and non-random selection in biology, which itself resulted from similar chemical processes that go right back to the bellies of stars. More on this will be said in the next few sections. Suffice it to say, that all of these historical processes have a link that extends its embrace across the disciplines. The entire Universe has a Darwinian history, with random variation and non-random selection to be found on every page. Evolution has proceeded in the cosmos, in the chemical elements, in life, and in culture. There is not a stage where the Darwinian algorithm 'stops working' and an entirely separate process begins. Instead we can apply the language of the first law of thermodynamics. Nothing has been created or destroyed. It has only changed form.

[8] Ladurie, 'History that Stands Still', 7.
[9] Ladurie, 'History that Stands Still', 9-10.

Chapter One: The Longue & Plus Longue Durées

This chapter describes the central themes, ideas, and historical perspectives of this thesis, both at very large scales and at more conventional scales. The second part of the chapter describes the historiographical context for a discussion of how demographic cycles operate in human history, how these impact small-scale historical events and also link to the more general rise of complexity.

I. A History of Big History & Unifying Themes

This section will briefly survey the efforts of Big History to engage with broad and even 'unifying' themes. Big History is the historical study of broad trends in the grand narrative of 13.8 billion years. Of particular value to this genre of study are themes that unify every stage of the tale: cosmology, geology, biology, and human history. Such attempts to find a unifying theme were also made in the works of eighteenth and nineteenth century *philosophes* and were only hampered by the limitations of scientific knowledge. By the time a full chronology of 13.8 billion years was revealed by breakthroughs in cosmology and radiometric dating in the latter part of the twentieth century, the ability to analyse these trends historically once again became possible. Eric Chaisson and Fred Spier, in their brilliant seminal works, have managed to find unifying themes through examination of complexity and energy flows.[10] These works are tremendous achievements, for, as the reader can imagine, finding a historical process that unites the entire narrative of 13.8 billion years is not an easy thing to do. To this category of unifying themes we may potentially add the Darwinian algorithm – an algorithm of random variation and non-random selection – as an area of future inquiry. The algorithm is present in many physical processes: the cosmic, the geological, the

[10] Eric Chaisson, *Cosmic Evolution: The Rise of Complexity in Nature*, (Cambridge: Harvard University Press, 2001), and the updated treatment 'Energy Rate Density as a Complex Metric and Evolutionary Driver' *Wiley Periodicals* (2010) 16:27-40, and Fred Spier, *Big History and the Future of Humanity*, (Chichester: Wiley-Blackwell, 2010).

biological, the cultural, and perhaps beyond. It even extends its influence to conventional history, the *longue durée*, and human population dynamics. It may constitute yet another unifying theme of Big History. Furthermore, it might underwrite every stage of the rise of complexity in the Universe.

The hunt for a unifying theme of Big History has a long lineage that extends back far into the past, interspersed with long stretches of silence along the way.[11] The periods of taciturnity were caused by the general focus of the sciences on specialised pursuits within their individual 'silos' of expertise. The first real concerted and conscious attempt to unify the story of the physical processes of the universe to the dynamics of human society was made by Alexander von Humboldt (1769-1859), a Prussian natural philosopher, who set out to write *Kosmos* (1845-1859), but died before he could complete it. The book was to be a history that began in the depths of space, amongst the stellar clouds, then proceeded to the solar system, then to the Earth, then to organic life, reconciling their story to the history of humanity, with the goal of exploring 'the unity of nature.'[12] Perhaps one could go back further to Descartes, the Baron d'Holbach, Kant, and Hegel, who all strove, in their way, to unite humanity to the larger story of the natural world.[13] But Humboldt was the first in the modern era to deliberately set out to do what big historians intend to do today. Death inconveniently got in the way.

Robert Chambers (1802-1871) did a little better. He anonymously published the *Vestiges of the Natural History of Creation* in 1844. His book began with the inception of the

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[11] The best 'history of Big History' can be found in Fred Spier, *Big History and the Future of Humanity*.
[12] Alexander von Humboldt, *Kosmos: Entwurf einer physischen Weltbeschreibung*, (Stuttgart: J.G. Cotta'scher Verlag, 1845), 55-56 & 79-80.
[13] Paul-Henri Thiry Baron d'Holbach, *Système de la nature, ou des loix du monde physique et du monde moral*, (Amsterdam: Anonymous, 1770), René Descartes, *Le Monde, ou, Traité de la lumière*, (Paris: Anonymous, 1664), Immanuel Kant, *Allgemeine Naturgeschichte*, (Konigsberg: Petersen, 1755), Georg Wilhelm Friedrich Hegel, *Enzylopädie*, (Hamburg: Felix Meier Verlag, 1817).

Universe in a fiery mist and ended with the history of humanity.[14] He kept his authorship secret until after he died. He even made an attempt to explain the dynamics of that story, portending the theory of evolution by natural selection. Here was the first glimmer of a unifying theme.

The nineteenth and twentieth century division of the sciences and humanities into various specialisations and academic silos forestalled much of the further progress of the grand universal narrative.[15] Popular works like those of H.G. Wells and Hendrik Willem van Loon filled the gap, but not with the same gravitas, due to the works, by nature, having less empirical and scientific rigour to drive the point home.[16] The *Columbia History of the World*, the next thing approximating a unified history of the cosmos, devotes 45 of its 1237 pages to anything that happened in the 13.8 billion years prior to the rise of agriculture 10,000 years ago.[17]

Then, finally, the pendulum swung. By the early 1980s, it became clear that the natural sciences contained a clear narrative from the Big Bang to modern day and this unity began to find expression in an increasing number of written works. For the first time it was actually possible for the mainstream to grasp the entire chronology.[18] This began the process of thinking about both natural and human history as part of the unified whole. In 1980, astrophysicist Eric Jantsch wrote *The Self-Organizing Universe: Scientific and Human Implications of the Emerging Paradigm of Evolution*, now out of print, which tied together all universal entities into a collection of processes. It constitutes the first modern unifying Big

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[14] Robert Chambers, *Vestiges of the Natural History of Creation*, (London: John Churchill 1844).

[15] The best explanation and case against this tendency are expressed in David Christian, 'The Return of Universal History' *History and Theory* (2010) 49:6-27.

[16] H.G. Wells, *The Outline of History: Being a Plain History of Life and Mankind*, (New York: Garden City Publishing, 1920), and Hendrik Willem van Loon, *The Story of Mankind*, (New York: H. Livreight, 1921).

[17] John Garrety, Peter Gay (eds) *Columbia History of the World*, (New York: Harper and Row, 1972).

[18] A phenomenon best discussed in David Christian, 'The Evolutionary Epic and the Chronometric Revolution' in Genet et al., (eds) *The Evolutionary Epic: Science's Story and Humanity's Response*, (Santa Margarita: Collingswood Foundation Press, 2009), 43-50.

History.[19] Jantsch did a credible job of examining human history as an extension of cosmic evolution and as just one of many structures operating beyond thermodynamic equilibrium. Jantsch's work constitutes the first attempt, not to cram the entire tale of the Universe into one narrative like the *Columbia History of the World*, but to actually find a common strand or dynamic that streamlines, unites, and underwrites the entire grand narrative. It is thus possible to explore history from the Big Bang to modern day without being weighed down by the scale of the chronology.

Around the same time astrophysicists, geologists, and biologists such as Preston Cloud, Siegfried Kutter, George Field, and Eric Chaisson began writing and teaching courses about the cosmic story. These attempts admittedly spared little room for human history. Then at the end of the decade history professors like David Christian in Sydney and John Mears in Dallas began to craft grand narratives that incorporated the human story more seamlessly into a larger universal narrative. Fred Spier did the same at Amsterdam and Eindhoven. From here, a Cambrian-style explosion of courses and works has occurred.[20]

For all the work that has been done to produce a coherent narrative, there remains the question of a theme or central process that binds the various strands of the grand story together, without reference to vague generalities or metaphors. Two admirable efforts have been made and continue a-building.[21] The first involves Eric Chaisson's *Cosmic Evolution*

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[19] Eric Jantsch, *The Self-Organizing Universe: Scientific and Human Implications of the Emerging Paradigm of Evolution*, (Oxford: Pergamon, 1980).

[20] For recent survey of size and of the field, Barry Rodrigue and Daniel Stasko, 'A Big History Directory, 2009: An Introduction' *World History Connected* (2009) vol. 6, no. 9, and the canon of seminal works includes but is not confined to Fred Spier, *The Structure of Big History: From the Big Bang until Today* (Amsterdam: Amsterdam University Press, 1996), *David Christian, Maps of Time: An Introduction to Big History*, (Berkeley: University of California Press, 2004), Cynthia Stokes Brown, *Big History: From the Big Bang to the Present* (New York and London: The New Press, 2007); and Eric Chaisson, *Epic of Evolution: Seven Ages of the Cosmos* (New York: Columbia University Press, 2006).

[21] The best summaries can be found in Fred Spier, 'How Big History Works: Energy Flows and the Rise and Demise of Complexity' *Social Evolution and History* (2005) 4: 87-135 and Eric Chaisson, 'Using Complexity Science to Search for Unity in the Natural Sciences' in Lineweaver, Davies and Ruse (eds) *The Self-Organizing Universe: Cosmology, Biology, and the Rise of Complexity*, (Cambridge: Cambridge University Press, 2013).

(2001) that depicts Big History as the rise of complexity, which, he argues, occurs when energy flows through matter become increasingly dense.[22] Chaisson even proposed a way of objectively measuring this trend. Free energy rate density is the energy per second that flows through an amount of mass. In this way Chaisson empirically established that complexity has been rising in the Universe for 13.8 billion years.

The theme of rising complexity was incorporated into David Christian's *Maps of Time* (2004) which further employed it in the human tale. The book also coincided with John and William McNeill's *The Human Web* (2003) and went back further to the beginning of time, for which William McNeill (somewhat superlatively and, one hopes, humorously) compared himself to John the Baptist and David Christian to Jesus of Nazareth for historicising the natural sciences.[23]

Fred Spier, most recently in his book, *Big History and the Future of Humanity* (2010), has emphasised the Goldilocks principle, and how the rise of complexity occurs when conditions like temperature, pressure, and radiation are 'just right' for the rise of complexity to occur. Spier claims that the rise of complexity combined with energy flows and the Goldilocks principle form the beginnings of an overarching theory of Big History.[24] Indeed, the rise of complexity seems to be the common strand in the cosmic tale, at least in these early versions of the story. There is a question of whether the Goldilocks principle that allows this complexity to arise is coincidental or whether it is part of a more dynamic pattern and a greater scheme of evolutionary selection.

The unique approach of Big History, the interdisciplinary genre of history that deals with the grand narrative of 13.8 billion years, has opened up a vast amount of research agendas. Or,

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[22] Eric Chaisson, *Cosmic Evolution: The Rise of Complexity in Nature*, (Cambridge: Harvard University Press, 2001).
[23] William McNeill, 'Leaving Western Civ Behind' *Liberal Education* (2011) Summer: 47.
[24] Fred Spier, *Big History and the Future of Humanity*, (Chichester: Wiley-Blackwell, 2010).

to engage an evolutionary metaphor, it has triggered a scholarly speciation event where hundreds of new niches have opened up waiting to be filled. The ecological terrain is vast and the numbers that currently populate it are few. The research comes in a variety of forms. My particular niche encompasses the 'Darwinian algorithm' and the *plus longue durée*. The idea is that an algorithm of random variation and non-random selection is present in many physical processes in the Universe, and also within human history.

II. Random Variation & Non-Random Selection in Big History

This section will outline how the Darwinian algorithm operates from the cosmological level and then briefly survey the many works on the algorithm in cosmology, quantum physics, stellar evolution, geology, and cultural evolution.

I will explain how the Darwinian algorithm relates to the rise of complexity in the Universe and offers another potential unifying theme for Big History and the *plus longue durée.* In its essence, it would appear that an algorithm of random variation and non-random selection operates at many levels that directly impact not only the grand narrative but even human history. There is much research in this field to be done, however, it is of direct relevance to our examination and expansion of French *annaliste* concepts and therefore worthy of our attention here.

a) The Random Variation & Non-Random Selection of Universes

To understand the beginnings of the Darwinian algorithm in universal processes, we must first venture firmly into Big History territory and examine the beginnings of our Universe. Many historians may doubt the value of such scientific notions for historians but one of the central goals of this thesis will be to show that they can indeed yield valuable insights at the scale of conventional historical research.

At the moment of the Big Bang, a singularity occurred of such intense heat and pressure that the laws of physics would have broken down. At 10^{-43} seconds (0.0000000000000000000000000000000000000000001) gravity had come into being. Between 10^{-36} and 10^{-32} seconds, the Universe cooled allowing strong nuclear and electroweak forces to become distinct, completing the fundamental forces that control the physical processes of our Universe. The Universe inflated due to the creation of a false vacuum and gravitational repulsion and negative pressure, and the fabric of space-time grew faster than the speed of light (which is almost 300,000 km per second) to an enormous size, while continuing to cool, and then the decay of energy reheated the universe to its ultra-hot state. Quantum fluctuations created minute variations in density, which were then inflated to such a scale that they created clumps of hydrogen and helium, which in turn created our galaxies, and are mirrored in the temperature of Cosmic Background Radiation (CBR).[25] Thus, during a tiny fragment of a second, most of the heavy lifting that set the physical processes of our Universe in motion was accomplished. The clock was wound, the rules of the game were set, and the rest of the tale can be told with staggering accuracy using the familiar laws of physics.

What of other regions beyond the cosmic horizon of the visible Universe? Our region endured a brief surge of inflation that explains small irregularities, the expansion rate, and the nature of further development. Many physicists are inclined to think that there are other regions, each undergoing a different amount of inflation and developing physical properties vastly different to our own. The Planck satellite results in 2013 may perhaps have given us the

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[25] The account of these events is given a decent treatment in many works, for instance, David Christian, *Maps of Time: An Introduction to Big History*, (Berkeley: University of California Press, 2004), 24-27, John Barrow, *The Book of Universes: Exploring the Limits of the Cosmos*, (London: W.W. Nortion and Company, 2011), Cesare Emiliani, *The Scientific Companion: Exploring the Physical World with Facts, Figures, and Formulas*, (New York: John Wiley, 1995), 82, Stephen Hawking, *The Universe in a Nutshell*, (New York: Bantam, 2001), 78, and many, many more.

first empirical evidence of this.[26] Inflationary cosmology predicts that once inflation takes hold in one region, it causes accelerated expansion and inflation in other regions, producing a ripple effect.[27] Inflation may be still underway in regions beyond our cosmic horizon. We might be just one bubble where inflation has slowed down, like a hole in a block of Swiss cheese. Other regions in the 'multiverse', totally inaccessible to us, may also slow down in a runaway reproduction of universes. Until recently, physicists thought that one set of physical laws governed by a Grand Unified Theory was possible, and then we thought string theory illuminated a small number of possible sets of physical laws, now M-Theory suggests that a vast number of functioning sets of physical laws with different properties, dimensions, and fundamental forces can exist and function.[28] The estimated number of sets of physical laws that is favoured by physicists at the present time is 10^{500}.[29] That number embraces all the possible sets of physical laws that could form the basis for a universe when it cools down enough for the inflationary stage to begin, and it pops into existence, like a bubble in boiling water. These sets of laws fall together in the inflationary stage as a universe cools. Their formation appears to be the outcome of a random process.[30] Each set of laws determines density, temperature, fundamental forces, constants, dimensions, and whether or not things like matter exist. The actual number of universes based on those sets of physical laws is probably much higher, with many variations, but they all fall within the selection constraints of 10^{500}. Those universes that do not fall within those constraints do not get to exist.

Here is the fundamental basis for the Darwinian algorithm, an algorithm of random variation and non-random selection, a major research area in Big History. 10^{500} is therefore a

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[26] A patch of cold in CBR that cosmologists speculate is the imprint of another universe, P. Ade, et al, 'Planck 2013 Results: High Frequency Instrument Data Processing' *Astronomy & Astrophysics* (in press).
[27] Alan Guth, 'Eternal Inflation and its Implications', *Journal of Physics A: Mathematical and Theoretical* (2007) 40:6815-6817.
[28] Michael Duff, 'The Theory Formerly Known as Strings' *Scientific American* (1998) 64-69.
[29] Stephen Hawking and Leonard Mlodinow, *The Grand Design*, (New York: Bantam Books, 2010), 118.
[30] Barrow, 214.

very important number. It is the number of working sets of physical laws, the number of parameters in which a universe can occur. It is the primordial niche of all evolution, the foundation for an evolutionary process that seems to arise time and time again alongside the rise of complexity in our Universe.[31] The algorithm even seems to govern the formation of universes themselves. A Darwinian algorithm is anything that obeys a process of random variation and non-random selection. The game of 'universal natural selection' appears to be the first instance in the cosmic story where such an algorithm happens. The selection constraints appear to be the number of sets of physical laws in which a universe can start to exist. Universes appear randomly in inflationary space and only those universes that fall within the constraints of 10^{500} and are capable of forming coherent physical systems are non-randomly selected to form universes. In such a scenario, universes are not constrained by any form of direct competition, but a form of 'niche selection' where the physical attributes of a universe that are capable of dwelling within a cosmic set of constraints make a form of non-random selection possible.

Nevertheless, the primordial niche is extremely wide, as you might expect from a form of selection that goes back to the very beginning of universes. From those parameters arise numerous systems of random variation and non-random selection within each universe that inhabit smaller and smaller niches and produce greater and greater forms of complexity. We shall explore those systems of random variation and non-random selection within our own Universe presently. But first, to give you an idea of how many variations of sets of physical laws could exist within the primordial niche, take a trillion of them, and then multiply that trillion by a trillion. Then another trillion x trillion x trillion x trillion x trillion x trillion x trillion x trillion x trillion x trillion x trillion x trillion x trillion x trillion x trillion x trillion x

[31] Daniel Dennett, *Darwin's Dangerous Idea: Evolution and the Meanings of Life*, (New York: Touchstone, 1996), 48-61.

trillion x trillion. By comparison, 10^{14} is the number of years before the end of star formation, when every single last star will flicker out and the universe will wander in a cosmic graveyard of pitch black.[32] 10^{40} is roughly the number of years before the death of matter.[33] And 10^{100} is roughly the number of years before the total heat death of our Universe.[34] The number of different sets of physical laws that form the game of cosmic selection is greater still. That is the sheer magnitude of 10^{500}. Some of those universes that arise would operate without electromagnetism. Some of those universes would never form clumps of hydrogen and helium, and by extension stars and galaxies. Some of those universes would never form atoms at all. And some of those universes would be based very different properties, fundamental forces, and dimensions. Trying to understand how those properties, forces, and dimensions operated using the physical concepts with which we are familiar in our Universe would be like trying to explain colour to a dog. But if the number of potential sets of physical laws is *anything less than infinite*, which at present most physicists agree it is, then there is a clear selection constraint on what universes can emerge from inflationary space and form another hole in our cosmic block of Swiss cheese.[35]

b) Random Variation & Non-Random Selection in Cosmology, Geology, & Culture

From this primordial niche came a number of physical processes that also engage the Darwinian algorithm within our own Universe. These have been explored in a vast array of

[32] 100 trillion years. Fred Adams and Greg Laughlin, *The Five Ages of the Universe,* (New York: The Free Press, 1999), 35-39.
[33] Adams and Laughlin, ‘A Dying Universe: The Long-Term Fate and Evolution of Astrophysical Objects’ *Reviews of Modern Physics* (1997) 69:337-372.
[34] If total heat death is indeed what awaits it. There are a number of possible scenarios and perhaps others undiscovered. Ibid.
[35] I feel safe in the company of Hawking and Mlodinow, 118, in asserting the point that the number of coherent physical laws is indeed less than infinite.

scientific and scholarly works that go as far back as Herbert Spencer.[36] At the cosmic level, Lee Smolin and E.R. Harrison have both proposed models for universes themselves, with those more likely to produce black holes or intelligent life, respectively, being favoured because both hold the potential to produce new universes.[37] Both hypotheses remain highly speculative and favour a hereditary connection, where the characteristics of one universe impact those of a universe that follows it. At the end of the day such selection criteria and heritability may not even be required since the number 10^{500} is so large that it covers every variation to make inheritance between universes unnecessary. Yet the number is still mathematically finite making selection possible, even if the inflationary multiverse itself is infinite, as some physicists say it could be.[38]

Wojciech Zurek has created a model whereby the predictable physics of the Newtonian realm emerge from the chaos of the quantum world – a model that recently gained some new evidence.[39] If this is correct, then it provides a very important explanation for the uncertainty in quantum physics. The chaos at the quantum level does not abrogate the idea that the Universe functions in a certain way because the very randomness at the quantum level is fundamental to the prevailing system. Quantum physics produces random variation; the Newtonian realm provides constraints for non-random selection. Only certain quantum variations can manifest themselves at macro-scales. There is a sort of order to all the disorder. There is a method to the madness.

Leonid Grinin has put forward the case for Darwinian mechanisms being at play in astrophysical and solar evolution. The creation, destruction, and renewed creation of various

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[36] Herbert Spencer, *First Principles*, (London: Watts & Co, 1862).
[37] Lee Smolin, *The Life of the Cosmos*, (London: Phoenix, 1997) and E.R. Harrison, 'The Natural Selection of Universes Containing Intelligent Life' *Quarterly Journal of the Royal Astronomical Society* (1995) 36:193.
[38] Guth, 'Eternal Inflation and its Implications', 6817.
[39] Wojciech Hubert Zurek, 'Decoherence, Einselection, and the Quantum Origins of the Classical' *Reviews of Modern Physics* (2003) 75: 715-765 and A.M. Burke et al., 'Periodic Scarred States in Open Quantum Dots as Evidence of Quantum Darwinism' *Physical Review Letters* (2010) 104: 17801:1-4.

solar objects 'tries' many versions, some of which turn out to be more effective in being reproduced. In all generations of stars there is constant annihilation of some objects and emergence of new ones, resulting in change and development with each generation. And while the variation of traits in stellar evolution is much slower than in the evolution of life, we still do see it occur with respect to change of a few generations of stars and galaxies that differ from each other as regards their sizes, structure, and composition. Also, in stellar evolution, excessive variation is necessary to open up new evolutionary trajectories and 'niches' that are provided by the laws of physics. Diversity, as in all forms of random variation and non-random selection, is important.[40]

In the geological realm, Robert Hazen, et al., have proposed an evolutionary model for the generation of new minerals.[41] While making sure to clarify that the model differs from biology, the authors highlight several places where selection, punctuation, and gradients for change are present, exponentially increasing the number of mineral types throughout geological history, from stellar *nebulae*, through planetary accretion, and all the changes thereafter. Physics, changes in environment, pressure, temperature, and so forth, open niches for further chemical reactions, some of which are more successfully preserved in the mineralogical record than others. Some of those variations produced in these physical niches became essential to the inception of life. This would not have been possible without the chemical and mineral evolution from about hundred species during the accretion of the Earth 4.5 billion years ago to nearly 2000 around the time of the first organisms 3.8 billion years ago. Since then mineral evolution has produced over 4500 mineral variations, and these only the ones that have so far been documented.

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[40] Leonid Grinin, 'The Star-Galaxy Era of Big History in the Light of Universal Evolutionary Principles' *Proceedings of the First International Big History Association Conference* (in press).
[41] Robert Hazen, et al., 'Mineral Evolution' *American Mineralogist* (2008) 93:1693-1720.

But the most thorough examination of the Darwinian algorithm in areas beyond the realm of biology (from which it gets its name) has been within cultural evolution: the operation of random variation and non-random selection in the vastly accelerated accumulation of human ideas from generation to generation. The idea was first pioneered by Donald Campbell and later revived by Richard Dawkins, and then developed most effectively, in my opinion, by Peter Richerson and Robert Boyd.[42] In cultural evolution, any ideas, knowledge, beliefs, values, skills, and attitudes that are more practical or more appealing, are easier to learn or are better geared toward survival, and are more likely to lead to social prominence than others, spread more easily from person to person. Those cultural practices that lead to early death or social stigma are less frequent or simply disappear.[43] 'From so simple a beginning,' to borrow a famous phrase, came a flood of works on cultural evolution in recent years.[44] The explosion of works on cultural evolution also provoked a great deal of debate.[45] Two of the most rigorous bits of research, in my opinion, have been Lake and

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[42] Donald T. Campbell, 'Blind Variation and Selective Retention in Creative Thought as in other Knowledge Processes,' *Psychological Review* (1960) 67: 380-400 and Richard Dawkins, *The Selfish Gene*, (Oxford: Oxford University Press, 1976), Robert Boyd and Peter Richerson, *Culture and the Evolutionary Process*, (Chicago: Chicago University Press, 1985).

[43] Peter Richerson and Robert Boyd, *Not by Genes Alone: How Culture Transformed Human Evolution*, (Chicago: University of Chicago Press, 2005), 5-12.

[44] Many works have been written on the subject, though I believe Richerson and Boyd remain the most successful at explaining it. Richard Dawkins, by contrast, as recently as *The God Delusion*, (New York: Houghton Mifflin, 2006), 228 claimed Susan Blackmore, *The Meme Machine*, (Oxford: Oxford University Press, 1999) held that honour. A number of other works have also been written on the subject: Daniel Dennett, *Darwin's Dangerous Idea: Evolution and the Meanings of Life*, (New York: Touchstone, 1996), Stephen Shennan, *Genes, Memes, and Human History: Darwinian Archaeology and Cultural Evolution*, (London: Thames and Hudson, 2002), Robert Aunger, *Reflexive Ethnographic Science*, (Walnut Creek: Alta Mira, 2004), J. Heinrich, R. Boyd, P. Richerson, 'Five Misunderstandings about Cultural Evolution' *Human Nature* (2008) 19: 119-137, A. Mesoudi, A. Whiten, K. Laland, 'Towards a Unified Science of Cultural Evolution' *Behavioural and Brain Sciences*, (2006) 29: 329-383, W.G. Runciman, *The Theory of Cultural and Social Selection*, (Cambridge: Cambridge University Press, 2009), Kate Distin, *Cultural Evolution*, (Cambridge: Cambridge University Press, 2011),Ruth Mace, Clare J Holden, and Stephen Shennan (eds), *The Evolution of Cultural Diversity: A Phylogenetic Approach*, (London: UCL Press, 2005) – particularly David Bryant, Flavia Filiman, and Russell Gray, 'Untangling Our Past: Languages, Trees, Splits and Networks' which advocates the NeighborNet program to plot trees for both vertical and horizontal transmission for all the Indo-European languages, John Ziman (ed), *Technological Innovation as an Evolutionary Process*, (Cambridge: Cambridge University Press, 2000), and a close runner up to Richerson, Boyd, and Black more is Stephen Shennan (ed), *Pattern and Process in Cultural Evolution*, (Berkeley: University of California Press, 2009), notable for its many in-depth investigations.

[45] For instance, see Joseph Fracchia and R. Lewontin, 'Does Culture Evolve?' *History and Theory* (1999) 38: 52-78, and the resulting debate between them and W.G. Runciman in *History and Theory* (2005) 44, 1-13, 14-29,

Venti's work on nineteenth century bicycle technology and Ritt's work on the formation of dialects and new languages.[46] Once again, ideas are produced in wide variety by a succession of human brains attending to a variety of tasks and demands. Those ideas that are useful or obtain some form of cultural appeal are selected. The variation and selection of certain cultural innovations is best explained through the example of the Industrial Revolution. Beneath the garden of revolutionary innovations that raised the levels of human production by leaps and bounds, there is a graveyard of failed, impractical, obsolete, or unpopular ideas. This evolution can (and has been) traced and mathematically charted using evolutionary models, such as that found in Lake and Venti's work.

Finally, at the inaugural IBHA conference, my colleague and fellow big historian, Christian Jennings, and I discussed how Darwinian algorithms are already used to fill a range of useful functions in the computer realm.[47] Not all mechanisms of information in a computer are processed in a Darwinian algorithm. But since the 1970s, numerous programs have employed a 'genetic algorithm', which is a search heuristic that mimics the process of natural evolution. The computer automatically finds better ways to run programming through a game of variation and selection. It is currently employed in bioinformatics, engineering, economics, chemistry, mathematics, and more. Various entities of the Universe may consist of different forms of information – whether energy flows, DNA, or cultural ideas – chemical elements, DNA, human behaviours, and ones and zeros in a computer, all code a specific form of information that has a specific result. In one way or another, they all are subject to a form of

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and 30-41, in several back and forth exchanges. Fracchia and Lewontin's misunderstanding of what cultural evolution actually led both sides to more or less repeat the same arguments at each other. Fracchia and Lewontin insisted that cultural evolution was just metaphor while Runciman reiterated that the random variation of cultural ideas and the selection and spread of useful or successful ones was assuredly not metaphorical.

[46] Mark Lake and Jay Venti, 'Quantitative Analysis of Macroevolutionary Patterning in Technological Evolution: Bicycle Design from 1800 to 2000' in Stephen Shennan (ed.), *Pattern and Process in Cultural Evolution*, Berkeley: University of California Press, 2009 and Nikolaus Ritt, *Selfish Sounds and Linguistic Evolution: A Darwinian Approach to Language Change*, (Cambridge: Cambridge University Press, 2004).

[47] An idea also explored by John Holland, *Adaptation in Natural and Artificial Systems*, (Cambridge: MIT Press, 1975), *Hidden Order: How Adaptation Builds Complexity*, (New York: Basic Books, 1996).

evolution and thus an algorithm or random variation and non-random selection. The energy flows of the Universe take part in a massive, multi-faceted, computation. This computation amounts to our entire history from the biggest scales to the smallest.

All that remains is to place the various scales and forms of evolution into a unified narrative and perhaps even to codify them mathematically in a grand unified theory. This may be the angle that such theories have so far lacked. At any rate, the spectre of the algorithm has already been spotted by a number of scholars working in a disparate array of disciplines. This could be what unites them all – an elegantly simple process, a form of variation, selection, and preservation that underwrites all things.

c) The Darwinian Algorithm & French Annaliste Population Cycles

A word ought to be said about how the Darwinian algorithm relates to the work of Le Roy Ladurie. That pivotal *annaliste* historian identified how the quality of life and the level of the French population went through several cycles that could not break through a carrying capacity of about 20 million. The carrying capacity was set by agricultural efficiency, levels of fertilisation, employment of new strains of crops, and forms of crop-rotation, among other things. While population rose very fast in periods of plenty (like from 1450-1550) the capacity of these innovations to produce more food did not. The 'collective learning' (already mentioned and a concept that we shall soon explore) of medieval and early modern society did not produce and adopt successful variations and innovations fast enough to keep pace with the population. This trend is also seen more widely throughout the agrarian period (10,000-250 years ago) in many regions of the world, many of which will be explored in this work.

Collective learning is a part of cultural evolution, within which the selection criteria is any innovation that generates a higher carrying capacity or more connectivity between innovators. Without this, technological accumulation over several generations is extremely difficult. In the agrarian era cultural innovations just were not adopted quickly enough to keep pace with a more rapid rate of population growth. The result was cycles of starvation and decline, which were coupled with the rise of sociopolitical instability that influenced historical events. And after such periods of strain, there were episodes of prosperity and plenty that fostered the rise to greatness of many human states and civilisations. Eventually the carrying capacity was raised by collective learning, but not without vastly influencing the events that form the basis of conventional ancient, medieval, and early modern history. And in the last 250 years, certain human innovations have been selected and combined to produce a 'Cambrian explosion' of new innovations, higher populations, enhanced communications, and rising complexity. That is how the Darwinian algorithm fits into traditional French population cycles of the *longue durée*. The past 10,000 years of our history have been very much shaped by Darwinian algorithm on multiple levels.

III. The Relationship between the Darwinian Algorithm & Complexity

a) Variation & Selection Produce Higher Levels of Complexity

In this section we survey the relationship of the Darwinian algorithm to levels of complexity in nature. It would appear that the Darwinian algorithm plays a direct role in increasing the level of free energy rate density by increasing the number of available variations, the number of viable selection paths, and thus the intensity of energy flows. Few variations emerge from the quantum realm to the Newtonian, only about a hundred elements emerge from stellar evolution, a few thousand variations emerge from chemical/mineral evolution, millions of variations emerge in the biological realm, and in culture the many variations of innovations are increased further still. At each stage the free energy rate density increases as does the magnitude of energy that can be harnessed to sustain those variations within selection niches. Eric Chaisson has produced a milestone work that shows how the 'free energy rate density' or amount of free energy held in a given measurement of mass increases at various stages of complexity (see table below). As a result, 'free energy rate density' is used in this work as a rough quantitative gauge of complexity itself.[48]

Generic Structure	Average Free Energy Rate Density (erg/s/g)
Galaxies	0.5
Stars	2
Planets	75
Plants	900
Animals	20,000
Australopithecines	20,000
Hunter-Gatherers (i.e. 250,000-10,000 y/a)	40,000
Agriculturalists (i.e. 10,000-250 y/a)	100,000
Industrialists (i.e. 1800-1950)	500,000
Technologists (i.e. present)	2,000,000

(**Table 1.1** Amount of free energy running through a gram per second, and the australopithecine and human free energy rate density is determined from the average energy consumption of an individual, Chaisson 2010: 28 & 36)

If the Darwinian algorithm is present at every stage in the rise of complexity in the Universe, it may be that the algorithm itself tends to cause ever greater forms of complexity. Variations are selected and open more selection paths, and those are sustained by more concentrations of free energy. For instance, an organism requires a much higher free energy rate density than a star, and a rocket engine higher still. And it would appear that the number of possible outcomes is relative to the complexity of the process under discussion, which may explain, as I said, why relatively few outcomes make it from the quantum to the Newtonian level, why only a few thousand variations emerge from the geological level, whereas in biological evolution the number of possible selection paths is exponentially greater, and the number of cultural paths is multiplied further still. When we arrive at something as complex as culture and human society, with an average free energy rate density of all the various time periods (hunter-gatherer, agrarian, modern) that is many times higher than the average product

[48] There are still lingering questions about whether Chaisson's metric represents a rise in 'complexity' and still more about what 'complexity' really is. Nevertheless, the demonstrable unifying trend in the grand narrative is a rise of free energy rate density. I have no objection to associating this trend with 'complexity' (a loaded word with idiomatic baggage) since it accords with structures that are generally deemed 'more complex'. But it is that rise of free energy rate density that interests and impresses me. Attach whatever noun to it you please.

of genetic evolution or a galaxy, there are a mind-boggling number of cultural and technological combinations. Essentially, if you were to take a human brain and a brain sized chunk of a star, there is no question that the former would have a much higher density of free energy at any given time.

The core of the relationship between the Darwinian algorithm of random variation and non-random selection and free energy rate density appears to be that *the level of complexity seems to increase with the number of viable selection paths*. And while the Darwinian algorithm is not deterministic in increasing the level of complexity, since it is a blind process and many things in the Universe remain in a simple state (whether it is the prevalence of hydrogen atoms or the majority of life being bacterial), random variation does open the door for complexity to arise. The reason is that in a Universe that constantly generates random variation and non-random selection, such a large amount of variation guarantees some variations will involve a higher degree of complexity, provided there are physical niches capable of sustaining them. *A countless array of variations means that some variations will fill a niche that is more complex, and those niches generally seem to open up more selections paths that can sustain an even higher level of free energy rate density*. That is why the Darwinian algorithm is so fundamental to the rise of complexity. As far as I know, this application of rising complexity (free energy rate density) to the Darwinian algorithm of random variation and non-random selection has not yet been espoused in such a way in other scholarly works beside my own.

b) The Faster Evolutionary Pace of Cultural Evolution

It would appear, for the time being, that cultural evolution and the complexity it bestows is the highest point in this process of which we are yet aware. There are two tiers of human evolution. The first is genetics, which operates in the same way for humans as for other organisms. In ways that remain somewhat unclear, and which will be later explored, the evolution of genetic traits gave humans a large capacity for imitation and communication. Those two things enabled the second tier. Culture operates under similar laws, but on a much faster scale, thanks to the accumulation of knowledge via collective learning. Cultural variations are subject to selection and the most beneficial variations are chosen. Unlike genes, these variations can be transmitted between populations of the same generation and can be modified numerous times *within* that generation. Like a highway overpass looming over older roads, cultural evolution can blaze along at a much faster rate of speed. Ultimately, cultural innovations accumulate extremely rapidly. Population pressure results in some of this accumulation to be geared toward increasing the human ability to extract resources from the environment, (e.g. by domesticating plants to feed a larger population with a smaller land area than hunting or by harnessing the power of fossil fuels). This process raises the carrying capacity, which produces more people, who produce more innovation, which in turn raises the carrying capacity. The cycle continues and grows in complexity. More humans generate more ideas and the connectivity between those humans via trade, communication, and collaboration allows new ideas to accumulate from older methods. If expressed as a general principle, it may be hypothesized that *the rate of growth of the carrying capacity of a human population is relative to the number and connectivity of variant innovations*.

The second evolutionary tier of culture, a swifter form of evolution, should not come as a surprise in a Darwinian algorithm. Gradually, through natural selection, not only can a species become better at surviving, they can improve the *rate or pace* at which they improve their survival chances. This follows the logic that improving the rate or pace of improvement of the probability of survival is just as naturally selected for as improving the probability of survival itself. Cultural evolution is the result of such a dynamic. Logically, a third tier is likely to emerge in which growing knowledge of our genes allows us to directly guide our evolution. If we discard the artificial concept of tiers and indulge in a 'selfish gene' model *à la* Richard Dawkins, then over a relatively short evolutionary process of 200,000 years, human genes have developed the ability to evolve more rapidly and efficiently. I would define standard evolution as the change in the traits of a population of organisms through successive generations to sustain or increase their complexity. Cultural evolution can be described as the change in traits and behaviours between populations of the *same* generation and through successive generations to sustain or increase their complexity.

c) On the Origin of the Darwinian Algorithm

So as not to let any vagueness imbue the idea of the Darwinian algorithm with a sense of 'mysticism' or unexplained omnipresence, it pays to talk about the concrete physical conditions in which the Darwinian algorithm emerged. We have already established that the Darwinian algorithm of random variation and non-random selection is first operating when universes cool down in the inflationary phase and form a set of coherent physical laws that fall within the constraints of M-theory (with current science, including physicists like Stephen Hawking, estimating 10^{500} possible niches).[49] As stated previously, their formation appears to be the result of a random process of quantum fluctuations in inflationary space.[50] These possible sets of physical laws form the basis for all the niches in which further variations can be selected. That is the foundation of all forms of evolution in our Universe, the set of physical laws of which involves a combination of gravity, electromagnetism, and strong and weak nuclear forces. These four fundamental forces created physical niches for the forms of stellar, geological, biological, and cultural evolution that we shall explore in this work.

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[49] Hawking and Mlodinow, 118.
[50] Barrow, 214.

We must not confuse the number of possible sets of physical laws with the number of universes themselves, which could well be infinite, as cosmic horizons continue to emerge in inflationary space. And multiple variations in composition could emerge from the same set of coherent physical laws and dimensions. The current estimate is 10^{500} possible sets of physical laws. This number could change in future, but if the number of possible sets of physical laws is anything less than infinite, then there is a clear selection constraint at work in the formation of cosmic horizons out of inflationary space. There is also a question if any kind of random variation and non-random selection infiltrates regions of inflationary space in some way, but this remains to be seen. The emergence of cosmic horizons, the 'bubbles' in a block of Swiss cheese, is relatively well understood by physicists. The actual cheese (inflationary space) is a bigger problem. And none of this brings us any closer to understanding the nature of the Big Bang (what it is and how it occurred) since it happened in ultra-hot and ultra-dense conditions that are completely alien to our conception of physics and during which any coherent set of physical laws would have broken down. Understanding that from our frame of reference is rather like trying to explain colour to a dog. It is currently beyond our comprehension.

But it appears that the Darwinian algorithm which seems to govern so many changes in our own Universe emerged from fairly concrete physical processes in the inflationary stage. That the fundamental forces in our Universe enable physical niches for further variation and non-random selection is fairly self-evident. The major question is why inflationary space continues to exist in regions beyond our cosmic horizon and why some regions slow down and others do not. Right now models of 'eternal inflation' models indicate this occurs due to quantum fluctuations, but these models, as Alan Guth has recently pointed out, remain incomplete. All we know, Guth says, is that 'eternal inflation offers at least a hope that a small number of *vacua* may be favoured' for an unknown reason to emerge in inflationary space and that a new kind of physics beyond inflation is required to understand what happened at its past boundary (i.e. the Big Bang).[51] Whatever the answer to these questions may be, it seems evident that a form of variation and selection is at play in the emergence of cosmic horizons, and, in our Universe at the very least, this algorithm continues to play a role in further transformations. It is in that sense that the origin of the Darwinian algorithm is firmly rooted in fairly concrete and discernible physical processes at the cosmic level.

d) How Big History Trends Connect to Annaliste Population Trends

We now know that there is no hard-and-fast division between the organic and inorganic worlds. We are made of the same stuff. There is, however, a difference in behaviour. Stars, minerals, and the rest of the inorganic world do not actively seek out matter and energy from the environment, (i.e. they do not seek out matter and energy like an organism). Even objects as gigantic as stars burn their fuel like lamps and candles, and eventually flicker out. Eventually, every single last tiny slow-burning star will be extinguished. Only life has the ability to actively go out and extract energy from the environment to keep itself going. We do not just sit still and wait for death to take us. We fight – for a time. If we want to preserve our vast complexity, we have to continue harvesting matter and energy to keep ourselves going. All other considerations are secondary. As Fred Spier has pointed out, seeking out matter and energy to sustain ourselves is the bottom line of human history and for life in general.[52] Spier's 'bottom line' ultimately is the same battle with disorder, chaos, entropy and the second law of thermodynamics that all complexity has carried on since the very beginning of the Universe, and it is a battle that physicists believe it must eventually and inevitably lose.

[51] Guth, 'Eternal Inflation and its Implications', 6817.
[52] Fred Spier, *Big History and the Future of Humanity*, (Chichester: Wiley-Blackwell, 2010), 77 & 116.

Spier's bottom line of history also animates much of the core of Le Roy Ladurie's treatment of the *longue durée* population cycles. Ladurie dealt with the historical effects of agricultural shortage, famine, and population decline in the medieval and early modern period. Throughout the existence of the human species, we have managed to harness energy to sustain or increase our survival. Harnessing increased amounts of energy via cultural evolution further increases our numbers, which increases the number of innovators. From so simple a beginning in the Palaeolithic there emerged the mass of agrarian civilisations involving hundreds of millions of cultural actors and innovators. While the carrying capacity of the agrarian era was gradually raised, between 10,000 and 250 years ago, there were periods where population growth exceeded the pace of agrarian innovation, and states and empires underwent periods of stagnation and decline. This was the province of Ladurie's *longue durée* between 1300 and 1700 AD, where the French population dwelt around a population ceiling of 20 million, with many declines and recoveries. This is how the conventional French *annaliste* conception of the *longue durée* ties to the wider scope of complexity in Big History. It is how Big History revives and expands the French *annaliste* concept of charting broad trends in an all-encompassing and interdisciplinary history.

Cultural complexity, the ability to harness more and more energy, and the capacity to provide for a greater number of innovators is directly tied to the population dynamics and the sociopolitical instability that sometimes results. Thus the Darwinian algorithm, its manifestation in cultural evolution, and the impact it has on population dynamics directly influenced the historical events, the rise and fall of dynasties and empires, and the fluctuating human life-ways and standards of living that characterised much of the conventional history of the ancient, medieval, and early modern periods. The deep tides of the ocean directly influenced the waves, splashes, and foam of the surface. Thereby the big is linked to the small, which is the very core of the *annaliste* and Big History styles.

IV. Historiography of Longue Durée Cycles

a) Early Works on Population Thinking

In order to place Ladurie and his work in a larger historiographical context, this section will deal with the evolution of population thinking in scholarship over the course of several centuries, with a focus on the population debates among historians in the latter half of the twentieth century.

The source of the debate rests in the relationship of population to economics and historical events and the apparent conflict between ecological and sociological variables in the *longue durée* of human history. The idea that population dynamics play a role in historical events, the strength of a civilisation, and the average standard of living for its people is not new. Many pre-modern thinkers drew a very general connection between overpopulation and the rise of famine, disease, and warfare. Plato and Aristotle both identified a connection between overpopulation and the rise of sociopolitical instability and this shaped their views on immigration and birth control.[53] Confucius also saw that overpopulation could lead to civil strife and a drop in the standard of living, and modern Chinese scholars have endeavoured to find out how closely changes in dynasties are tied to population dynamics and sociopolitical instability.[54]

The concern of these great thinkers should not come as a surprise because in the era of agrarian civilisations, the carrying capacity did not rise quickly and population strain was felt

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[53] Plato, *The Republic*, trans. Allan Bloom (New York: Basic Books, 1991 [c.380 BC]), II:372-3, Aristotle, *A Treatise on Government*, trans. William Ellis, (Charleston: Forgotten Books, 1947 [c.330 BC]), II:6.
[54] P-T Ho, *Studies on the Population of China: 1368-1953*, (Cambridge: Harvard University Press, 1959), W-L Chao and S-C Hsieh, *History of the Chinese Population*, (Beijing: People's Publisher, 1988), and CY Cyrus Chu and Ronald Lee, 'Famine, revolt, and dynastic cycles: Population dynamics in historical China' *Journal of Population Economics* (1994) 7:351-378.

every few centuries. Tertullian, an early Christian author who was particularly anxious about the question, lived in a period of overpopulation and subsequent population decline in the Roman Empire (c.160-220 AD).[55] While some have pointed out the absurdity of Tertullian's claims that the earth did not have enough resources to provide for everyone in an age when the population was only a fraction of what it is now (c.250 million) the carrying capacity for the human population in his time was much lower than it is today.[56] The high watermark of the Roman population (c.160 AD) was reduced in Tertullian's lifetime by famine, pandemic, and frequent civil warfare, making the harshness of overpopulation very real *at the time*.[57] Early modern scholars also drew the general connection between population strain in a region and the rise of disasters that reduced the population, the most frequently cited example being Machiavelli, who linked overpopulation with plagues, famines, and (less presciently) floods.[58]

The most thorough examination of these trends in the pre-modern era, however, was done by Ibn Khaldun. The late medieval Islamic philosopher not only recognised a connection between population and human history, but systematised it into a series of patterns or waves.[59] He also drew a connection between population dynamics and state collapse. Khaldun lived in the Maghreb in Northwest Africa, on a thin strip of land between the Mediterranean and the desert. When a Maghrebian civilisation grew powerful, the elites (who practiced polygyny) would multiply rapidly causing an increase in competition for resources, an increase in faction and infighting, and a decline in social cohesion (which Khaldun referred to as '*asabiyyah*'). The agrarian civilisations that lined the coast faced nomadic pastoralists who inhabited the Sahara. When elites were few and social cohesion was high in the agrarian world, a united

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[55] Tertullian, *De Anima*, ed. Jan Hendrik Waszink, (Leiden: Koninklijke Brill, 2010 [c.200 AD]), 30.
[56] Estimate of world population from Massimo Livi-Bacci, *A Concise History of World Population*, trans. Carl Ipsen, (Oxford: Blackwell, 1992), 31.
[57] Peter Turchin and Sergei Nefedov, 233-236.
[58] Niccolò Machiavelli, *Discourses on Livy*, trans. Leslie Walker, (London: Penguin Books, 1984 [1517]), II:5.
[59] Ibn Khaldun, *Muqaddimah*, trans. Franz Rosenthal, (Princeton: Princeton University Press, 1967), 2:272-278.

state could keep the nomads at bay. The moment that elites grew too numerous and the state degenerated into faction and civil war, they were easily conquered by the nomads leading to a change in dynasty or state collapse. Thereafter the pattern began anew. Due to the polygyny causing higher birthrates and the rapid proliferation of the elite, Khaldun assigned a total duration of 80-120 years for such cycles. His work was the first systematic application of population dynamics to shifts in social structure, state collapse, and historical processes. I will be making use of the modernised version of these ideas via the work of my colleague Peter Turchin, which is described near the end of this chapter.

b) Malthus Identifies Agrarian Population Cycles

The modern application of long demographic cycles began with Thomas Robert Malthus, a well-to-do country vicar from the downs of Surrey in southern England. In 1798, he first published *An Essay on the Principle of Population,* which he gradually expanded into a full-length book.[60] The core of his thesis was that human population growth has a consistent tendency to outstrip the resources of the land. Indeed, this is the founding principle of modern ecology for all animal species. It also applies very readily to humanity, both in the nomadic hunter-gatherer lifestyle of the Paleolithic and in the agrarian era c.10, 000 years ago to c.1800 AD. Malthus noted that the population grew much faster than the rate of agricultural production. He pointed out that during periods of overpopulation, food prices increased, real wages dropped due to an oversupply of labour, and shrinking incomes reduced the standard of living of the middling and lower classes to intolerable levels. The strain on the carrying capacity provoked recurrent famines, malnutrition created greater susceptibility to pathogens, and general discontent spilt forth into riot, faction, and war. The outcome was a population 'crash' until numbers became low enough for food prices to drop, wages to rise, and the

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[60] Thomas Malthus, *An Essay on the Principle of Population: As it Affects the Future Improvement of Society with Remarks on the Speculations of Mr. Godwin, M. Condorcet, and Other Writers*, (London: J. Johnson, 1798).

standard of living to resuscitate itself. The result of the constant tension between the shortage of resources and the tendency of the human population to increase rapidly was an oscillation between periods of prosperity and disaster. Malthus had successfully identified the long cycles, or s-curves, that prevailed in the agrarian era.

As mentioned earlier, Malthus also established one of the founding principles of ecology and evolutionary biology. His *Essay on Population* was the direct stimulation for Charles Darwin's theory of natural selection.

> In October 1838, that is, fifteen months after I had begun my systematic enquiry, I happened to read for amusement 'Malthus on Population,' and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observation of the habits of animals and plants, it at once struck me that under these circumstances favourable variations would tend to be preserved, and unfavourable ones to be destroyed. The result of this would be the formation of new species. Here then I had at last got a theory by which to work.[61]

Malthus inspired Darwin's population-based theory that explained what governs the selection of traits in animals and thus drives biological change, adaptation to niches, and speciation over time. The concepts of both agrarian s-curves and natural selection lent themselves to some unpleasant conclusions by nineteenth century thinkers that are worthwhile discussing. Death is central to both systems. In s-curves, death is the only way to relieve the pressure caused by growth in population outstripping the increase of agricultural production. In natural selection, when resources are limited, death is inevitable for those individuals who are outcompeted for resources in their ecosystem and their extinction is a necessary part of evolution. In both systems, the well-being of the individual is endangered, the well-being of the whole is impossible, the suffering of many is inevitable, and death is, from a certain point of view, desirable, because without it neither evolution nor agrarian civilisations could sustain themselves.

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[61] Charles Darwin, *The Autobiography of Charles Darwin*, ed. Francis Darwin, (London: John Murray, 1887), 82.

The problem was that Malthus continued to apply his stark principles to human populations in his own period. Malthus had no way of knowing he was living in the middle of a transformation – an explosion of production no less significant than the transition from Palaeolithic foraging to the greater productivity of agriculture. The carrying capacity was being raised by new technologies, and the recurrent population crises of the agrarian era seemed to be coming to an end. Industrial production was increasing the productivity well ahead of prices, thus raising the carrying capacity and rendering Malthus's principle of population less and less applicable. Unfortunately, Malthus and his adherents continued to apply his logic to industrial society for much of the nineteenth century even while his 'iron law' of population continued to rust. The Malthusian mindset impeded calls for the improvement of working conditions, the introduction of modest welfare services, and efforts to better the condition of the poor because it suggested that the death of the poor and starving was part of a 'natural' process that should not be tampered with.

Malthus rejected the egalitarian ideals of the French Revolution and the potential for the limitless improvement of society through intellectual progress or some kind of social reform. He disagreed with Rousseau's view of man as fundamentally good, and saw in the downturn of population cycles the flaws of the animal side of human nature, and our tendency to breed and to glut ourselves on our resources regardless of long term consequences. In this sense, mankind and society could never be perfected along the lines of Malthus's chosen intellectual adversaries, Godwin and Condorcet. Harkening back to Hobbes, Malthus painted a picture of man as a fundamentally flawed beast who is either ruled by authority or must be left at the mercy of the harshness of nature. And to be sure, mankind is, in a certain sense, nothing more than a pack of 'monkeys in shoes.' We are animals with maladaptations, evolutionary flaws, and obsolete instincts that are ill-suited to the sudden appearance of agriculture and industry. However, unlike evolutionary psychologists of modern day who would see the flaws in the human character as an extension of biology, and the bad wiring of evolution and overpopulation as a natural tendency of most species in ecology, Malthus deplored it on Judeo-Christian grounds. Man was born in sin. Some would be redeemed and some would not. In a strange application of the already strange doctrine of 'predestination', Malthus reasoned that those born into poverty had no place 'at nature's mighty feast' and their reduced circumstances were the responsibility of their own undeserving existence. They were already forsaken by God and they endangered the standard of living of the rest. His ideas built the case for poverty being inevitable and that charity only perpetuated the problem by keeping the surplus population alive.

The writings of Malthus were taken up by many nineteenth century thinkers to justify lack of support for the poor, oppose social reform, avoid 'encouraging' the tendency toward overpopulation, and view the suffering and death of the poor as inevitable or even a positive thing. This hard-nosed ideology created needless suffering in the nineteenth and twentieth centuries, since for one of the first times in all of human history, the carrying capacity was rising fast enough to support a rapidly increasing population. This tendency also provoked opposition to Malthusianism, particularly in the writings of Karl Marx, who stated that food shortage was the result of social structure not of ecology, something that echoed down the years to the debate between neo-Marxist historians and the neo-Malthusian *annalistes* in the 1970s and 1980s.

c) Ricardo Identifies How Overpopulation Widens the Wealth Gap

David Ricardo, a contemporary of Malthus, further developed the concept of demographically-driven long cycles and one of his greatest contributions for our purposes was that he showed how the upper echelons of society profited from circumstances of overpopulation and stagnating production.[62] Population growth might decrease wages, which increases profits, because more labourers competing in the workplace mean their employers will not have to pay them as high. If one presumes that there are no improvements in agricultural production (and indeed the rate of innovation in the agrarian era was relatively slow) the amount of profit and capital increases steadily with the growth of population until all available land is brought under cultivation. Thereafter increasing production for more people requires more capital put into either labour numbers or land/infrastructure development, eventually leading to a diminished return for a proportionally similar input. As the input of a landholder on his property increases for the same return, he raises the rents on his land to compensate. This dynamic is accentuated by overpopulation, high property prices, and a general shortage of land. At the same time, increased population, increased demand, and the increased cost of producing the same output raises the price of food, which greatly profits the landholder, much to the detriment of the labourer. As a result, the interests of the landlord are 'always opposed to the interests of every other class in the community.'[63]

Unfortunately this sort of trend does not create a wealthy nation, as Ricardo points out. It creates a wealth inequality gap. A nation's wealth is based not on the price of goods but on the amount of goods that are circulating through a market. This is why Ricardo disagreed with Malthus about imposing the Corn Laws, and suggested a form of free trade to lower prices on goods and thereby to enhance the standard of living of the average subject. I do not wish to wade into the morass of Ricardian economics (including the idea of 'natural wages') and while Ricardo vastly developed the Malthusian question in other respects, by far his greatest contribution for our purposes is to point out how long cycles in population have a varying

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[62] David Ricardo, *An Essay on the Influence of a Low Price of Corn on the Profits of Stock: Showing the Inexpediency of Restrictions on Importation with Remarks on Mr. Malthus' Last Two Publications*, (London: John Murray, 1815).
[63] Ricardo, 20.

impact on different social orders. In times of low population wages are high and prices are low and the worker lives well. In times of high population the landowner/producer profits from the overabundance of cheap labour and the high price he can assign to essential goods. Thus in all long cycles there is a class divide. He did not delve into the social dynamics of an actual population crash.

d) 20th Century Economists Search for Long Durée Cycles

In the twentieth century, the study of long cycles drifted to the Continent in the works of Nikolai Kondratiev, François Simiand, Jenny Griziotti-Kretschmann, and Wilhelm Abel. Nikolai Kondratiev was a Russian economist who in 1925 published a work that identified roughly fifty to sixty year cycles of alternatively rapid and slow growth.[64] He soon fell afoul of the Soviet regime for his opinions, was successively fired, shipped off to a Gulag, and eventually executed for his pains. The cycles, according to Kondratiev, were divided into periods of expansion, stagnation, and decline. In this way his cyclical model was very similar to the cycles that ecologists study in demographics. Although a model for economic cycles, it is still an example at an attempt at *longue durée* cycles. Observing how economies in the late eighteenth and throughout the nineteenth centuries seemed to vary in pace of growth over time, he assigned the cause to the shaky logic that at some point the market is saturated with a certain major product. This could occur for a variety of reasons later guessed at by a variety of theorists. Unfortunately no sound logic was crafted to explain these economic fluxes and today 'Kondratiev cycles' are not accepted by the majority of economists. However, the idea of a division of growth into phases of expansion, stagnation, and decline is another major contribution to theories of long waves when assigned to more demographic and structural mechanisms, rather than just economic ones.

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[64] Nikolai Kondratiev, *The Major Economic Cycles*, (Moscow: Voprosy Koniunktury, 1925).

In the meantime, work continued to be conducted in Western Europe exploring long cycles. In 1932, François Simiand looked at price movements over the early modern period and identified a series of long waves of rise and decline in the cost of various goods.[65] Simiand hypothesised that the driving force was a change in the availability of precious metal for currency, which then impacted the rate of inflation. At no point did Simiand or his followers give primacy to a strictly demographic driving force, and erred more on the side of monetarist explanations. At best they suspected some proximate change in the yield of the harvest drove the fluctuations in prices.[66] These explanations were never fully satisfactory, even to their authors, and lacked a strong empirical base. Not long after, however, Italian historian Jenny Griziotti-Kretschmann produced a work that was strongly couched in empirical evidence.[67] Her findings did not conform to the Kondratiev sequence of fifty to sixty year waves, did not rely on its theory of saturation, and also were at variance with Simiand's explanation of the availability of precious metals. Instead Griziotti-Kretschmann assigned the fluctuations to proximate changes in the structure of the economic and political systems of the time. This unfortunately could not account for the fact that similar waves struck regions with vastly different economies and political systems.

e) Wilhelm Abel Revives the Malthusian Model

The turning point in this period of research came with the work of Wilhelm Abel in 1935, which looked at Western Europe from 1200-1900 and contained a wealth of evidence, time-series information, and clear illustrations of the fluctuation in prices of various goods,

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[65] François Simiand, *Les fluctuations économiques à longue période et la crise mondiale*, (Paris: Félix Alcan, 1932) and *Recherches anciennes et nouvelles sur le mouvement général des prix du XVIe au XIXe siècle*, (Paris: Domat Montchrestien,1932).
[66] C.-E. Labrousse, *Esquisse du mouvement des prix et des revenus en France au XIIIe siècle*, (Paris: Dalloz, 1932).
[67] Jenny Griziotti-Kretschmann, *Il problema del trend secolare nelle fluttuazioni dei prezzi*, (Pavia: University of Pavia, 1935) and 'Richerche sulle fluttuazioni economiche di lungadurate' *Giornale degli Economisti* 73 (1933), 461-508.

along with corresponding graphs on wages, rents, and population numbers.[68] He also identified several long waves of prices: an increase c.1200-1300, a decline 1300-1450, an increase 1450-1600, followed by stagnation and decline 1600-1700, and an increase 1700 and erratic fluctuations during industrialisation in the nineteenth century, before declining by 1900.

Abel was more successful than his contemporaries in making sense of the price waves because he placed an emphasis on grain prices, which as the most basic amenity took precedent over all other goods in an agrarian economy, while other authors had focused on a collection of items. Abel also measured prices not in currency but in kilograms of silver to avoid clouding the data. Abel did not assign the cause of these fluctuations to the availability of precious metals or currency. Instead he identified a correlation between population levels and food prices and an inverse correlation between those and wages. It appeared that an increased population raised the price of food due to increased demand and lowered that of wages due to an oversupply of labour. A strong demographic element closely tied to population growth seemed to have a strong influence over the fluctuation of these waves.

At a stroke the Malthusian model was revived. Naturally, as pointed out above, the Malthusian model failed to make sense for the Industrial Revolution. But for the era of agrarian civilisations a clear explanatory mechanism for *longue durée* cycles was found. The slow rise of the carrying capacity between the invention of agriculture and advent of industry was responsible for s-curves in the population every few centuries even while the world's population grew as a broad trend. A population grew rapidly in the agrarian era, outstripped the yield of the land, and crashed. Meanwhile, at large scales of many centuries or millennia, the yield of the land was slowly raised as generations passed by due to improvements in

[68] Wilhelm Abel, *Agrarkrisen und Agrarkonjunktur*, (Berlin: Verlagsbuchhandlung Paul Parey, 1935) and the English reprint *Agricultural Fluctuations in Europe: From the Thirteenth to the Twentieth Centuries*, trans. Olive Ordish, (New York: St. Martin's Press, 1978).

technology and agricultural methods. This was a result of what we refer to as collective learning, which we shall later explore in greater detail.

f) Is the Driving Force of History Demographics or the Class Struggle?

After the war, a number of Marxist historians took up the demographic question. In 1946, Maurice Dobb looked at the population decline in Western Europe c.1315-1450 and saw it as the result of an increasing number of elites proportional to the total population, who were growing more aggressive in their conspicuous consumption. The peasants were then squeezed so badly they started dying.[69] All of this is built up into the Marxist historical concept of a 'crisis of feudalism' (echoed by Guy Bois) as part of reconciling historical facts to Karl Marx's model of a transition from feudalism to capitalism. Dobb did not employ a pure Malthusian model, but preferred to attribute the driving cause to social structure. The intensification of feudalism, according to Dobb, led to the death of large numbers in the population, which in turn backfired by destroying the incomes of the landowning class and caused the disintegration of feudalism.

Paul Sweezy, another Marxist who, writing in 1950 said that Dobb's book on the transition from feudalism to capitalism was important because they were living in an age of 'transition from capitalism to socialism', nevertheless took Dobb to task on this theory. Sweezy asserted that Dobb does not adequately explain why feudalism became so intense at that point in time. He also doubted whether there was a significant growth in the numbers of the landowning class. Finally, Sweezy hypothesised that the growth in number of elites and their extraction of resources from the masses was due to the expansion of trade following what some medievalists call the 'Great Leap Forward' of the eleventh century.[70] This implies a

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[69] Maurice Dobb, *Studies in the Development of Capitalism*, (New York: International Publishers, 1946), 42-47.
[70] Paul Sweezy, 'The Transition from Feudalism to Capitalism' *Science and Society* 14 (1950) 134-167, esp. 142-144 and Paul Sweezy, et al. *The Transition from Feudalism to Capitalism*, (London: NLB, 1976), 38-39 &106.

longer process of transition from feudalism to capitalism than some models that place it in the sixteenth or seventeenth centuries. Both Marxists treat population fluctuations as a mere symptom of the changes in social structure. They saw little connection between population fluctuations and changes in modes of production.

Other Marxists did not find the demographic factor to be at all compatible with the model of a transition to feudalism. E.A. Kosiminsky, for instance, completely denied a long term population decline 1350-1450, though this position is roundly contradicted by a vast mass of historical evidence.[71] To varying degrees, at this early stage, Marxist historians did not assign much importance to the demographic fluctuations and long cycles in wages and prices identified by Abel. Their focus was primarily on the shifts in social structure that may or may not have been associated with them.

Around the same time, however, economic historian Michael Postan, a British historian and refugee of the 1917 October Revolution, rejected the theory that price fluctuations were determined by the availability of precious metals. He assigned prime importance to the demographic factor. Working mostly with English sources, Postan's attack concerned monetarist theories and he more or less reaffirmed the findings of Wilhelm Abel, whereby there is a correlation between population numbers, prices, the real wage, rents, and so forth. He was more ambiguous about the role elites played in these cycles and what sort of dynamics they experienced. For the most part, however, Postan found that overpopulation had reduced living standards and raised prices at the end of the 1200s and early 1300s, and identified a reversal of this trend following the Black Death and the Hundred Years War. He

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[71] E.A. Kosiminsky, *Studies in the Agrarian History of England in the Thirteenth Century*, (Oxford: Oxford University Press, 1956); for empirical contradiction one need look no farther than the work of fellow Marxist historian Guy Bois, *La crise du féodalisme: économie rurale et démographie en Normandie orientale du début du XIVe siècle au milieu du XVIe siècle*, (Paris: Fondation nationale des sciences politiques, 1976) which shows an enormous drop of population 1350-1450, on the order of 50-75%. Numerous other empirical works on the late medieval population that contradict Kosiminsky are too numerous to list here, since virtually all of them written on the question do. Some of them are cited below.

did not like to associate himself with Thomas Malthus, however, preferring either to identify with a 'Ricardian model', or, more emphatically, to assert the uniqueness of the new demographic position. While virulently anti-communist throughout his career, Postan did not explicitly reject the application of the Marxist historical model or the impact of changes in social structure on population, and once referred to Karl Marx as 'that universal genius'.[72]

Emmanuel Le Roy Ladurie was less hesitant to associate himself with the theories of Malthus. Ladurie was the disciple of Fernand Braudel in the French *Annales* school, which also boasted scholarly greats like Lucien Febvre, Marc Bloch, George Duby, Ernest Labrousse, and Jacques Le Goff. The *Annales* school was frequently opposed to the philosophy of Marxist historians and rejected class conflict as central to historical change. The implications of Malthusianism in the medieval and early modern period were already troublesome to the interpretations of some Marxist historians, and when adopted by a traditionally hostile school it had all the makings of a bitter debate. Ladurie's mentor, Fernand Braudel, taught him to look beyond largely 'ephemeral' social structures toward longer, deeper, hardly perceptible processes that make up the Braudelian concept of the *longue durée*.[73] Ladurie's work also came along in the middle of a trend toward demography in French historical studies.[74] While Braudel gave birth to the concept of the *longue durée*, Ladurie articulated a plausible theory about its mechanics and driving force.

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[72] Michael Postan, 'Some Economic Evidence of Declining Population in the Later Middle Ages' *Economic History Review* (1950) 2: 4 and for distancing from Malthus, Michael Postan and John Hatcher, 'Population and Class Relations in Feudal Society' *Past and Present* 78 (1978) 24-28, see also Postan 'Moyen Âge' in *IXe Congrès international des sciences historiques*, 2 vols (Paris: A. Colin, 1950), 'Medieval Agrarian Society in its Prime: England' in *Cambridge Economic History* vol. 1, ed. M. Postan, (Cambridge: Cambridge University Press, 1966), and *Essays on Medieval Agriculture and General Problems of the Medieval Economy*, (Cambridge: Cambridge University Press, 1973).
[73] Braudel later took on the mantle of demography in his own treatments, Fernand Braudel, *The Identity of France: People and Production*, trans. Sian Reynolds, (Glasgow: Collins, 1990).
[74] Ladurie's work came along in a general climate of work on demography in French historical studies, such as Robert-Henri Bautier, 'Feux, population et structure sociale au milieu du XVe siècle: L'example de Carpentras' *Annales* (1959) 14:255-268, E. Baratier, *La démographie provençale du XIVe au XVIe siècle*, (Paris: Ecole Practique des Hautes-Études, 1961), Guy Fourquin, *Les campagnes de la region parisienne, à la fin du Moyen Age*, (Paris: Presses Universitaires de France, 1964), Marc Bloch, *French Rural History: An Essay on its Basic*

Ladurie's doctoral thesis, *Les paysans de Languedoc* was published as a book in 1966 and in English in 1974. Wholeheartedly adopting the interpretation of Wilhelm Abel and applying it to the data on population figures, prices, and wages in the medieval and early modern period, Ladurie's work was the first systematic example of how history could be written from the perspective of long demographic cycles. He demonstrated, using numerous historical examples, how a population expands beyond subsistence levels, degenerates into famine, plague and war, until the population is low enough to return to prosperity, a high standard of living, and renewed growth. He also pointed to the cyclical nature of this process and also noted how Malthus was writing at the end of this period of cycles. Ladurie's work sent shockwaves into the English-speaking world.[75] It changed the way many historians viewed history, not only the demographic question, leading to a flood of related works on population, prices, and wages, the foremost of which was the vastly extensive work by Jacques Dupâquier.[76]

Characteristics, trans. Janet Sondheimer. (London: Routledge and Kegan Paul, 1966), Yves Durand, 'Recherches sur les salaries des maçons à Paris au XVIIIe siècle' *Revue d'Histoire Économique et Sociale* (1966) 44:468-480.

[75] Emmanuel Le Roy Ladurie, *Les paysans de Languedoc*, (Paris: SEVPEN, 1966), and the English translation *Peasants of Languedoc*. trans. John Day. (Urbana: University of Illinois Press, 1976), see also *The French Peasantry: 1450-1660*, trans. Alan Sheridan, (Aldershot: Scolar Press, 1987), *The Royal French State* (Oxford: Blackwell, 1994), and with Michel Morineau, *Histoire économique et sociale de la France, de 1450 à 1660*, (Paris: Presses Universitaires, 1977), with Joseph Goy, *Tithe and Agrarian History from the Fourteenth to the Nineteenth Centuries: An Essay in Comparative History*, trans. Susan Burke, (Cambridge: Cambridge University Press, 1982).

[76]Jacques Dupâquier et al. *Histoire de la Population Française*, 4 vols, (Paris: Presses Universitaires de France, 1988), see also Micheline Baulant, 'Le prix des grains à Paris de 1431 à 1788' *Annales, Histoire, Sciences Sociales* (1968) 3:520-540, 'Le salaire des ouvriers du bâtiment à Paris de 1400 à 1726' *Annales, Histoire, Sciences Sociales* (1971), 26:463-483, Russell, J.C. 'Population in Europe 500-1500' in *The Fontana Economic History of Europe*, ed. Carlo Cipolla, (London: Collins, 1969), M. Belotte, *La region de Bar-sur-Seine à la fin du Moyen Age: du début du XIIIe siècle au milieu du XVIe siècle, etude economique et sociale*, (Lille: Université de Lille, 1973), A. Croix, *Nantes et le pays nantais au XVIe siècle: Étude demographique*, (Paris: SEVPEN, 1974), J. Jacquart, *La crise rurale en Ile-de-France: 1550-1670*, (Paris: Armand Colin, 1974), Pierre Charbonnier, *Une autre France: La seigneurie rurale en Basse Auvergne du XIVe au XVIe siècle*, (Clermont-Ferrand: Institut d'Études du Massif Central, 1980), H. Neveux, *Vie et déclin d'une structure économique: les grains du Cambrésis, fin du XIVe – début du XVIIe siècle*, (Paris: École des hautes-études en sciences sociales, 1980), Elisabeth Carpentier, and Michel Le Mené, *La France du XIe au XVe siècle: population, société, économie*, (Paris: Presses Universitaires de France, 1996), William Jordan, *The Great Famine: Northern Europe in the Early Fourteenth Century*, (Princeton: Princeton University Press, 1996), David Fischer, *The Great Wave: Price Revolutions and the Rhythm of History*, (Oxford: Oxford University Press, 1996), Robert Allen, 'The Great Divergence in European Wages and Prices from the Middle Ages to the First World War' *Explorations in Economic History* 38 (2001) 411-447.

Ladurie also polarised the debate. It did not help that Ladurie adopted an increasingly fanatical Malthusian tone and was very hard in his rejection of key Marxist concepts, for instance, 'it is in the economy, in social relations, and even more fundamentally, in biological facts, rather than the class struggle, that we must seek the motive force of history' and that structural things like class were 'meek' before the great Malthusian 'forces of life and death'.[77] With language like that, it is no wonder that Marxist historians, at their intellectual and scholarly height in the 1970s, got their backs up. For the neo-Malthusian faction evolving under Ladurie, class was largely excluded from the question of a broader historical evolution through long cycles. For the Marxist historians, for whom the class struggle was central, this was intolerable.

g) The Brenner Debate

It was these febrile conditions that kicked off what is known as 'the Brenner Debate'. In a 1976 edition of *Past and Present*, Robert Brenner, a fairly devoted and doctrinaire Marxist historian who never, unlike many of his generation, dropped or moderated his adherence to Marxism after the Cold War, attacked what he called 'demographic determinism' as obscuring the 'real' processes that drive historical change, i.e. class.[78] For Brenner, it is not an exaggeration to say class structure was all-consuming and always had to be analysed in order to understand long term economic development. The class struggle had outcomes that directly determined how an economy evolved from feudalism to capitalism. This is why Brenner objected to demographic explanations since after the Black Death, Europe took different courses. Western Europe lost serfdom, Eastern Europe regained it. England made a gradual move to constitutional monarchy, France moved to absolutism. Such was his

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[77] Emmanuel Le Roy Ladurie, 'L'histoire immobile' *Annales E.S.C.* 29 (1974), 675 & 689.
[78] Robert Brenner, 'Agrarian Class Structure and Economic Development in Pre-Industrial Europe' *Past and Present* 70 (1976) 30-75 and reprinted in T. Ashton and C. Philpin (eds) *The Brenner Debate: Agrarian Class Structure and Development in Pre-Industrial Europe*, (Cambridge: Cambridge University Press, 1985), from which the so-called 'Brenner Debate' draws its name.

reasoning. Brenner nevertheless tipped his cap to Ladurie for producing something with compelling logic that 'seems almost foolproof'.

But Brenner pointed out that the Malthusian model was not enough to explain why the population stayed low for a hundred years after the Black Death. According to Malthusian theory, overpopulation indeed could have provoked population decline, but after a drop-off as catastrophic as the Black Death, one should have seen the population rapidly rebound due to the sudden drop in food prices and hike in wages due to a labour shortage. Indeed these things occurred, but the population remained low. For instance, the population of France had a population of 18 or 19 million before the successive waves of the Black Death but did not begin to recover from a low point of 10 million until after 1450, and only reaching 18 or 19 million again c.1550.[79] Thus, Brenner concluded, the continuing stagnation of Europe in the fifteenth century had to be explained by analysis of class structure and the overexploitation of the peasantry by the elite. Brenner went on to assert that peasants had no incentive to abandon traditional life ways and were forced into capitalism by the exploiting classes.

It must be noted, however, that Brenner drew fire from other Marxists for both factual and theoretical inaccuracies. Foremost among his Marxist critics was Guy Bois, who congratulated Brenner for his 'courageous attack' on the 'Malthusian orthodoxy' that was 'crushing Marxist historiography in its tentacles' but accused him of making up his mind about Marxist 'generalisations' and then imposing them irrespective of what was shown by the historical source material. Bois also questioned Brenner's 'ideological motivations' behind his 'unbalanced injection' of class conflict as the determinant of historical development. Bois argued that you cannot explain the Industrial Revolution in the nineteenth and twentieth century purely by class structure, so why presume you can for the medieval and early modern

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[79] Turchin and Nefedov, *Secular Cycles*, (Princeton: Princeton University Press, 2009), 240-242.

period?[80] He accused Brenner of oversimplification, particularly in relation to the differences between England and France, treating them as success and failure stories. Bois claimed that capitalism was a by-product of feudalism as a whole (ignoring Brenner's own example of West and East). Bois had, of course, recently completed his own masterful work on French population and prices in Normandy.[81] The book was extremely well supported with empirical evidence, birth rates, population estimates, lists of worker's wages in Rouen, and showed many demographic fluctuations after the fashion of Abel and Ladurie, but used a Marxist interpretation whereby class struggle and exploitation was the driving force of human historical change.

Nevertheless, demography played a very central role in Bois's interpretation. He admonished Brenner that the Malthusian model was a useful tool that should not be abandoned by the Marxist school purely because it appeared to overshadow its core principles. One had to adapt and incorporate. In fact, Bois advocated the wholesale removal of population dynamics from the *Annales* school and its annexation to the Marxist one. Unfortunately in his work and in subsequent commentary, Bois never fully managed to distinguish why his analysis *was* Marxist and not 'neo-Malthusian' with a simple Marxist veneer. And indeed many of his conclusions and much of his research can be employed to follow the Malthusian dynamics of what looks and feels like the *longue durée* without even taking time to explain away the Marxist aspects of his analysis. In many ways it reads and feels like an *annaliste* history, as Ladurie himself was quick to point out.[82]

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[80] Guy Bois, 'Against the Neo-Malthusian Orthodoxy' *Past and Present* 79 (1978) 60-69, which despite its name is mostly devoted to quarrelling between the two Marxists.
[81] Guy Bois, *La crise du féodalisme: économie rurale et démographie en Normandie orientale du début du XIVe siècle au milieu du XVIe siècle*, (Paris: Fondation nationale des sciences politiques, 1976), and the English version, *The Crisis of Feudalism: Economy and Society in Eastern Normandy, c.1300-1550*, (Cambridge: Cambridge University Press, 1984), see also *La grande depression médiévale, XIVe-XVe siècles: le precedent d'une crise systémique.* (Paris: Presses Universitaires de France, 2000).
[82] Emmanuel Le Roy Ladurie, 'En Haute-Normandie: Malthus ou Marx?' *Annales: Histoire, Sciences Sociales*, 33 (1978) 115-124.

In contrast, the response of the 'demographic camp' to Brenner was fairly muted. Michael Postan, for instance, remained respectful of Marxist historiography and went no further than to claim Brenner 'misrepresented' his views and that demography was not omnipresent in all economic and social activity according to his model. Postan found the accusation that he ignored social factors was unwarranted. On the contrary, Postan claimed, the Marxist view was too narrow. There is more to the feudal system than class conflict, he said. He accused Brenner of assigning the landlord too much power over the peasantry and pointed out they too were afflicted by the processes of population collapse, referring to their impoverishment and the high wages they had to pay after the Black Death right up to the sixteenth century. In relation to Brenner's objection that East and West parted ways after the population decline of the fourteenth century, Postan pointed out that similar processes do not need to produce identical results. He also rejected the title 'Malthusian' and claimed that he could not be described as such unless *all* demographic theories could be described as Malthusian. He preferred to be called 'Ricardian', but even that, he said, did not quite fit the demographically-driven theory that was coming into being.[83] Indeed we still lack an accurate label for it.

Ladurie, in his own response, was perfectly comfortable being classed as a 'neo-Malthusian' but claimed that his was not a Malthusian model, because the theory had advanced since then, as indeed it had. He denied that his model excluded class structure, but in fact incorporated it. He accused Brenner of completely ignoring the work of Wilhelm Abel. He accused Brenner of oversimplification, for relegating the surplus extractors and ruling classes into one group. He also cited the work of Guy Bois on Normandy, which highlighted many of the variables of Ladurie's own theories and he claimed that the fact Bois called

[83] Michael Postan and John Hatcher, 'Population and Class Relations in Feudal Society' *Past and Present* 78 (1978) 24-37.

himself a Marxist added all the more objectivity to the corroboration of his theory. Ladurie also stated that Brenner greatly underestimated the role of epidemics in the fourteenth and fifteenth century, and assigned more credit to the exploitation of the upper classes as a cause of population decline than to the devastation of pathogens. Ladurie also denied that the presence or absence of serfdom confirms or disproves the validity of demography playing an enormous role in medieval history. He pointed out that the intensification of labour services in the thirteenth century directly coincides with predictions of a neo-Malthusian model in times of overpopulation and he pointed out that the French system was not so very different from England as to be more authoritarian in later periods, since in France too serfdom diminished. The rise of serfdom in Eastern Europe, Ladurie said, was also not contradictory since there were also holdovers in Burgundy and the Franche-Comté, and it would appear serfdom was not dependent on demographic processes to thrive or decline.

France did not escape Malthus in the seventeenth century like England, Ladurie claimed, not because of any significant institutional differences, but because agricultural reform and the raising of the carrying capacity only took place from 1720 (and not after 1800 as Brenner suggested). Ladurie accused Brenner of being too disparaging of French agriculture in the eighteenth century, which indeed underwent many significant improvements that for the first time in French history raised the carrying capacity from a peak of about 20 million people (attained in the early fourteenth, mid-sixteenth, and seventeenth centuries) to nearly 30 million by the end of the 1700s. Indeed Brenner's desolate view of eighteenth century French agriculture is extremely antiquated. Historical research, including that explored later in this work, has shown that eighteenth century agriculture in France was extremely innovative. Finally, Ladurie said that surely the Marxist route of peasant disenfranchisement *á l'anglaise* was only one path to modernisation and capitalism. Peasant economies were perfectly capable of supporting the transition to capitalism, Ladurie pointed out, as seen in Holland, Belgium, South France, Northern Italy, Japan, and Catalonia.[84]

h) The Unexplained Problem of Population Depression

While Postan and Ladurie's responses, in addition to the critique of Bois, diminished the credibility of many of Brenner's objections to the demographic thesis, they still failed in one significant respect. None of them could account for the fact that the population remained low for another hundred years after the Black Death (known as a population depression). Indeed the population in many areas dropped even lower, as Guy Bois illustrated for Normandy. Brenner responded to his Marxist and non-Marxist critics with a lengthy article in which article failed to establish any new objection or convince many people of his own position.[85] But the crucial blow was already struck. The demographic school could not adequately account for the population depression in Western Europe c.1350-1450. Ladurie and Postan were unable to mount an effective response or to adequately incorporate the social side of the equation in a mechanistic way and soon even the Marxist school gradually fell into decline and disrepute in the late 1980s and 1990s. There the matter rested.

A second wave of criticism of the demographic camp came from monetarist and neo-classicist economic historians in the 1990s and 2000s. Prominent among them were David Weir, George Grantham, and Jan de Vries. They rejected both the Marxist and Malthusian models as somewhat antiquated. In the spirit of much history of the post-Cold War era, these historians gave up on the idea of a metatheory for history since human activity was just too complicated to be condensed to a set of broad patterns or scientific-sounding laws. While little time was spent discrediting the Marxist school, since they largely took Marxism's disgrace for granted due to political events, the neo-classicists brought up all the old arguments against the

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[84] Emmanuel Le Roy Ladurie, 'A Reply to Professor Brenner' *Past and Present* 79 (1978) 55-59.
[85] Robert Brenner, 'The Agrarian Roots of European Capitalism' *Past and Present* 97 (1982) 16-113.

Malthusian case: that it fails to account for social complexity and diversity of economic and political structures and that it fails to account for sustained population depressions.

None of them clearly articulated anything to replace those theories, nor do they seem to feel any need to, dwelling, as deconstructionists of all stripes often tend to do, on the ‘complexities’ of the situation. Grantham was known for putting forward notions of ‘cliometrics’ as a promising new discipline whereby economics could be the driving force of historical interpretation. Jan de Vries, a Dutch scholar, put forward the idea of ‘the industrious revolution of the seventeenth century’ being responsible for the industrial revolution, claiming that the downturn of the economy in the seventeenth century provoked people to work harder. This idea has managed to hold on to credibility, but it does not fully account for regional diversity outside of Holland and England where the same pinch was felt with no indication of a shift, or an empirically supported transition between the ‘industrious’ to Industrial revolutions that was any more clearly indicated by the evidence than the old Marxist transition from feudalism to capitalism.[86]

The work of the neo-classicists and monetarists also largely ignored the findings of economists François Simiand, Jenny Griziotti-Kretschmann, and the decisive proof put forward by Wilhelm Abel. The papers cited here also have a tendency to set up a straw man target in Ladurie’s *l’histoire immobile* by pointing out the numerous instances of growth and innovation in pre-industrial Europe. Unfortunately, the term as Ladurie used it does not imply

[86] David Weir, ‘Life Under Pressure: France and England 1670-1870’ *Journal of Economic History* (1984) 44:27-48, George Grantham, ‘Contra Ricardo: On the Macroeconomics of pre-Industrial Economies’ *European Review of Economic History* (1999) 2:199-232, Philip Hoffman and Jean-Laurent Rosenthal, ‘New Work in French Economic History’ (2000) *French Historical Studies* 23:439-453, George Grantham, ‘Explaining the Industrial Transition: A non-Malthusian Perspective’ *European Review of Economic History* (2008) 12:155-165, Jan de Vries ‘The Economic Crisis of the Seventeenth Century After Fifty Years’ *Journal of Interdisciplinary History* (2009) 40: 151-194, Anne McCants ‘Historical Demography and the Crisis of the Seventeenth Century’ *Journal of Interdisciplinary History* (2009) 40:195-214. Philip Hoffman has also tried to paint a portrait of steady growth in agricultural productivity by using a questionable system of measurement that combines prices, wages, and leases, rather than counting what was actually produced per worker or hectare, *Growth in a Traditional Society: The French Countryside, 1450-1815*, (Princeton: Princeton University Press, 2000), 81-86 & 130.

that no growth or innovation occurred, but rather that the carrying capacity that existed before the Industrial Revolution meant that waves of growth were followed by periods of decline – one step forward, one step back – rather than complete stasis.

Nevertheless, the decline of metatheories in general after the Cold War and the general disparagement of Ladurie's school meant that as far as mainstream economic historiography was concerned, the Malthusian vision of long cycles was effectively dismantled. The population fluctuations of the medieval and early modern era were moreover assigned to more proximate causes and no broad or repeating patterns were recognised to exist. Thus a void was created where the old Malthusian and Marxist metatheories once were, which these post-Cold War monetarist and neo-classicist historians did not expect (or want) anyone to fill, except perhaps with a gradual accumulation of many short-chronology pieces of specialised research.

i) The Return of Meta-Theory & an Answer to the Depression Problem

However, in the very same works in which the neo-classicists were tearing strips off the Malthusian theory, most of these historians were suitably impressed by the 'demographic-structural' model put forward by social theorist Jack Goldstone in 1991.[87] Jack Goldstone not only was reintroducing the Malthusian mechanism into economic history (he calls himself 'post-Malthusian') but also the concept of long cycles and repeating patterns. Once more the idea of long cycles was revived. Furthermore, Goldstone's idea of population growth kicking sociopolitical instability into social structures in cyclical patterns contradicts the rejection of broad patterns and meta-theories, the assertion that human activities are 'too complex' to interpret in broad patterns, and the reliance on more proximate causes for economic change.

Goldstone took Ladurie's thesis about overpopulation leading to cycles of rise and decline and used social structure to explain why the population was often held low by the

[87] Jack Goldstone, *Revolution and Rebellion in the Early Modern World*, (Berkeley: University of California Press, 1991). For instance see the McCants article, 203-204.

political instability that followed the decline of the incomes of the elite. Instead of overpopulation being the direct cause of state collapse, it provoked the socio-political instability that was responsible for it. Goldstone's focus was more on the cause of revolutions, but here at last was a closer answer to why populations remained in depression long after the initial fourteenth century crash than the Marxist or *Annales* schools could ever conceive. Another admirable attempt at sketching the 'long cycles' was by David Fischer. His focus was more on the role of price movements rather than illustrating a purely demographic process. Fischer did tie his price movements, however, very closely to population fluctuations, and in this respect is the successor of Wilhelm Abel. He identified the same waves that Abel did and Fischer also identified another wave of prices in the twentieth century and warned of impending crisis at some point in the twenty-first century.[88] Finally, Ian Morris has in two books addressed the effect of population on human social development, created a rough metric for social development, which roughly accords with the rise and fall of population and sociopolitical stability charted by the others mentioned here.[89]

Not all attempts at a revival of long cycles or population-driven mechanisms have been positive. Immeasurable damage has been done to the credibility of the concept by the work of Gregory Clark in *Farewell to Alms: A Brief Economic History of the World*. Educated at Cambridge and Harvard, Clark seriously contends that the origin of the Industrial Revolution has a genetic basis. He commences his book by claiming that the average person before the Industrial Revolution was no better off than a human being from 100,000 BC and sweepingly writes off all the changes that occurred in between that time, as well as all the previous historical explanations for the Industrial Revolution. Instead he invokes a bizarre form of

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[88] David Hackett Fischer, *The Great Wave: Price Revolutions and the Rhythm of History*, (Oxford: Oxford University Press, 1996), 181-203.

[89] Ian Morris, *Why the Rest Rules for Now: The Patterns of History and what they Reveal about the Future*, (New York: Farar, Straus, and Giroux, 2010) and *The Measure of Civilization: How Social Development Decides the Fate of Nations*, (Princeton: Princeton University Press, 2013).

natural selection. His thesis boils down to this: rich men in England between 1250 and 1800 had more kids than poor men. The poor families of 1250 slowly died out. The kids of rich men had to move down the social hierarchy in order to find work. The family traits of patience, hard work, ingenuity, innovativeness, and education were biologically selected for and spread through the population. Nowhere was this process more complete than in England because of the 'stability' and slow growth of the English population and 'the extraordinary fecundity of the rich and economically successful.'[90] The Industrial Revolution, according to Clark, occurred in England not because of the accident of coal deposits or invention, but because the English were genetically superior and 'driven by the selective survival of types in an institutionally stable society of private property rights.'[91] Unfortunately for the Third World, Clark also asserts that its failure to industrialise subsequently is due to low worker discipline and inefficiency. He claimed that most of the population of the Third World does not descend from the 'strivers' of the Malthusian era. Clark states that the Third World has no real excuse for failing to industrialise other than being fundamentally incapable of doing so.[92] Such a work takes the worst elements of both Thomas Malthus and Charles Darwin and applies them to humanity *ad absurdum*.

Of the writings on long cycles of the post-Cold War era, the most effective has been those of Jack Goldstone. Building on his ideas, an ecologist Peter Turchin came up with a synthetic theory that revived many of Ladurie's ideas and reconciled them with the Marxist emphasis on power relations and surplus extraction. Suddenly there was no contradiction between the demographic and the structural. The ideas of Marxist and Malthusian schools in this regard were reconciled. Population pressure exerts a powerful influence over socio-

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[90] Gregory Clark, *A Farewell to Alms: A Brief Economic History of the World*, (Princeton: Princeton University Press, 2007), 11. Shortly thereafter the hardworking English farmer is compared to the 'slovenly, idle and drunken' farm-workers of Poland on page 14.
[91] Clark, 266.
[92] The highlights of Clark are 1-14, 260-266, and 377.

political instability, historical events, and the ebb and flow of state power. The dynamics are so constant that they can be identified in cycles of a few hundred years of expansion and contraction.[93] The cycles can be divided into two phases and four sub-phases, harkening back to Kondratiev: expansion and stagnation-inflation in the good times (imperiogenesis) and crisis and depression in the bad (imperiopathosis).[94] The major variables in these cycles are population growth, prices, real incomes, elite numbers, the wealth inequality gap, and social cohesion, a borrowing from Ibn Khaldun's *asabiya*, which can be defined simply as the capacity of a society to cooperate in an efficient, effective, and unified fashion.[95] However, Turchin stressed that this in no way attempts to preach a mono-causal version of history. Far from it, a number of exogenous variables such as geopolitics, diseases, and climate change also apply.

Initially, when a population is low, there is plenty of food, a relative labour shortage, and so food prices are low and wages are high. Most of the population of a nation enjoy a contented, prosperous, and perhaps even steadily improving standard of living. High living standards translate into political stability. A rebellion is seldom waged on a full stomach. As a result of these high living standards, the population tends to grow.

Eventually a population approaches its carrying capacity. There are shortages of food and an oversupply of labour. Prices rise, wages drop, and the standard of living declines. Unless population pressure is relieved by agricultural innovation or territorial expansion, this can lead to a disastrous crisis. As the crisis point is approached, the average person is paid less and has to pay ever more for the basic essentials. Famines increase in severity, the

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[93] The average appears to be roughly 300 years for a full cycle, but depends greatly on specific conditions.
[94] Peter Turchin, *Historical Dynamics: Why States Rise and Fall*, (Princeton: Princeton University Press, 2003), *War and Peace and War: The Life Cycles of Imperial Nations*, (New York: Pi Press, 2006), with Sergey Nefedov, *Secular Cycles*, (Princeton: Princeton University Press, 2009).
[95] Peter Turchin has tried to popularise the term '*asabiya*' for social cohesion, a term used by North African fourteenth century social theorist Ibn Khaldun, a partial inspiration for Turchin's theory.

susceptibility of people to disease also increases, as does the possibility of widespread epidemics. It also increases the level of civil unrest among the masses.

At the same time as the crisis point is approached, it is a veritable ‘golden age’ for the elite. Landowners pay lower wages and charge higher rents. Middling landowners are forced off their farms and land coalesces in the hands of the few. The inequality gap widens. Elite incomes grow. Contented in this golden age, they are more likely to support the government in the defence of the status quo. But the significant fact is that elite numbers and appetites grow.

Then the crisis point is reached. People starve, social cohesion collapses, the number of people living at subsistence level grows, grain reserves disappear, diseases ravage a malnourished landscape, there are rural and urban uprisings and, ultimately, people die. As the general population shrinks, the elites, cushioned by their status and their wealth, do not die at the same rate. The social pyramid becomes immensely top-heavy. This is called elite overproduction. It makes up a period of stagnation in the common sphere and inflation of elite numbers, and has come to be known as the ‘stagflation’ period.

These elites, numerous as they are as a proportion of a dwindling population, begin to see their incomes shrink. And they do not like it. The result has been called ‘intraelite-competition’ or ‘intraelite conflicts’ or put simply, elite infighting. Factions form, both against the government and against each other. While the government’s tax revenues shrink due to depopulation, it is increasingly unable to quell, confront, or control or buy off these factions. As a consequence, there is a period of intense and bloody conflict, much more violent than coups in times of prosperity. The situation explodes into civil war. Around the same time the nation can become extremely vulnerable to aggressive external invasion. Additionally elites may latch onto popular discontent and become mass leaders, and this renders popular movements, which in the past might have been easily suppressed, more potentially threatening, violent, and destructive.

As a result, the first crisis, spurred mainly by demographic causes, is followed by a second crisis or 'depression' which is largely manmade. That is why a society following initial depopulation does not immediately rebound. The social side of the equation holds recovery down, and this can last for decades. Eventually, however, a population does rebound. Elite numbers are reduced. Low numbers in the general population combined with high wages and low food prices lead to another period of expansion, peace, and stability. The new golden age, however, comes at the tremendous cost of the preceding period of starvation and bloodshed.

These are the predictions for the theory of secular cycles, in any given phase:

Predictions	Expansion	'Stagflation'	Crisis	Depression
Population	Increasing	Deceleration	Decreasing	Decreasing/stagnation
Elite Numbers	Low	Increasing	High, faction	Decreasing
Social Cohesion	Increasing	High	Collapse	Revival/Relapse
Instability	Low	Low, increasing	High	High, declining
Rural Settlements	Increasing	Slow increase	Decline	Lack of increase
Cultivated Land	Increasing	Slow increase	Decline	Lack of increase
Free Land	Abundant	In short supply	Increasing	Abundant
Peasant Land	High	Low	Low, increasing	High
Land Prices	Low, increasing	High	Declining	Low
Grain Prices	Low	Increasing	High	Decreasing
Real Wages	High	Declining	Increasing	High
Rents	Low	High	Declining	Low
Consumption	High	Declining, poverty	Subsistence	Variable
Grain Reserves	High	Declining	Nonexistent	Variable
Urbanisation	Low	Increasing	High	High, declining
Artisanship	Low	Increasing	High	Declining
Trade	Low/Local	Increasing	Declining	Low/Local
Usury	Absent	Increasing	High	Decreasing
Large Estates	Few	Increasing	Many	Decreasing
Inequality	Low	Increasing	High	High, declining
Epidemics	Quick recovery	Sluggish recovery	No recovery	Variable
Internal Peace	Increasing	High	Crisis	Fragmentation
Coin Hoarding	Decreasing	Low	Increasing	High
State Finances	Increasing	High expenditure	Bankruptcy	Poor
Taxes	Increasing	Heavy burden on peasantry	Crisis	High/Collapse
Ideology	Optimistic	Social Pessimism	Popular movements for social justice	Pessimistic ideology, cult of death
State Policy	Laissez-faire	Interventionist	Social reforms, revolutions	Weakening of state

(**Table 1.2** Based on Turchin and Nefedov, *Secular Cycles*, 33-34)

Peter Turchin has already assigned chronologies to a number of full secular cycles: for England 1150-1485 and 1485-1730, for France 1150-1450 and 1450-1660, for Rome 350-30 BC and 30 BC-285 AD. Nefedov has done the same for Russia 1460-1620 and 1620-1922. There is still a great deal more to be done, however. Turchin and Nefedov study each of these cycles in a very short space. There is understandably not room for much more than a survey in their book. What is more, in spite of the plausibility of the theory, Turchin is an ecologist, not a historian. He tends to gloss over historical trends that do not fit his model and assigns dates that accord better with major political events rather than real changes. For instance, his treatment of the Western European medieval cycles dates their starting point from 1150, even though demographic recovery probably began at least a century before then. His treatment of the Roman Empire glosses over upheaval and demographic decline in Italy in the first century AD. Turchin himself acknowledges that the dating of cycles is not very precise. It is questionable whether he has even *very approximately* assigned the correct dates to each major phase: expansion, stagflation, crisis, and depression, or whether his is sacrificing empirical accuracy for theoretical symmetry with well-known events.

In addition, Turchin does not adequately account for the influence of exogenous factors. Kohler et al. test his theory for the population growth and violence seen in Pueblo societies and found that generally the model holds true except when influenced by climate, external war, and so forth. They also point out, very rightly in my opinion, that a complex phenomenon such as war cannot have a single cause.[96] Yet if you read Turchin's treatment of the French cycle from *circa* 1150-1450 you almost gain the impression that the Hundred Years War was included in the symptoms of an imperiopathosis phase, even though he claims the invader, England, was undergoing the same phase at the time. External warfare really ought to

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[96] Timothy Kohler, Sarah Cole, and Stancea Ciupe, 'Population Warfare: A Test of the Turchin Model in Pueblo Societies' in *Pattern and Process in Cultural Evolution*, ed. Stephen Shennan, (Berkeley: University of California Press, 2009) 290-1.

be counted as an exogenous factor and human agency ought to be given more credit – in regard to the Hundred Years War, this included dynastic feuds, diplomatic quarrels, and centuries-old territorial claims. The core of the theory is plausible but it still requires the constant testing of both ecologists and historians. At any rate, this is the theory of secular cycles, a reconciliation of the Malthusian and Marxist schools of the 1970s and 1980s that employs both population change and social structure as the driving forces of history.

j) Reconciling Marx & Malthus to Describe the Longue Durée

The idea that history moves in cycles or waves of some kind is not a new idea. The idea goes back many centuries. Modern population theorists like Malthus and Ricardo, economists like Wilhelm Abel, and historians like Le Roy Ladurie have all illuminated possible mechanisms for these waves and have gone to pains to show their inner workings. The resulting historical debate in the latter half of the twentieth century fell between the 'neo-Malthusians' and Marxists, a divergence that harkened back to the diverse philosophies of Malthus and Marx themselves. The 'Brenner debate' was never really resolved to anyone's satisfaction. In fact, both schools of thought on the question of long cycles and 'driving forces of history' fell by the wayside as the concept of metatheory itself became rather unfashionable. Two related attempts have been made to revive the theory and reconcile the Malthusian and Marxist camps by Goldstone and Turchin. Neither of these scholars are historians. The former is a social theorist and the latter is an ecologist with a background in the sciences. *The question now is whether such population-based theories of long cycles can find a home again within academic history.* There is also the question of whether the implications of s-curves in the agrarian period can be connected to population development beyond the 10,000 year period between agriculture and industry. Are the mechanisms explored by Goldstone and Turchin merely linked to a particular epoch, or are they linked to the entire domain of human history? Indeed do they perhaps link to mechanisms that exist outside of human history that stretch into the biosphere or even the cosmos?

V. Discussion: Widening the Lens

In this chapter we have contracted the scope from very broad physical processes in the Universe to the question of population cycles in human history to link Big History to the *annaliste longue durée*. Let us now widen out the lens again. When it comes to demographic cycles, it is clear that human behaviour is more complex than most animals that ecologists study in nature. Our history is not just influenced by traditional Malthusian dynamics but instead our complex social structures and hierarchies create conditions that can hold a human population low long after an initial collapse. Furthermore, a rise of sociopolitical instability in those social structures can often be more destructive than more 'natural' population decline. We shall further explore how these dynamics impacted human historical events in the ancient, medieval, and early modern period in several case studies in chapter 4.

No matter how complex those human cycles are, however, they find their ultimate foundation in population dynamics. Underpopulation creates conditions of prosperity and social stability, overpopulation tends to provoke the opposite. And since human historical cycles may be influenced to a great degree by population dynamics this means that much of human history is dependent on the state of the 'carrying capacity'. As long as the species has existed, *Homo sapiens* has needed to innovate to be able to extract more and more energy from the environment and sustain ever larger populations. The alternative is periods more familiar to other living species, where the ecosystem is overburdened and exhausted leading to population declines (a process which, as Darwin discovered from reading Malthus, drives natural selection). It is here that Ladurie and Malthus link up with Darwin.

Humans, however, possess the ability to accumulate more innovation with each passing generation than is lost in the next, a concept we in Big History call ‘collective learning’ which will be explored in detail in chapters 2 and 3. Over many centuries or millennia, total population levels do not remain stagnant. Although in the agrarian period collective learning was not fast enough to stave off *longue durée* cycles of overpopulation and decline, ultimately collective learning raised the carrying capacity and the overall trend of the human population of the Earth has been upward. Each new generation, no matter what part of a cycle in which they landed, contributed to a growing pool of knowledge.

Some of that knowledge improved agricultural techniques, which produced more people, who produced more knowledge, which raised the carrying capacity. Collective learning thus explains the steady curve of human population growth from the beginning of our species 200,000 years ago.[97] Useful techniques were selected and improved upon by countless generations, and in this sense collective learning forms a part of the wider scheme of cultural evolution, wherein humans generate many variations of ideas and apply them to the extremely wide range of viable selection paths that form human culture. As a result of this, human populations today harness more free energy density (or complexity) than anything else that we know of in the Universe. To remind the reader that this is no outrageous claim, Eric Chaisson of Harvard has determined the free energy rate density of even simple human technologies are

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[97] The approximate date of the beginning of *Homo sapiens* follows my supervisor David Christian in *Maps of Time*, the fossil evidence of an anatomically identical *Homo sapiens* from Omo 195,000 years ago, ‘Fossil Reanalysis Pushes Back Origin of Homo sapiens’ *Scientific American* (February 2005, and the work of McBrearty and Brooks, ‘The Revolution that Wasn’t: A New Interpretation of the Origin of Modern Human Behaviour’ *Journal of Human Evolution* (2000) 39:453-563, which rejects the idea of some sort of genetic breakthrough 40,000 years ago that enhanced our cognitive abilities to such an extent it merits being called a separate species. As will be seen from my own work, it would appear that collective learning was already present in earlier hominine species going back perhaps as much as 1.8 million years, so the distinction between Homo sapiens 200,000 years ago and 40,000 years ago is a minor one for our purposes.

many times higher than that of stars or planets, to the tune of hundreds of thousands or even millions of times.[98]

At the beginning of this chapter, we surveyed theories dealing with how the same algorithm of random variation and non-random selection also goes on in other physical processes in the cosmos. We looked at the game of ‘universal cosmic selection’ that forms from a ‘primordial niche’ of possible sets of physical laws. Within our Universe, the same elegant mechanism of random variation and non-random selection continued, filling physical niches with an ever-growing amount of variety of elements and chemicals and an increasing amount of free energy rate density. We shall explore these physical processes in greater detail in the following chapter. All told, the Darwinian algorithm has increased the level of complexity in certain pockets in the Universe. Cultural evolution and collective learning appear to be a very swift and potent manifestation of that process. From collective learning stems the innovations that determine the human carrying capacity at particular periods. And from the human carrying capacity come the cycles of overpopulation and underpopulation that animate the *longue durée* and influence historical events. This is how the Darwinian algorithm, Big History, and the idea of the *longue durée* fit together. This is how the large clasps hands with the small. It is how Big History forms the *plus longue durée* – the longest duration. Or, to employ the Braudelian metaphor, it is how the crashing waves of the surface are pulled along by the deep swelling tides of the ocean.

[98] Chaisson, *Cosmic Evolution*, 139.

Chapter Two: Complexity in the Pre-Agrarian Plus Longue Durée

I. The Darwinian Algorithm before the Palaeolithic

a) Stellar Evolution

We now widen the lens to survey an extremely broad historical landscape. This section will briefly survey the physical processes that follow from the concept of universal natural selection, which sets in motion the precise balance of physical laws of the Universe. It is a story of the gradual rise in complexity and variation that results from the Darwinian algorithm. The precise levels of the four fundamental forces and the quantum fluctuations that gave rise to clumps of hydrogen and helium produced around a hundred elements after years of stellar evolution, which then coalesced into thousands of chemical combinations in what Robert Hazen calls 'mineral evolution'. This discussion relates to the population dynamics of the *longue durée* because it was this process of rising complexity and variation that enabled biological evolution and eventually cultural evolution. At every stage, physical laws created a niche that allowed more elemental and chemical variations to arise, despite the largely uniform constitution of the early universe. What is also striking about this period is the seamlessness of the process, with one stage of variations leading to the rise of others. Throughout the pre-human story, the Darwinian algorithm was at work, increasing the number of variations and viable selection paths and raising the level of complexity in ever-narrowing pockets of the Universe: from stars, to planets, to life, to culture.

In the minuscule splinter of a second after the Big Bang, the precise balance of gravity, electroweak, and strong nuclear forces in our Universe determined much of what came next. If gravity had been a few shades stronger, if the strong interaction had been a few degrees weaker, or if a force entirely strange to our Universe had arisen, the entire cosmic horizon would have been irrevocably changed. As it was, the Universe cooled, allowing atoms of hydrogen and helium (with a tiny pinch of lithium) to form. Gravity pulled the clouds of gas very close together, and a crushing amount of density heated those clouds anew. Protons within those clouds smashed together with such brutal force that they overcame their repulsion and achieved nuclear fusion. The first stars flared into life, and these giant nuclear explosions were suspended in space for millions and even billions of years, and radiated energy outward to the rest of the cosmos.

As they end their lives, large stars bloat up like the body of a dead cow in a wet field, and within them are forged many new elements, proceeding up the periodic table to iron. Neutron-capture allows even heavier elements. And in the largest stars, most other elements are produced as they die in a brilliant flash of a supernova, and these building blocks are scattered across the galaxy to later contruct even greater forms of complexity: planets, organisms, and your mother's wedding ring. Lawrence Krauss has an excellent mental exercise for this. Look at your right hand. That was made in the belly of a star. Look at your left hand. That was made in the belly of a different star.[99] We are, in fact, made of stardust. Furthermore, we are indistinguishable from the energy flows that sprang into being just a fragment of a second after the Big Bang. The cards have been reshuffled, but no sleight of hand has placed any new ones in the deck. Nothing is new under the sun – or within them. Nothing is created or destroyed. This imbues our cosmic story, both past and future, with a sense of seamlessness. Combine it with the fact that many mathematicians believe the Universe is finite and has a constant zero curvature and is therefore shaped either like a table-top or a *torus* (donut shape) and the fact that analysis of the light from 200,000 galaxies has determined that if we were to stand 'outside' Universe to us it would look beige (officially

[99] See lecture of Lawrence Krauss at AAI Conference 2009, see also Lawrence Krauss, *A Universe from Nothing: Why There is Something Rather than Nothing*, (New York: Free Press, 2012).

designated 'Cosmic Latte') and I would like to congratulate the reader for being a rather bland, unremarkable, albeit congealed, inhabitant of a 'latte-hued' table-top or beige donut.[100]

The physical laws of our Universe emerged from a possible set of 10^{500} variations. Within our own cosmic horizon, variations have remained quite few and restricted by physical laws. The vast mass of quantum physics, with its virtual particles flickering in and out of existence, and following unpredictable trajectories, only emerge with a few, more predictable variations, into the Newtonian realm. Stellar evolution, involving stars with a relatively low free energy rate density, produces around a hundred elements within their bellies and as a result of extreme temperatures when they go nova. These elements, however, produce even more chemical combinations that become apparent in planetary accretion. Slowly more variations explore possible selection paths within the constraints of physics and a higher free energy rate density can be achieved. Instead of a hundred elements, physical processes produce an enormous number of chemical compounds. Some of them become minerals, and geological evolution produces several thousand variations that are shaped, permitted, and restricted by the physical processes that a planet like ours undergoes when it begins the long process of gravitational accretion from the debris of exploded stars. Not only is this a change of form or an increase of diversity. The free energy rate density of planets is significantly higher than that of stars. Even at the stage of stellar and geological evolution, the Darwinian algorithm is increasing the density of energy flows, and, as my colleague Eric Chaisson and I would assert, complexity.[101]

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[100] Brian Greene, *The Hidden Reality: Parallel Universes and the Deep Laws of the Cosmos*, (New York: Alfred A. Knopf, 2011), 21 & 25, and Ivan Baldry, Karl Glazebrook, et al, 'The 2dF Galaxy Redshift Survey: Constraints on Cosmic Star Formation History from the Cosmic Spectrum' *The American Astronomical Society* (2002) 569: 582-594.

[101] The somewhat semantical debate about free energy rate density as a metric for that loaded word 'complexity' is one that still rages in Big History circles even now. It cannot be completely resolved here. I find myself fully convinced by Chaisson's logic and unswayed by criticisms from our mutual colleagues. The problem is that 'complexity' has the baggage of colloquial use, and thus can be determined in a myriad of different ways with many different and contradictory criteria. Even if 'complexity' should be defined in a way that does not include

b) Mineral Evolution

It is within the realm of geology that the sense of continuity in the Universe, between the organic and the inorganic, really comes to the fore. Geology is the lynchpin of all existence. Hulking inanimate structures come together to form intricate and complex environments that can shelter and foster fragile life, once all the crash and thunder has died away. It is a mistake, however, to think that geology is just a stable surface on which to host the next level of the grand narrative. Even here the Darwinian algorithm is at play, producing an increasing variation of mineral variations and raising the free energy rate density of celestial objects beyond the level seen in stars. Organisms have a profound impact on ever-changing geological formations, and these in turn impact evolutionary niches, as the organic and inorganic walk hand in hand toward greater forms of complexity. Nowhere is this clearer than in the steady rise of mineral species both before and after the dawn of life. In the firestorm of stellar *nebulae*, scattered amongst the enormous quantities of hydrogen and helium, there are approximately 60 mineral species (chemical combinations of those elements forged within stars) including many carbides, nitrides, oxides, and silicates.[102]

Gravity then goes to work. The vast bulk of matter (c.99.9%) is collected in a gigantic fireball in the centre of each stellar nebula, while the straggling crumbs begin to orbit the sun in the same fashion as the rings around Saturn. Over the course of tens of thousands of years, this material accretes due to electrostatic forces, chemical interactions, and collisions, to form planetesimals. Low temperature aqueous alteration produces new chemical configurations:

free energy rate density, it is the rise of free energy rate density that we see throughout cosmic evolution. That is the unifying theme of Big History. It also always coincides with faster forms of the Darwinian algorithm and the occurrence of more complex organic and technological objects. The rise of free energy rate density from stars to planets to life to culture is proven. When considering whether or not this means ‘rising complexity’, the reader is welcome to define ‘complexity’ using whatever dictionary they please.

[102] Hazen, 1694.

olivine, pyroxene, chlorite, serpentine, talc, and silicate products.[103] As planetesimals slam into each other, even higher temperatures are achieved (100-950 degrees Celsius) producing even more configurations and increasing the number of mineral species to c.150. After one million years of accretion, our solar system contained roughly 30 proto-planets, and the massive pressure inside of them flared up their cores causing melting and differentiation, raising the number to 250 mineral species.[104] Within 100 million years, accretion had done its job and the basic form of our current solar system had come into being: eight, formerly nine, planets, plus the woeful Pluto and all the planetary shrapnel of the Kuiper belt.

On Hadean Earth (4.5-3.8 billion years ago), whose red skies and oceans of lava were closer to the Judeo-Christian vision of Hell than the cold Greek underworld, Hades, igneous melting and reworking of minerals created gabbro, diorite, gramodiorite, and granite. Temperature variations, pressure variations, magma composition, and magma chamber geometry produced greater variety still. Here the rise of complexity for Mercury, large asteroids, and the Moon (probably gouged out of the Earth by a planetesimal collision) came to an end at roughly 350 mineral species.[105] Physical and chemical principles do not allow a niche for much further mineral variation in these environments. Further activity combined with the presence of volatiles on Earth, Venus, and Mars kept the generation of variations going: with the release of gasses through volcanoes, the creation of hydroxides and the first clays, and the first crystalline H_2O at the poles.[106]

As the volcanoes belched smoke into the air, the crust and shallow mantle decoupled from the deep recesses of interior, and the crust, no more than the skin on some boiling soup,

[103] Hazen, 1698.
[104] Christian, *Maps of Time*, 60, and Hazen, 1698-1699.
[105] Hazen, 1699 and U. Wiechert, et al., 'Oxygen Isotopes and the Moon-Forming Giant Impact' (2001) *Science* 294: 345-348.
[106] Volatiles are substances with low boiling points, like nitrogen, water, carbon dioxide, ammonia, hydrogen, methane and so forth.

oxidised. Venus and Mars got this far. But we only have conclusive evidence that Earth produced the extensive granite, chemically enriched crust, and plate tectonics, which are necessary to reach the next level of complexity. Without them, the planet remains restricted to only a few hundred chemical combinations, the leap from chemical to primitive organism becomes less likely, and the free energy rate density (erg $s^{-1}g^{-1}$) will remain only a fraction of what the Darwinian algorithm can actually attain: lingering at roughly 8% the density of basic biological life and just a tiny 0.015% of the free energy rate density generated by modern society.[107]

From 4.0 to 3.5 billion years ago, we see the formation of granitoids, cratons, and the micro-continents that are key to further mineral evolution. A craton is an old and stable part of the continental lithosphere that is found in the interiors of the tectonic plates. Most of those we study are 2.7 billion years old but have ancient nuclei dating back to 3.5 billion years ago.[108] In order to preserve these cratons, one needs tectonics to forcefully drive granitoid production to preserve the scale of the early crust, along with continued differentiation bringing heat-producing elements to the upper crust. Only those cratons that become embedded in a younger lithosphere survived, and only those cratons that grew to sufficient size to avoid deformation acquired the long term stability that produces more mineral complexity.

This is just one more aspect of mineral evolution where geologists have detected an element of 'survival of the fittest'.[109] While this is an unusual form of selection that is only governed by physical and chemical processes (that are assuredly not random, even if they appear to the human eye to be somewhat chaotic) cratons are important for achieving a higher level of mineral variation. Even then, mineral evolution can stop there. However, plate

[107] Chaisson, *Cosmic Evolution*, 139.
[108] R.H. Smithies, M.J.van Kranendonk, and D.C. Champion, 'It started with a plume—early Archaean basaltic proto-continental crust' *Earth and Planetary Science Letters* (2005) 238: 284–297.
[109] W. Bleeker, 'Archaean tectonics: A review, with illustrations from the Slave craton' in C.M.R. Fowler, C.J. Ebinger, and C.J. Hawkesworth, (eds), *Geological Society of London, Special Publication* (2002) 199:151–181.

tectonics, oceans, and the atmosphere led to even more variations. None of these features can be considered exogenous since all three are the direct result of the chemical constitution of the Earth from the very beginning of its existence. Tectonics, which sprang into being somewhere between 3 and 4 billion years ago, had a significant impact on the growth of mineral complexity. At volcanic ridges there were massive sulphide deposits and concentrations of precious metals, and also side production of selenides, tellenides, arsenides, antimonides, and an array of sulfosalts. It is the constraints of physical processes that allowed these increasing numbers of variations to arise. The Earth proved a particularly fertile niche for these variations. So, as you can see, this is how Darwinian algorithms and increasing complexity can be found even in the realm of geology and geochemistry.

From stellar evolution arise just under a hundred elements, which physical processes can then transform into hundreds and even thousands of chemical/mineral variations (compounds). The complexity (free energy rate density) of these structures is higher than in stars. According to Chaisson, geological processes are on average about 37.5 times denser in free energy than stellar ones.[110] Variation increases with complexity, which opens up more avenues to channel and retain that free energy. Within the right Goldilocks conditions, this ratchet of complexity can occur in a Universe that otherwise remains quite simple, composed mostly of hydrogen and helium. Just as the majority of biological life remains bacterial, the inanimate Universe keeps most of its matter quite simple, but the increase in variations and physical niches means that, on a sufficient timescale, that some of those variations will become complex. It is like constantly making the same wager until you win the jackpot, if you had an inexhaustible supply of money and had no concern about making a profit. Earth was one of those places where the ubiquitous universal gamble paid off. The selection mechanism

[110] Chaisson, ‘Complexity’, 28.

at this moment remains physical laws, and there is no difference between the physical niches that permit the perpetuation of chemical combinations on planets and the physical niches that preserve or extinguish biological species. In fact, without those chemical combinations, biological life would not have sprung into being, as we shall see in the next section. We are surveying one long, continuous process that has endured since the origin of time and space itself.

c) The Darwinian Algorithm in the Origin of Life

In this section we will continue our theme of rising complexity and variation and proceed to the bridge between the chemical and the biological, showing how this transition marks a significant threshold in increasing complexity. Once again there is no decisive break in the continuity of the process or an alteration of kind between the organic and inorganic. The section looks at the rising number of chemical variations on Earth, the recent breakthroughs in synthetic replicators that show other forms of nucleic acid can also produce biological replication, and how life itself then continues to increase the number of chemical and mineral variations in geology – even after life arises. The evolutionary epic starting with the first cells c.3.8 billion years ago and the classical application of the Darwinian algorithm demonstrate that with the appearance of life, we get a higher complexity (free energy rate density) and a correspondingly larger number of variations, stretching from a few thousand chemical variations into the millions. This section also explores the significance of extinction events and the nature of 'species' and its relation to the immutability and continuity of the process that started in the bellies of stars. Then finally we set the stage for biological species capable of the next stage of complexity – collective learning, accumulation of knowledge and behaviours, and what is known as cultural evolution.

We do not yet know the exact chemical trigger of the first organisms at some point between 3.8 and 4.0 billion years ago. But we do know there was one. The exact mechanics of how life emerged from a ‘warm little pond’ or within the vicinity of oceanic vents is not, at present, the issue. The point is that it was enabled by the chemical compounds that were stirring in the pot since the accretion of the Earth. Life is an extension of chemical diversification, which itself is an extension of the elemental diversification that goes right back to the bellies of stars. And this crescendo of random variation, and non-random selection, and rising complexity, goes right back to 10^{500} and the inception of the physical laws of our Universe.

By the time of its formation, the inanimate physical and chemical processes of the crust had generated approximately 1000-1500 mineral species.[111] The precise timing of the emergence of life is dependent on whether common compounds at this stage were enough to set the ball rolling. If so, the emergence of life would have been possible much earlier in Earth’s history than we currently have evidence for. Life might be created at the threshold of, give or take, 1000 solid chemical compounds, the right physical processes, and a hospitable atmosphere. However, if the chemical compounds and physical processes required were more exotic, then it is clear that organisms arose a little later and the threshold of mineral species and chemical diversity is slightly higher, thus driving the process closer to the 1500 chemical and 3.8 billion year marks, by which time we are fairly certain that life already existed.

Within these 1000-1500 chemical variations one can perceive a form of random variation and non-random selection. You cannot have life without enough chemical variations to provide good odds of it occurring. Without the random variation of chemical compounds of minerals, gases, and liquids, which were the direct result of Earth’s accretion, life would not

[111] Hazen, 1705.

be possible. Only those chemical combinations that yield an entity that directs molecular mechanisms to actively extract energy from the environment are permitted to attain a higher level complexity, namely, life.[112] And it would appear that within the Darwinian algorithm not just *one* variation can be selected to form such a complex entity. A number of chemical variations hold this potential. Recent experiments have established that it is not just deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) that can replicate and evolve. Synthetic polymers, dubbed XNAs, use alternative molecules like threose, anhydrohexitol, and many more, to behave as replicators within a Darwinian algorithm.[113] This means that Goldilocks circumstances for life are not confined to the slim margin of environments that can foster DNA and RNA, but conceivably other chemical variations can be selected to create this higher level of complexity as well, provided it has the right evolutionary niche. The striking parallel between the shift in perspective provided by XNA and the shift in perspective provided by M-Theory, which expanded the working sets of physical laws from one to 10^{500}, is worth noting. In all cases of the Darwinian algorithm, a profusion of random variation is the key to the rise of complexity in the Universe and non-random selection is the key to its preservation. That is how the whole thing has worked for 13.8 billion years.

The transition between cosmology, geology, and biology, is really quite seamless. We must remember that, in this Universe, matter is just a more congealed form of energy. Additionally, life is just another shuffling of the deck in the seamless rise of complexity from elements to chemical compounds to us. Life is more complex because of the way it channels energy flows, in ways much more complex and intricate than the workings of a star. In order for life to sustain its structure and replicate its information to successive generations, it must

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[112] Definition of life from Fred Spier, *Big History and the Future of Humanity*, (Chichester: Wiley-Blackwell, 2010), 77.

[113] V.B. Pinheiro et al., 'Synthetic Genetic Polymers Capable of Heredity and Evolution' *Science*, (2012) 336: 341-44.

actively harvest energy to maintain its high free energy rate density. As a result of this, life is capable of generating variation at a much faster rate than nuclear fusion in stars or the grinding work of mineral evolution.

But it is merely an extension of the same process: diversification and rising complexity in the cosmos. It is a change of degree and not of kind. In this sense it does not do to take the divide between the organic and inorganic too far, especially because the evolution of life has an inextricable union with mineral evolution. The biggest example of this was when photosynthesising cyanobacteria prompted a dramatic rise in oxygen levels c.2.5 billion years ago. There were also glaciation events, carbonate depositions, and some of the highest stromatolite diversity in Earth's history (accretionary stacks formed in shallow water of the grains of biofilms of microorganisms, particularly cyanobacteria). Oxidative and hydrated weathering is responsible for 2425/4259 tabulated mineral species. Life sprang out of the structure of the Earth and, conversely, without the existence of life on Earth over 57% of known mineral species would not exist.[114] Geology and biology have marched forward for billions of years, hand in hand. They will continue to do so long into the future – throughout, and perhaps well beyond, the Anthropocene, an age where life and the geological record of Earth is increasingly influenced by the human species.

d) The Darwinian Algorithm in the Evolution of Life

We now turn to the evolutionary epic and the conventional operation of the Darwinian algorithm in biology. This manifestation of the algorithm was the earliest noticed by man, Darwin's evolution by natural selection, and is really an extension of a process that was already underway. At present there are 8.7 million eukaryotic species known to be on the

[114] Hazen, 1707.

planet, with an estimated 85% remaining uncatalogued and undiscovered.[115] This is a far cry from the few thousand known variations of mineral evolution. Biological evolution moves at a much faster rate than mineralogical evolution. Continuing the process of variation and selection, the number of increasingly complex variations of life grew in the long term by leaps and bounds, despite all extinction events. Until 2 billion years ago, the biosphere was dominated by prokaryotes: tiny, single-celled organisms with DNA floating freely within them. They were capable of transmitting genetic information horizontally to their neighbours as well as vertically to their descendants.[116] Horizontal genetic exchange allowed them to fill a large variety of niches and to pass on their genetic information with high efficiency. The parallel between this horizontal transmission and that of cultural evolution in a eukaryotic species like humans (that are otherwise confined to vertical transmission of genetic information) is worth noting because in cultural evolution it is the horizontal transmission of information within the same generation that makes the evolutionary process so much faster. Any organism that uses horizontal transmission can increase the rate of their adaption, making them highly flexible and successful in the biosphere to the point that they can potentially traverse and conquer every inch of the globe.

The emergence of multi-cellular beings is also worth noting, since even there one witnesses a seamless transition between forms. Single-cell organisms developed a tendency toward symbiosis that was favoured by natural selection. Single cells become intertwined to such a point of cooperation that one cell becomes interdependent upon another, a common DNA is formed, and a multi-cellular state is achieved. Indeed, the reader is the single-cell equivalent of a heartless multi-national corporation that is so large it obscures the role of the

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[115] Camilo Mora, Derek Tittensor, Sina Adl, Alastair Simpson, Boris Worm, 'How Many Species are there on Earth and in the Ocean?' *PLoS Biology* (2011) 9:1.

[116] E.Koonin, K. Makarova, and L. Aravind, 'Horizontal gene transfer in prokaryotes: quantification and classification' *Annual Review of Microbiology* (2001) 55:709-742.

individual.[117] By the time of the Cambrian explosion, 530 million years ago, there was a staggering array of multi-cellular forms whose attributes enabled their adaptive radiation to thousands upon thousands of new niches in the oceans. These niches fostered simple underwater plant life and even predators. Biodiversification gradually produced greater and greater forms of complexity, just like mineral diversification. For 4.5 billion years, chemical and physical changes on Earth have created and destroyed niches for different variations of both the organic and inorganic. These chemical and physical changes have occasionally restricted what variations can be selected and preserved, but the long term trend toward variation and rising complexity has been upward. In this regard, there is no difference between the process undergone by mineral and organism, except that the free energy rate density and the number of variations in biology is much greater. But it is fundamentally the same process.

The profusion of multi-celled life began in the seas. Filled to the brim with different kinds of trilobites, a biological class that lasted an impressive 291 million years, along with shell-dwelling brachiopods, molluscs, and also the first fish – the earliest vertebrates from whom we are descended. The nervous system of the spine allowed these fish to react to stimuli, in order to avoid pain and seek sustenance. These nerves clumped together at one end of the spinal column and became a mass tangled lump – the ancestral brain. This is yet another example of the Darwinian algorithm creating a higher level of complexity, since a brain has an even higher free energy rate density than most other organic material. The human brain is approximately 7.5 times denser in free energy than the rest of the human body and is 300,000 times denser than a galaxy. A few hundred million years of evolution of multi-cellular organisms produced enormous organisms: the first sharks and also giant underwater scorpions

[117] Christian, 119.

that grew up to eight feet long.[118] Mosses and the first vascular plants crept out of the ocean and onto the banks of rivers and streams. Slowly and timidly the first fern and shrub-like forests emerged, and then at the end of the Devonian period (416-359 million y/a) there emerged the first true forests of wood.[119] Arthropods, protected by their exoskeletons and possessing means of locomotion independent from water were the first animals to colonise the land. Meanwhile, a huge multitude of bony fish and sharks fruitfully multiplied in the seas. Some of these evolved into four-limbed tetrapods: ancestors of amphibians, reptiles, and mammals, including us. Even bats have the vestiges of these limbs and digits, with elongated fingers that form the scaffolding of their wings.[120] The first tetrapods had to dwell by the water, in which they laid their eggs. Then during the Carboniferous (359-299 million y/a) the forests sprang to life, later providing a vast amount of coal. Arthropods, enormous bugs, including dragonflies with a two foot wingspan and a land version of those fascinating giant scorpions, ruled the Earth. Some tetrapods evolved the ability to survive in drier conditions away from water, and to lay their eggs on dry land. From these arose the first dinosaurs and mammals.[121] Then in the middle of the Carboniferous the rainforests disappeared and were replaced with vast regions of arid desert, in which the reptiles prospered.

At the end of almost every geological time period (ie: the Cambrian, Ordovician, Silurian, Devonian, Permian, Triassic, Cretaceous, and Paleogene) there is some form of extinction event that eliminates a vast proportion of eukaryotic life. The end of the Permian was particularly brutal. For reasons as yet not fully known, 250 million years ago, 90% of

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[118] Simon Braddy, Markus Poschmann, and O. Tetlie, 'Giant Claw Reveals Largest Ever Arthropod' *Biology Letters* (2008) 4:106-109.
[119] W. Stein, F. Mannolini, L. Hernick, E. Landling, and C. Berry, 'Giant Cladoxylopsid Trees Resolve the Enigma of the Earth's Earliest Forest Stumps at Gilboa' *Nature* (2007) 446:904-907.
[120] Richard Dawkins, *The Greatest Show on Earth*, (New York: Free Press, 2009), 288.
[121] Sarda Sahney, Michael Benton, and Paul Ferry, 'Links between Global Taxonomic Diversity, Ecological Diversity, and the Expansion of Invertebrates on Land' *Biology Letters* (2010) 6:544-547.

marine species and 70% of terrestrial species were carried off into oblivion.[122] Even between these massive speciation events, we must remember that extinctions of species regularly took place. In fact, 99.8% of all species that have ever existed are now gone.[123] We must remember that extinction is the engine of evolution, a fact often ignored in a guilt-ridden age where humans try to preserve faltering species like museum pieces.

In the long term, despite even these massive extinction events, the niches are refilled and the amount of variation increases. Just like not all mineral variation leads to a higher level of complexity, neither do all biological variations lead to higher forms of complexity. Scientists have pointed out that natural selection in itself does not favour complexity, yet 'some' lineages do become more complex.[124] And just as 'some' lineages have grown complex while others have remained simple, so have 'some' atoms of hydrogen fused into other elements while a vast amount of others have remained simply hydrogen. The fact that bacteria or relatively simple eukaryotic species still form such a large proportion of the Earth's biomass today should not deter us from viewing the long trend of rising complexity. The Darwinian algorithm appears to produce variations, and the majority are selected and preserved at a very simple rate of complexity, but because an endless amount of variation is essential to the prevailing system, increasing it also increases the *probability* that some of those successful variations will be more complex. Never mind shooting fish in a barrel – if you put enough bullets into a barrel, eventually you hit a fish. This dynamic applies equally to the realms of cosmology, geology, and biology. It is a constant and ubiquitous rolling of the dice in our Universe.

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[122] Vincent Courtillot, *Evolutionary Catastrophes: The Science of Mass Extinction* , (Cambridge: Cambridge University Press, 1999), 1-3.

[123] A safe and commonly expressed estimate, particularly by Dawkins, and not the result of any serious quantitative work; the overwhelming majority of species that have existed are now extinct.

[124] John Maynard Smith and Eörs Szathmáry, *The Origins of Life: From the Birth of Life to the Origins of Language*, (Oxford: Oxford University Press, 1999), 15.

e) The Potential for Cultural Evolution

The Permian extinction devastated the synapsids, including the proto-mammals. They gave way, albeit momentarily, to the reptiles – the archosaurs – who were more capable of surviving in the extremely arid environments of the early Triassic. The other end of the period saw an extinction event that wiped many ecological niches clean, leaving room for the dinosaurs. The Jurassic and Cretaceous saw these giant reptiles as lords of the Earth and for the next 134 million years they thrived. It is noteworthy that this time period is roughly 670 times longer than our species has existed and over 25 times longer than our hominine ancestors roamed the lands of Africa, beginning the evolutionary process that would unleash the forces of cultural evolution.

During this period, the panoply of variations sustained by dinosaurs did not, however, yield a species capable of culture and innovation. Selection pressure did not require it of such massive beasts. Yet we shall never know what might have happened had their existence not been cut short by yet another extinction event. Some tenuous theories have emerged about the possibilities of post-Cretaceous dinosaur evolution, the most popularised involving the large-brained troodontids.[125] Despite the rather fanciful and futile nature of these speculations, it is indeed possible that niches might have opened up to provoke alternatives to *Homo sapiens*. It certainly would not be out of keeping with what we know of the Darwinian algorithm. As with the 10^{500} possible sets of working physical laws and also XNAs producing the same effects as DNA and RNA, we cannot presume that only one variation of biology – namely, us – would have produced a higher form of complexity. The Universe tends to randomly generate variations that are more complex. It is the same reason why the Drake equation, looking at 200 billion stars in a galaxy and 400 billion galaxies, makes it seem likely that intelligent life

[125] D. Russell and R. Séguin, 'Reconstruction of the Small Cretaceous Theropod *Stenonychosaurus inequalis* and a Hypothetical Dinosauroid' *Syllogeus* (1982) 37: 1-43, and criticism Greg Paul, *Predatory Dinosaurs of the World: A Complete and Illustrated Guide*, (New York: Simon and Schuster, 1988).

probably exists elsewhere in the Universe.[126] The probability dictated by such a vast number of variations will not permit the Universe to completely neglect these complex entities, no matter how strong its preference for simpler forms may be.

As it was, a piece of rock roughly ten kilometres across rudely interrupted things. It struck with millions of times more force than all the hydrogen bombs possessed by all the nations of the Earth combined. It brought death in the form of shockwaves, tsunamis, continent-wide forest fires, and a blanket of dust thrown up into the atmosphere that caused cold and perpetual darkness for months. Thereafter, the water vapour and carbon dioxide released from the impact caused an extreme greenhouse effect, blighting the Earth with sweltering temperatures and acid rain.[127] Flora and fauna died in a grim symphony, the sustenance for many large species was obliterated, and many niches of the Earth were brutally swept clean once again. The meek ancestors of primates nevertheless survived. The last common ancestor of proto-Primates and *Plesiadapiformes* lived around 63 million years ago, and was a tiny shrew-like creature that fed on insects.[128] Over the next 25 million years the adaptive radiation of mammals filled the Earth's niches until they became the dominant class of complex animals on the planet. Our own ancestral house, *Hominoidea*, hails from a common ancestor that lived approximately 20 million years ago, an ape that inhabited the trees and fed on various kinds of fruits. From it descended the human race and our modern cousins: gibbons, orang-utans, gorillas, chimpanzees, and bonobos.[129] We are, of course, famously

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[126] Nicolas Glade, Pascal Ballet, and Olivier Bastien, 'A stochastic process approach of the drake equation parameters' *International Journal of Astrobiology* (2012) 11:103–108.
[127] Walter Alvarez, *T-Rex and the Crater of Doom*, (New York: Vintage Books, 1998), 11-14.
[128] William Clemens, Cyrille Delmer, Emmanuel Gheerbrant 'Purgatorius, Plesiadapiformes and Evolution of Hunter Schreger Bands' *Zoological Journal of the Linnean Society* (2007) 149 : 611–28.
[129] Christian, 153.

separated from chimps by only a few million years and 1.6% of our DNA.[130] The seamlessness of the transition between forms stretches across the evolutionary epic.

f) The Role of the S-Curve in Human & Non-Human Complexity

How do demographic cycles fit into this story of increasing complexity driven by the Darwinian algorithm? Before moving on to the rise of cultural evolution in human history, this section shall very briefly discuss the role of the s-curve and population dynamics in human and non-human complexity. In natural ecology, all organisms are slave to some form of s-curve that results from a finite amount of resources available to an individual and a species, enabling them to survive and reproduce. When the carrying capacity of a biological population is reached, the population undergoes strain, decline, and recovery. While potentially destructive to life-forms, the shortage of resources does have the merit of spurring along evolution by natural selection. These same s-curves, however, were applied by *annalistes* like Emmanuel Le Roy Ladurie to human societies, though with vastly differing dynamics and results. This brings us to a second point: the important role of populations in both genetic and cultural evolution. Thomas Malthus's *Essay on the Principle of Population* illustrated how human population growth always tended to exceed the resources capable of supporting its burgeoning numbers. Darwin read it in 1838 and extrapolated it to other organisms whereby species over-breed, compete, and change over time to possess the traits that are best able to extract resources from their environment and perpetuate their survival. It was an epiphany for him. At last, he said, 'I have finally got a theory with which to work'.[131] Scarcity of resources is the bedrock of all the problems and ecological constraints that make natural selection of physical traits and instincts necessary. One can apply the ecological

[130] This statistic is omnipresent; Jared Diamond, *The Rise and Fall of the Third Chimpanzee: How Our Animal Heritage Affects the Way We Live,* (London: Vintage, 1991), 18.
[131] Charles Darwin, *The Autobiography of Charles Darwin*, ed. Francis Darwin, (London: John Murray, 1887), 82.

principle back to human history. In his recent book, big historian Fred Spier identifies the unifying theme of our long story:

> If we want to prevent our bodily complexity as well as all the complexity that we have created from descending into chaos, we must keep harvesting matter and energy flows on a regular basis. *This is the bottom line of human history*. I will therefore argue that during most, if not all, of human history, the quest for sufficient matter and energy to survive and reproduce... has been the overriding theme.[132]

Here is the bottom line of human history. It is our increasing ability to master energy (of which matter is really just a more congealed form) channelling the ultimate force in the Universe. Scarcity of these resources is what has kept life in the prison of natural selection and humans in the prison of tribal competition, war, and the market system. Scarcity perpetuates the unpleasant realities that have shaped biological evolution as well as much of human history. It is necessary to immediately point out before outraged social scientists begin sharpening their knives that this is not *all* there is to human history. But anything else humans have sought to pursue in history simply would not have been possible if we had not been able to feed ourselves. The theme of human history does not preclude any ideas about tradition, culture, politics, economics, gender, class-conflict, collaboration, or anything else for that matter. In fact, it embraces them.

We simply cannot engage with all those other forces of human history if we are dead. If we do not eat or drink, we die. Unlike other organisms, however, human beings have the advantage of a new manifestation of the Darwinian algorithm, cultural evolution, which aids them in this hunt for resources. It is a faster version of the Darwinian algorithm and one capable of creating even higher forms of complexity – the highest yet known to humans in the Universe.

There is no divide between natural history and human history. They are part of the same magnificent progression. The physical laws of the Universe are one set of 10^{500}

[132] Spier, 116. My Italics.

variations beyond our cosmic horizon. These laws favour the generation of variations, which by sheer force of probability occasionally produce higher forms of complexity amidst the vast army of simpler forms. Non-random selection is responsible for the preservation of these forms and their ability to perpetuate even greater forms of complexity in a benevolent feedback cycle. From the fundamental forces that produced clumps of hydrogen and helium and the first stars, to the stellar evolution that produced nearly 100 naturally occurring elements, to the mineral evolution that produced over 4000 solid chemical compounds, to the biological evolution that has produced millions upon millions of species, the overriding theme has been variation, selection, and rising complexity. Reaching beyond the old cliché about death and taxes – the Darwinian algorithm is one of the great certainties of our existence. As will be seen, the role of the s-curve and human innovation is the key to both the rise of complexity in cultural evolution and the explanation of older *annaliste* concepts of historical cycles and the *longue durée.*

II. The Longue Durée in the Palaeolithic

a) The Effect of Collective Learning on Rising Complexity

In this section we shall survey the evolution of collective learning in the Palaeolithic in both *Homo sapiens* and others of our genus, as well as the incipient forms in our evolutionary cousins. Collective learning is the ability for a species to transmit knowledge and behaviours by learning, and to accumulate them generation by generation. There are many questions about the origins and nature of collective learning that remain to be answered, questions that have occupied the minds of big historians, scientists, and linguists. We shall look at the number of candidate traits that led to collective learning, whether or not there are elements of it in other primates, and the extent to which it was possessed by our evolutionary ancestors, as indicated by archaeological evidence. We shall touch on the occurrence of the Tasmanian

Effect in the Palaeolithic, where accumulated knowledge actually disappears, and this shall be relevant to the following chapter on the subject. It is collective learning that is responsible for the rise of cultural evolution and the generation of variations on a much greater scale and at a much faster speed than even biology. There are millions of variations in biology that arise over several generations. In cultural evolution there are millions of variations in behaviours, ideas, and innovations that arise in a single generation. Correspondingly cultural evolution improves the ability of a species to harness energy and complexity increases as a result. With its slowly increasing potential to harness energy from the environment, human societies today possess a free energy rate density at least 25 times higher than the products of biological evolution. The process expands and grows in variation and complexity.

Slowly, the Darwinian algorithm links up with the *longue durée*. Collective learning gradually raises the carrying capacity, modifying the s-curves that dominate the ecology of organic life. Collective learning allows for technological accumulation, which produces more people, who produce more innovation, which in turn raises the carrying capacity. On the smaller scale, however, the histories of Le Roy Ladurie have noted many times where human populations have fallen prey to the s-curves, and experienced demographic strain and collapse. These periods of strain witnessed a rise in sociopolitical instability, which caused faction and in many cases civil war. The ‘natural’ Malthusian crisis caused by rapid population growth and slow technological accumulation was worsened by a manmade crisis that held the population low. Occasionally the manmade crisis also threatened to destroy the accumulation of collective learning.

Until a few million years ago there was nothing on Earth to indicate that anything else besides the *mêlée* of genetic evolution, with its constant generation and annihilation of diversity, would arise. It appeared the short, ignorant, terrifying existence of beasts of the field was the highest level of complexity of which the planet was capable. Then there emerged the evolutionary trait of collective learning, the ability of a species to accumulate learning over several generations to enhance their ability for survival. If harvesting energy to maintain our complexity is the bottom line of human history, then collective learning with all its demographic implications is without question the shape.[133] It has allowed us to accumulate innovation upon innovation and get better at extracting matter and energy from the environment, allowing the human population to increase by leaps and bounds and sustain profound levels of complexity – from the 40,000 erg/s/g in free energy rate density of hunter gatherers (80,000 times higher than a galaxy) to the average of million erg/s/g in agrarian society to the 500,000 erg/s/g of nineteenth century industrial society, or the 2 million erg/s/g of modern society (4 million times higher than a galaxy).[134]

Generic Structure	Average Free Energy Rate Density (erg/s/g)
Galaxies	0.5
Stars	2
Planets	75
Plants	900
Animals (i.e. human body)	20,000
Brains (i.e. human cranium)	150,000
Australopithecines	22,000
Hunter-Gatherers (i.e. 200,000-10,000 y/a)	40,000
Agriculturalists (i.e. 10,000-250 y/a)	100,000
Industrialists (i.e. 1800-1950)	500,000
Technologists (i.e. present)	2,000,000

(**Table 2.1** Amount of free energy running through a gram per second, and the australopithecine and human free energy rate density is determined from the average energy consumption of an individual, Chaisson 2010: 28 & 36)

The historian's view of all human history is no longer vague or boundless with a chaotic tangle of periods and research areas. Collective learning gives a clear and definite shape to the whole picture as well as an underlying theme. This is revolutionary not only for Big History, but for areas of conventional human history as well. The idea has its uses within archaeology,

[133] See fig. 2.2

[134] Specifically contemporary modern 'technologist' society, which generates an average of 40 million erg/s/g, see Chaisson, 'Complexity', 36.

within agrarian history, and within the study of the industrial era – not to mention our anxiety fraught examination of the looming trials of the twenty-first century. We are deeply indebted to Michael Kremer for being one of the first to clearly articulate the idea of accumulation over several generations and the population dynamics of potential innovators, David Christian for coining the term 'collective learning' and expounding it in his own works, and also anthropologists like Peter Richerson, Robert Bettinger, Michelle Kline, and Robert Boyd, for developing it mathematically and, in one case of a recent paper to the Royal Society, with a decent degree of empiricism.[135]

b) *The Evolution of Collective Learning*

There are some lingering questions and problems that big historians need to work on as we develop the concept of collective learning. The first questions are about origins: What precise ability enables collective learning? How did it evolve? What selection pressures made it spring into being? This engages with a much larger and much older debate over the nature of human uniqueness – something to which a refined version of collective learning can contribute. These ideas are universal grammar *à la* Noam Chomsky vs. symbolic reference *à la* Terrence Deacon, emergent thought vs. the computational model of the mind, the role of imitation and mimicry in the evolution of language, and the debate over group selection in humans that raged over a recent book by E.O. Wilson and the counterblast of Steven Pinker.[136] While the importance of collective learning and technological accumulation to human history has been clearly identified, it is much less clear what trait or set of traits enabled it in the first place. A number of theories exist and they all seem to revolve around the gradual and the

[135] M. Kremer, 'Population Growth and Technological Change: One Million BC to 1990' *The Quarterly Journal of Economics* (1993) 108: 685, Christian, 146-148, Peter Richerson, Robert Boyd, and Robert Bettinger, 'Cultural Innovations and Demographic Change' *Human Biology* (2009) 81: 211-235., Michelle Kline and Robert Boyd, 'Population Size Predicts Technological Complexity in Oceania' *Proceedings of the Royal Society B* (2010) 277:2559-2564.

[136] E. O. Wilson, *The Social Conquest of the Earth*, (London: Liveright Publishing, 2012), Steven Pinker, 'The False Allure of Group Selection' (June 2012) Edge.org.

sudden. Chomsky argues against gradualism and considers universal grammar an all or nothing proposition that somehow flickered into being.[137] Pinker argues for a more gradual evolution of a computational model of the mind similar to the evolution of the eyes.[138] Deacon argues for the appearance of symbolic reference as a sudden occurrence.[139] Dunbar claims that enhanced communication abilities and technological accumulation were the gradual result of selection pressures on complex interaction and coordination due to increasing group size and inter-group connectivity.[140] Finally, Corballis and Tomasello place gesticulation as the fundamental form of social learning with speech being the ultimate form – thus being a change of degree and not of kind.[141] Whatever the skill that allowed humans to accumulate more innovation with one generation than was lost by the next, it needs to have a clear explanation about how it evolved in real terms without recourse to metaphor and with identifiable selection pressures – sudden or gradual.

These questions tie into the next issue: the threshold between biological and cultural evolution. Where is it drawn? Is it the result of gradual evolution over several species or a sudden jump? If we knew what ability, origin, and selection pressures caused collective learning, we might be able to better answer that question. For now it is a big blank spot on the map. Do we draw the line at humans? And if so, how do we treat the nascent elements of collective learning in our evolutionary family? David Christian often gives the example of the Pumphouse Gang baboons, where a skilled hunter dies and information eventually degrades, vanishes, and the range of the species does not expand. He also gives a nod to what he calls

[137] Noam Chomsky, *On Nature and Language*, (Cambridge: Cambridge University Press, 2002), 80.
[138] Steven Pinker, *How the Mind Works*, (London: Allen Lane, 1997), 21.
[139] Terrence Deacon, *The Symbolic Species: The Co-Evolution of Language and the Brain*, (New York: W.W. Norton, 1997), 328-355.
[140] Robin Dunbar, *Grooming, Gossip, and the Evolution of Language*, (London: Faber and Faber, 1996), 3-17, 56-58, 62-64, 77, *The Human Story: A New History of Mankind's Evolution*, (London: Faber and Faber, 2004) , 28-29, 71-72, 125-126, *How Many Friends Does One Person Need? Dunbar's Number and Other Evolutionary Quirks*, (London: Faber and Faber, 2010), 22-33.
[141] Michael Corballis, *From Hand to Mouth: The Origins of Language*, (Princeton: Princeton University Press, 2002), 41-65.

the 'sporadic learning' in apes and in *Homo habilis* and *Homo ergaster*/*erectus*.[142] But if we place the threshold where more knowledge is accumulated with each generation than is lost by the next, we are confronted with questions about the significance of situations where knowledge neither degrades nor accumulates – it is simply preserved. For example, termite fishing, rock hammers, leaf sponges, branch levers, and banana leaf umbrellas are passed on by social learning, not instinct, and not sporadically, in certain populations of chimpanzees, and are withheld from others outside that cultural network.[143] They are sustained and passed on, usually from mother to offspring, and are not reinvented every generation. Here is a tremendous ability, however weak, probably possessed by our last common ancestor. This ought to tell us something about the nascent elements of collective learning. But, on the other hand, if this learning does not accumulate, but is only preserved, perhaps it can conceivably be dismissed, if we wish to maintain a sudden threshold with humanity and not a gradualist account.

Similarly, the stagnant nature of stone tools 2.6-1.8 million years ago may potentially be dismissed as 'sporadic learning', simply preserving knowledge but not accumulating it. Around 1.8 million years ago, however, the assertion grows more tenuous. Stone tool manufacture is less haphazard, with deliberate shapes being constructed that are passed on culturally. *Homo ergaster*/*erectus* also migrated into different environments in Asia, no mean feat, and there is evidence of a demographic boom in Africa that may have driven the migration. A demographic boom also indicates an enhanced ability to exploit niches in the

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[142] David Christian, *Maps*, 146, and 'Big History, Universal Darwinism, and Collective Learning' 7-8 (unpublished as of writing) to be published in *Proceedings of the International Big History Association Conference* at a later date.
[143] Pinker, *How the Mind Works*, 198-199, Ian Tattersall, *Becoming Human: Evolution and Human Uniqueness*, (San Diego: Harcourt Brace, 1998), 51-52.

ecosystem. There is also evidence of increased brain size and sociality.[144] All of these things are staple arguments for collective learning in *Homo sapiens* and the profound impact they had on the Palaeolithic world. There is no reason why the same arguments could not apply to *Homo ergaster*/*erectus*, albeit on a lesser scale. But this is a difference of scale, not a difference of kind.

Nevertheless, the jury is still out on whether there was any technological accumulation. When *Homo ergaster*/*erectus* first arrived on the scene 1.8 million years ago, they were making tools that had not changed significantly since *Homo habilis*. However, 1.78 million years ago we begin to see rare and crude new forms of teardrop hand-axes in Kenya.[145] But for the most part for 200,000 years we see no major widespread improvements in the stone tools of *Homo ergaster*/*erectus*. This remained the case in most migratory regions. The tools were functional. The object was to get a flake edge. No aesthetics were involved. But in Africa 1.5 million years ago, where *Homo ergaster* populations were at their densest, the hand-axes first made 1.78 million years ago became rapidly common. What is more, they improve in quality, shaped with a flat edge into multipurpose picks, cleavers, and other kinds of implements.[146] This has been considered by some archaeologists as the first clear sign of tinkering, accumulation, and improvement of a technology, if only a much weaker form of collective learning among *Homo ergaster*/*erectus* than *Homo sapiens*, who are the real champions at it.

Still, the assertion that *Homo ergaster*/*erectus* had crossed the threshold into mild collective learning can still be reasonably disputed and dismissed if the case is only based on such limited evidence. This argument is less feasible for the hominines of the last million years. *Homo antecessor*, *Homo heidelbergensis*, and the Neanderthals presided over the

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[144] Chris Stringer, *The Origin of Our Species*, (London: Allen Lane, 2011), 25-26, Ian Tattersall, *Masters of the Planet: The Search for Human Origins*, (New York: Palgrave Macmilan, 2012), 123-124.
[145] Tattersall, *Masters*, 105.
[146] Tattersall, *Masters*, 125-127.

systematised and regular use of fire in hearths (790,000 y/a), the earliest wooden spears (400,000 y/a), the earliest use of composite tools (400,000 y/a), the first evidence of intricately constructed shelters (350-400,000 y/a), and the first prepared core tools (300,000 y/a) all before *Homo sapiens* was ever heard of.[147] *Homo heidelbergensis*, became the first pan-Old World hominine (600,000 y/a), showing signs of technological improvement, with the earliest specimens using simpler tools than later ones, and even evidence of pigments at Terra Amata, a site in Europe (350,000 y/a).[148] Neanderthals adapted to climes that made clothing and other cultural innovations necessary for insulation and warmth. There is also limited evidence for use of pigments.[149] They used complex tool manufacture, with prepared stone cores, producing a variety of implements, sharp points, scrapers, teardrop hand-axes, wood handles, with deliberate use of good stone materials, and an endless supply of variations and signs of improvement over time.[150] Now, bearing in mind that *Homo sapiens*, without question, is by far the most talented at collective learning, there is very little doubt that these hominine innovations accumulated over several generations, did not fade away, improved in quality down the chronology, and yielded a certain degree of ecological success and extensification (the spread of a species' hunt for resources into new environments and ecosystems to sustain greater numbers, as opposed to 'intensification' which extracts more resources from a given area). Interestingly enough this happened in several hominine species for which there has yet to be clear evidence of symbolic thought and complex language, two things that are sometimes (and probably incorrectly) attributed as the *cause* of collective learning rather than more efficient vehicles for it. All this raises severe questions about the threshold that must be

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[147] N. Goren-Inbar , N. Alperson, M.E. Kislev, O. Simchoni, Y. Melamed, A. Ben-Nun, and E. Werker, 'Evidence of Hominin Control of Fire at Gesher Benot Ya'aqov Israel' *Science* (2004) 304:725-727, Ian Tattersall, *The World from its Beginnings to 4000 BCE*, (Oxford: Oxford University Press, 2008), 125.
[148] K. Oakley, 'Emergence of Higher Thought, 3.0-0.2 Ma B.P.' *Philosophical Transactions of the Royal Society B*, (1981) 292:205-211.
[149] Stringer, 163-165.
[150] Tattersall, *Masters*, 166-173, *Becoming Human*, 150-158.

addressed. It also bleeds into questions about human uniqueness and why it is so important for some people to draw an ironclad boundary between us and our evolutionary family that distinguishes us in essential kind. This sort of essentialism is alien to many forms of evolution. It would be a rash statement indeed to say that if *Homo sapiens* had never existed and had never out-competed other hominines, that these same hominines would not have possessed collective learning or attained some degree of cultural complexity. Much more work, at any rate, would be required before one could make such a statement. As it is, it appears a more gradual evolution of collective learning occurred over several hominine species.

c) *Palaeolithic Boom &and Bust*

The question of a 'Palaeolithic revolution' is another point of contention. Did *Homo sapiens* undergo a biological change c.50,000 y/a and does this explain the explosion of technological complexity that appears in the fossil record? Or did collective learning and population density achieve a point of saturation allowing for a faster pace of learning? Or did this complexity arrive in Africa prior to 100,000 y/a as McBrearty and Brooks have suggested?[151] If the latter, it is probably the result of collective learning maintaining a faster rate of accumulation in denser African populations than disparate migrant ones. Collective learning may have also played a role in the Out of Africa migrations themselves. Recent DNA studies have shown exponential human population growth in Africa preceded our most successful migration out of Africa c.60,000 y/a.[152] This coincides with evidence of an increase in the complexity of technology around the same time.[153] It is possible that there is a correlation between migration and population growth that may be explained by the gradual

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[151] Sally McBrearty and Alison Brooks, 'The Revolution that Wasn't: A New Interpretation of the Origin of Modern Human Behaviour' *Journal of Human Evolution* (2000) 39:453-563.
[152] Quentin Atkinson, Russell Gray, and Alexei Drummond, 'Bayesian Coalescent Inference of Major Human Mitochondrial DNA Haplogroup Expansions in Africa' *Proceedings of the Royal Society B* (2009) 276:367-373.
[153] Paul Mellars, 'Why Did Human Populations Disperse from Africa ca. 60,000 years ago? A New Model' *Proceedings of the National Academy of Sciences* (2006) 9381-9386, which attributes the rise of technological complexity to a unknown biological change, though collective learning and technological accumulation answers this question more effectively.

rise of collective learning. If such a connection exists for the ecological success of humans, it might also be applied to the prior migrations of *Homo ergaster*/*erectus*, *Homo heidelbergensis*, and the Neanderthals. The human correlation is also reinforced by genetic studies by Powell, Thomas, and Shennan that show population density in Africa may have reached a critical mass to allow more consistent technological accumulation without as many periods of loss.[154]

Decline in population pressure and collective learning can also lead to a Tasmanian Effect, where technology disappears or undergoes simplification. Jared Diamond coined the term for the extreme disappearance of technology in Tasmania.[155] Kline and Boyd recently established a similar case in Oceania, where technology declined in groups that were isolated or lost density.[156] My own work has unearthed a similar occurrence of technological disappearance and simplification in the extreme and sustained population decline of isolated parts of post-Roman Western Europe in the fifth and sixth centuries.[157] Finally, Zenobia Jacobs, Bert Roberts, Hilary Deacon, and Lyn Wadley established two Palaeolithic Tasmanian Effects in Africa, at Still Bay 72,000 y/a and Howieson's Poort 64,000 y/a.[158] All are cases where technology disappears or is simplified in areas that suffered isolation and population decline – a phenomenon deemed more likely in the Palaeolithic due to lower populations and lower connectivity. It might explain why collective learning took tens of thousands of years to get off the ground, relatively speaking, before the explosion of agriculture.

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[154] A. Powell, S. Shennan, M. Thomas, 'Demography, Skill Accumulation, and the Origins of Behavioural Modernity' *Science* (2009) 324:1298-1301.
[155] Jared Diamond, 'The Longest Isolation, the Simplest Technology' *Nature* (1978) 273:185-186.
[156] Michelle Kline and Robert Boyd, 'Population Size Predicts Technological Complexity in Oceania' *Proceedings of the Royal Society B* (2010) 277:2559-2564.
[157] See David Baker, 'The Roman Dominate from the Perspective of Demographic-Structural Theory' *Cliodynamics* 2 (2011): 217-251 and the first case study in this work.
[158] Z. Jacobs, R. Roberts, R. Galbraith, H. Deacon, R. Grün, A. Mackay, P. Mitchell, R. Vogelsang, et al. 'Ages for the Middle Stone Age of southern Africa: implications for human behavior and dispersal' *Science* 322 (2008) 5902: 733–5, L. Wadley, T, Hodgskiss, M. Grant, 'Implications for Complex Cognition from the Hafting of Tools with Compound Adhesives in the Middle Stone Age, South Africa' *Proceedings of the National Academy of Sciences* (2009) 106:9590-9594.

Culture evolves through the accumulation of small variations. Those ideas that are successful, attractive, or useful, in whatever way, are selected and spread throughout a society. Every invention of technology or breakthrough in practice, like in agriculture, comes from a series of small improvements contributed by a long dynasty of innovators. The single innovation of a genius might be of revolutionary magnitude and repercussions, but would have been impossible without the hundreds of tiny innovations made by the hundreds of generations that came before it. Newton said he stood on the shoulders of giants. It might be fairer to say that every ordinary person stands on the shoulders of other ordinary people – some with more than ordinary perceptiveness and absolutely extraordinary timing.

Our technologies, our institutions, our languages, are far too elaborate for even the most gifted of geniuses to create from scratch. Human beings have a tremendous capacity for language. We can share information with great precision, accumulating a pool of knowledge that all people may use. The knowledge an individual contributes to that pool can long survive their death. If our populations are large and well-connected enough, more information is acquired by each passing generation than is lost by the next. It can be accessed and improved by countless generations. This is the essence of cultural evolution which leads to ever greater forms of complexity than can be produced by mere biology. Finally, we arrive at the current manifestation of the Darwinian algorithm that has shaped so much of human history and eventually produced a free energy rate density 40 million times denser than a galaxy.[159]

III. The Rise of Agrarian S-curves & the Longue Durée

a) The Increase of the Human Population

In this section we bridge the gap between the Darwinian algorithm and the conventional *longue durée* of agrarian s-curves. From the origins of collective learning in the Palaeolithic, it

[159] Chaisson, 139.

is clear that from the rising carrying capacity and increase in cultural variants and innovations, that cultural evolution has great bearing on the narratives that were explored by Braudel and Ladurie. Nowhere is this more relevant than the discussion of population cycles. Our starting point is the low watermark of the human species from the Toba event 74,000 years ago when a volcanic eruption reduced the population to a few thousand, to our increased innovation and migration out of Africa, and the origins of agriculture through accumulated innovations in plant and animal domestication. From there we explore how innovation gradually raises the carrying capacity allowing the population to grow in the long term, though not without many cycles of rise and decline in the agrarian period. What Ladurie explored in early modern France was a microcosm of the population dynamics that reigned throughout the era of agrarian civilisations.

It is the impact on human population dynamics where cultural evolution has had the most perceptible impact on human history: innovation produces more people, who produce more innovation. Eventually there is so much generation of new ideas that the likelihood of a useful one is greatly enhanced. These ideas are selected and accumulated along with other ideas. Gradually this raises the human population to impressive heights and the Darwinian algorithm in a new form of cultural evolution goes into overdrive. The inception of the current arc of complexity is easily spotted. Around 74,000 years ago there was a catastrophic eruption at mount Toba, on the island of Sumatra, part of what is now Indonesia. It was worse than anything in recorded history. The eruption drastically lowered temperatures on Earth for several years.[160] Genetic studies show that the resultant decline in flora and fauna upon which humans could predate had reduced the population to near extinction. It is likely that in the aftermath of a period of starvation, on the entire face of the Earth there were scarcely more

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[160] Michael Rampino and Stephen Self, 'Volcanic Winter and Accelerated Glaciation following the Toba Super-eruption' *Nature* (1992) 359:50-52.

than 10,000 (and perhaps as few as 1000) human souls, which, as an aside, is what makes our long history of racism so abhorrent and absurd, particularly those ideological impulses inspired by Darwinism.[161] Here is a low watermark for the current trend of human population dynamics. Evidently the starvation did not last long. In approximately the same amount of time that separates us from the dawn of agriculture, the human species had recovered and c.60,000 years ago some of them migrated out of Africa across the world. By 30,000 years ago, the foraging human population had risen to half a million. By 10,000 years ago, the innovation of hunter-gatherer bands had allowed them access to almost every environment on Earth, from Eurasia to Australia to the Americas. We must remember that the carrying capacity for a foraging band is quite low and they need a vast area to supply relatively small numbers. Nevertheless, by the dawn of agriculture the ranks of our species had swelled to 6 million people, approaching the full capacity for supporting hunter-gatherers of which the entire surface of the Earth is capable.[162] Innovations began to mount up. Earliest recorded evidence for herding goats and sheep in Southwest Asia is 11-12,000 years ago, and one thousand years later, we have evidence for the farming of wheat, barley, emmer, lentils, and pigs. By 8,000 years ago East Asia had begun using millets and gourds, and the Americas had domesticated llamas and maize. By 6,000 years ago, Southwest Asia had domesticated dates and the grapevine, while East Asia had domesticated water chestnuts, mulberries, water

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[161] Martin Williams, Stanley Ambrose, Sander van der Kaars, et al. ‘Environmental Impact of the 73ka Toba Super-eruption in South Asia’ *Palaeogeography, Palaeoclimatology, Palaeoecology* (2009) 284:295-314, Michael Rampino and Stanley Ambrose, ‘Volcanic Winter in the Garden of Eden: The Toba Super-Eruption and the Late Pleistocene Population Crash’ in F. McCoy and W. Heiken (eds), *Volcanic Hazards and Disasters in Human Antiquity*, (Boulder: Geological Society of America, 2000), 78-80, Stanley Ambrose, ‘Late Pleistocene Human Population Bottlenecks, Volcanic Winter, and Differentiation of Modern Humans’ *Journal of Human Evolution* (1998) 34:623-651.

[162] Massimo Livi-Bacci, *A Concise History of World Population*, trans. Carl Ipsen, (Oxford: Blackwell, 1992), 31.

buffalo, and that mainstay of all Asian crops: rice.[163] All of a sudden, much larger numbers could be supported over a much smaller land area.

Agrarian civilisations brought about a greater degree of connectivity, faster population growth, and a new rapid pace for innovation. Suddenly there were a lot more minds to generate ideas and a lot less space between those minds in order to conference. Agricultural efficiency gradually improved (as we shall see in chapter 5) and practices slowly spread to new regions. From the upper limits of the carrying capacity for foragers, the population increased nearly tenfold by 3000 BC to 50 million people, and it took only another 2000 years to increase this number to 120 million.[164]

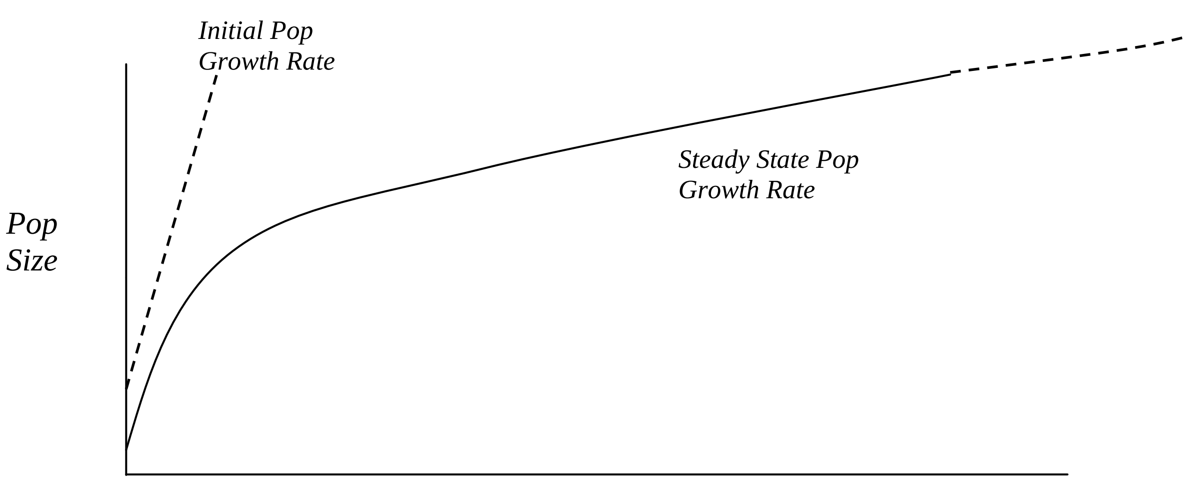
b) The Trap of Agrarian S-curves

But there was a problem. Cultural evolution tends in the long run to cause demographic growth, but it does not automatically guarantee that the right innovation will arise as a population approaches its carrying capacity, or the numbers of humans that can be supported in a given environment with a certain arsenal of technology that can produce a certain amount of productivity. The tinkering of ideas in cultural evolution is random, after all. For nearly 10,000 years, the growth in the carrying capacity of agriculture was sluggish compared to population growth, and so there was a series of miniature waves of population collapse and recovery throughout the period of agrarian civilisations. Not all learning was lost in each decline, so innovation accumulated in each cycle. The next expansion period brought renewed accumulation and thus gradually raised the carrying capacity. But it was not fast enough. The demographic time scale was short because human populations grew so quickly, while the accumulation of new ideas took longer. Thus you have the lag between the introduction of

[163] Neil Roberts, *The Holocene: An Environmental History*, (Oxford: Blackwell, 1998), 136.
[164] J.R. Biraben, ‘Essai sur l’évolution du nombre des hommes’ *Population* (1979) 34:13-25.

agriculture and the Industrial Revolution by 10,000 years in which population pressure assiduously bore down upon the rate of growth.

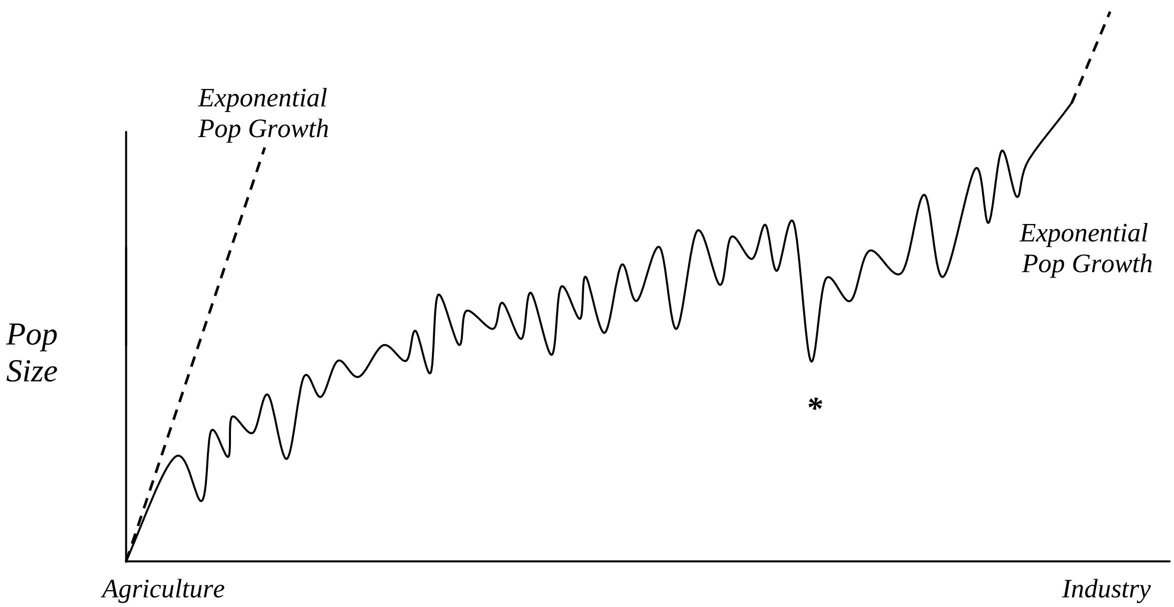
If collective learning can keep producing more to keep ahead of subsistence and starvation, the population continues to grow. If not, then the population temporarily bows to population pressure. As we shall see, this causes socio-political instability and sometimes periods of lengthy depression, elite infighting, civil war, and susceptibility to foreign invasion. This is the stage of the most risk, where learning can actually be lost, thus reducing the carrying capacity for when growth does resume. If, however, minimal or no learning is lost in those periods of decline, the carrying capacity continues to grow regardless of whether the population is in expansion, stagflation, crisis, or depression. Gradually the population grows as a long trend, regardless of the waves of mini s-curves when the population grows too fast, hits the carrying capacity, and temporarily recoils. Richerson, Boyd, and Bettinger hypothesise that after a rapidly growing population has hit the carrying capacity, it enters a 'steady state' population growth rate, where growth bows to population pressure but is gradually raised by innovation.[165]



(**Fig 2.1** Richerson, Boyd, Bettinger, 219)

[165] Peter Richerson, Robert Boyd, and Robert Bettinger, 'Cultural Innovations and Demographic Change' *Human Biology* (2009) 81: 211-235.

For most of the Holocene, the ‘steady state’ growth rate was hardly steady. The gentle curve belies the brutal nature of the population ramming against the carrying capacity.



(**Fig 2.2 –** The asterisk (*****) marks a period of severe population decline where learning is lost)

If we take the average length of a secular cycle to be a few hundred years, which seems to be the case (as will be seen in chapter 4), and we allow for many variations, this graph would represent the life-cycle of the last few thousand years of an agrarian civilisation between its adoption of agriculture and the introduction of heavy industry. The population losses of these *longue durée* cycles in periods of decline are not equal. Some disintegrative phases can be exacerbated by plagues, famines, or extended periods of civil warfare. Furthermore, the rate of growth is not constant either, since each innovation does not exert exactly the same amount of influence on the carrying capacity. Some innovations like the adoption of a better design of plough may have a slight improvement on total food production, whereas the adoption of legumes in a four-crop rotation can have a profound impact on the carrying capacity (see chapter 5). Also, the asterisk marks a hypothetical period where the population suffered a catastrophic decline and learning was forgotten on a large scale. It is astounding to think that this model roughly represents the demographic view of human development between the rise of agriculture and industry. Collective learning truly does form the 'shape' of human history. It is fast enough to allow long-term growth and the transition from agriculture to industry, and it was also slow enough to provoke regular demographic collapses in the agrarian era that came to influence many events in conventional history.

c) *The Darwinian Algorithm as the 'Plus Longue Durée'*

The notion that human populations grow and crash but do not derail the gradual rise of the carrying capacity (and free energy rate density) is very similar to other cosmic processes we have already witnessed. The numerous extinction events that follow many geological periods did not deter the gradual rise of biological complexity on the Earth. The shortage of available niches and the constraints that fortune placed on the evolution of species proved only slight ripples in a rising tide. Similarly, the preponderance of celestial bodies in the galaxy that do not attain a high level of variation through mineral evolution does not derail the overall trend toward complexity. Neither does the massive number of atoms in the universe that remain hydrogen and helium, nor the small fraction of the universe that is not dark energy, nor the number of 10^{500} sets of universal physical laws that are not capable of sustaining life or other forms of higher complexity – or even producing matter. The general trend is nevertheless the same. Similarly in the rise and fall of human populations, periods of disaster do not obstruct the path to growth. Despite the parade of s-curves, Tasmanian Effects, and the rise and fall of empires, the general trend in technological accumulation and the rise of complexity is upward. From there, extending beyond our own time, we do not yet know where complexity shall proceed.

We are now passing into the realm of traditional history but there still is a place for broad trends, Big History, and the intervention of the natural sciences. The Darwinian algorithm has assumed a form where the generation of new variations of ideas (which in turn produce higher complexity) is highly dependent on the available number of human minds to generate them. Thus cultural evolution becomes highly dependent on population ecology. The trends in the s-curves of the agrarian period, the rise of the carrying capacity, reverberate greatly in historical events and the rise and fall of great powers. In honour of the population-based histories of Fernand Braudel and Emmanuel Le Roy Ladurie, we shall focus on the dynamics of France, and its predecessors in Roman Gaul and the Frankish kingdoms. Thus we shall trace a sort of 'case study' in the impact of population dynamics on human history, cultural evolution, the impact of gradual innovation on the carrying capacity, and the crescendo of complexity.

New theories have advanced this kind of history in the last two decades. And the role of Big History and the Darwinian algorithm tie it right back to a process that has been proceeding for 13.8 billion years. If French *annalistes* like Braudel and Ladurie dealt with the *longue durée* of approximately 500 years of history, then it is safe to say that this extension represents the *plus longue durée* of history: the longest duration. There is a useful simile that one may use to conceptualise the various layers of the Darwinian algorithm. It is like the ocean. In the deepest, darkest waters at the bottom are the slow powerful currents of the cosmic, the geological, and the biological. Carried on top of them is the swelling tide of cultural evolution and technological accumulation. Above that are the large, majestic waves of s-curves and long trends in population dynamics that steadily rise and fall. Carried atop all that, propelled by what lies beneath, are the white caps and chaotic swirls of foam that represent historical events – quickly changing, quickly passing out of existence. Like conventional histories, I will focus on the chaos of the surface. But I shall explore how these events were shaped by the deep, tremendous force of the ocean.

Chapter Three: Population Decline & the 'Tasmanian Effect'

In the following chapter we will look at instances where knowledge accumulated by collective learning was lost, resulting in either the simplification or disappearance of technology. When this retrogression occurs, it holds the potential to actually lower the carrying capacity, thus further frustrating the dynamics of population strain and collapse that concerned Ladurie. We shall look at a few examples in the tribal societies of Tasmania, Oceania, and Middle Stone Age Africa. We shall then explore a similar impact in the agrarian civilisation of post-Roman Gaul. Doing this will help us better understand some of the mechanisms that drive both collective learning itself and also the demographic boom-and-busts during the agrarian era. Collective learning is a process where normally more innovation is retained than lost from one generation to the next. While much of the knowledge accumulated may be ecologically irrelevant, some will be relevant which is why the accumulation of knowledge allows a species to better exploit their environments, which in turn produces more people to innovate. Gradually the carrying capacity is raised. But when catastrophe strikes and a population is reduced and isolated, the accumulation of knowledge slows and the ability of a population to retain information is weakened. Studying examples of this mechanism will help us understand the immense danger that is present whenever population decline occurs, especially when it is backed up by large-scale manmade violence, the destruction of transport and communication infrastructure, the decline of literacy, and when it occurs over a protracted time period. Population declines occur every few centuries in the agrarian era, but the Tasmanian Effect is what made the agrarian population decline of the Western Roman Empire one of the most disastrous periods for collective learning.

The so-called Tasmanian Effect takes its name from the best known case of technological retrogression.[166] The inhabitants of Tasmania possessed many technologies shared by their Australian relatives to the north, but many of whose skills and technologies gradually disappeared after Tasmania was cut off from Australia c.10,000 years ago. The archaeological record shows that those technologies existed in the newly isolated Tasmania for several thousand years before they were lost. The contrast in size of tool kits between large and small populations of Oceania also demonstrates how collective learning is highly dependent on population numbers and connectivity. Finally, recent studies of Palaeolithic South Africa reveal two highly complex tool cultures slowly rising and then disappearing several thousand years apart. The Tasmanian Effect is more common in foraging societies because the populations are smaller and less well-connected than agrarian or modern ones.

But the Tasmanian Effect is not confined to hunter-gatherer societies. In agrarian civilisation, when populations are catastrophically reduced and isolated, the same phenomenon can occur. This is especially true in populations where literacy is sparse and even drastically reduced or there is loss or destruction of written documents. We shall study the impact of population decline, loss of connectivity, and the simplification or disappearance of technology in Gaul in the fourth, fifth, and sixth centuries. While Tasmanian Effects grow less common in the process of cultural evolution, especially when a society makes a transition to agriculture, it appears that they are still possible in cases of extreme demographic or manmade catastrophe. One thing that the Tasmanian Effect makes clear is that even when a species has collective learning and the long-term trend of the carrying capacity is up, it is not a guarantee. Like the temporary loss of variation in the great extinction events of the evolutionary epic, the *longue*

[166] Popularised by Jared Diamond, in historical, archaeological, and anthropological circles it is best known by that name. For this reason alone I will employ it here, though I have been warned by my Australian colleagues of the potential political indelicacy of the term. Suggested alternatives included the mouthful ‘technological retrogression’, with which no one is familiar. I’m afraid that I shall choose idiomatic clarity over verbal prudishness.

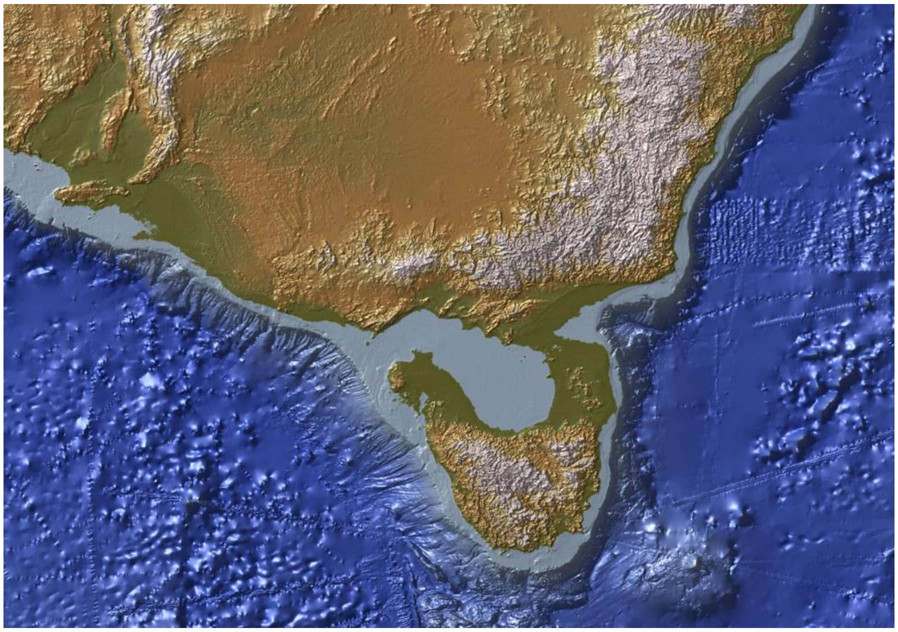
durée still presents humanity with many situations where the process of collective learning can be impeded or reversed.

I. The Tasmanian Effect in Foraging Societies

Jared Diamond famously observed that when Europeans first visited Tasmania in the seventeenth century, the native population was small, isolated, and lacked many of the tools and methods that aboriginal Australians on the mainland possessed. Tasmanians could not produce fire in hearths, they did not have boomerangs, shields, spears, no bone tools, no specialised stone tools, no compound tools like an axe head mounted on a handle, no woodworking, no sewing of clothes despite Tasmania's cold weather, and even though they lived on the sea coast, they had no technology for catching and eating fish.[167] Diamond hypothesised that this was caused by the loss of the land bridge between Australia and Tasmania c.10,000 years ago. A dwindling population and a lack of contact with the ideas of other communities eventually led to the loss of accumulated knowledge, because it seems that knowledge can be best preserved where there are many individuals sharing it. The technological retrogression of the Tasmanians has more or less been borne out by subsequent research, which is surveyed below. Small, disconnected populations simply cannot sustain the same level of collective learning as larger populations. Indeed, it may be that there is a demographic threshold below which collective learning finds it difficult to sustain itself. In the case of Tasmania, the population migrated from the Australian mainland before the end of the last ice age, when Tasmania was connected by a land bridge. They brought with them technologies similar to those on the mainland. Once the sea level rose and the land bridge was washed away, the extreme isolation that the shrinking Tasmanian population endured for

[167] Jared Diamond, 'The Longest Isolation, the Simplest Technology' *Nature* (1978) 273:185-186.

several thousand years gradually effaced the knowledge their people had previously carried with them.



(**Fig 3.1**Tasmania with sea level 60 metres below present. Map. University of Melbourne. Retrieved January 5 2013: http://jaeger.earthsci.unimelb.edu.au/ImageLibrary/Raster/Australia/Pages/se_b_n60_dry.html)

A subsequent recent study of Tasmania's archaeological and ethno-historical evidence has borne out the same result.[168] The Tasmanians upon European contact had lost a great deal of technology that was enjoyed not only by their neighbours across the Bass Strait but also by most groups of *Homo sapiens* in the Palaeolithic. Humans probably arrived in Tasmania from Australia 34,000 years ago, across a land bridge, and were indeed cut off 12,000-10,000 years ago by loss of the land bridge.[169] Archaeological evidence shows that at the time of migration, the Tasmanians were producing bone tools, cold-weather clothing, fishhooks, hafted tools, fishing spears, barbed spears, fish/eel traps, nets, and boomerangs, and continued to do so even after the island was cut off by the rising seas. These tools gradually declined in frequency, variety, and quality between 8000 and 3000 years ago before completely

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[168] J. Heinrich, 'Demography and Cultural Evolution: why adaptive cultural processes produced maladaptive losses in Tasmania' *American Antiquity* (2004) 69:197-218.

[169] R. Jones, 'Tasmanian Archaeology: Establishing the Sequence' *Annual Review of Anthropology* (1995) 24: 423-446.

disappearing from the archaeological record.[170] Thereafter, to hunt Tasmanians used one-piece spears, rocks, and throwing clubs, and their entire toolkit consisted of 24 items, as opposed to the hundreds of tools possessed by the indigenous peoples to the north.[171] Bone tools are on the Tasmanian record from at least 18,000 years ago, just as they were in Australian records and also enjoyed by Palaeolithic man in Africa from 89,000 years ago.[172] The archaeological record also shows that from 8000-5000 years ago, the Tasmanians relied heavily on fishing. It was second in their diet only to seal hunting, and fishing was much more prominent than hunting wallabies. By 3800 years ago, fish bones disappear from archaeological sites and fish was not part of the Tasmanian diet when Europeans arrived.[173] These findings may rule out a 'cultural choice' of Tasmanians to use a simpler toolkit, given that the environment was ideal for fishing on the island and could have provided an abundance of food. At present scholars can come up with no cultural reason that trumped ecology for the practice of fishing to die out completely. Some have nevertheless tried to claim the doctrine of cultural choice, like D. Read, who claims that because limited numbers of Tasmanians were able to survive with a drastically reduced toolkit, it represents a deliberate choice of Tasmanians to give up fishing and so forth.[174] But these studies have been shown to misread archaeological evidence, since once fishing and other technologies disappeared, for thousands of years they do not appear once on the record. Evidently, not once was the life-way revived, even though fishing was a highly valuable food source in that area.[175] All told, Jared Diamond's hypothesis forty years

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[170] Henrich, 198.

[171] L. Ryan, *The Aboriginal Australians*, (London: Queensland University Press, 1981) for the best overview of long-term aboriginal Australian archaeology.

[172] C. Webb and J. Allen, 'A Functional Analysis of Pleistocene Bone Tools from Two Sites in Southwest Tasmania' (1990) *Archaeology in Oceania* 25:75-78.

[173] Henrich, 199.

[174] D. Read, 'Tasmanian Knowledge and Skill: Maladaptive Imitation or Adequate Technology' *American Antiquity* (2006) 71 164-184 &

[175] Joseph Henrich, 'Understanding Cultural Evolutionary Models: A Reply to Read's Critique' (2006) *American Antiquity* 71:771-782 and A. Powell et al., 'Demography, Skill Accumulation, and the Origins of Behavioural Modernity' (2009) *Science* 324:1298-1301.

ago about a loss of knowledge due to connectivity and a shrinking population has been largely borne out by subsequent research.

It is not the only case where such a phenomenon has occurred, though it is undoubtedly one of the most extreme. Other Pacific groups have a history of losing canoe, pottery, and bow technology.[176] The Inuit were decimated by a plague and lost knowledge to construct kayaks, bows and arrows, and the leister, until it was reintroduced by migrants from Baffin Island.[177] Neither of these cases, however, have been studied thoroughly enough by modern research or can be confirmed empirically to be a Tasmanian Effect. For one thing, the frequency of inter-group contact kept these shrinking populations from sustained loss of collective learning. Inter-group contacts also therefore blur the archaeological connection between technological complexity and population size.[178]

However, one successful test of the connection between population size, connectivity, and the loss of knowledge, has recently been conducted by Michelle Kline and Robert Boyd. In various islands in Oceania, both technology and the frequency of inter-group connectivity is more possible to gauge, because island groups are more geographically bounded.[179] The ecological similarity between these Pacific environments allowed Kline and Boyd to focus on fishing technology, preventing geographical differences from distorting the results. The groups also had a common cultural descent. Toolkits found on European contact were examined on the basis of number and also the complexity of those tools based on a formula devised by W. Oswalt, that measures technological complexity in a mean average of 'techno-units' which are

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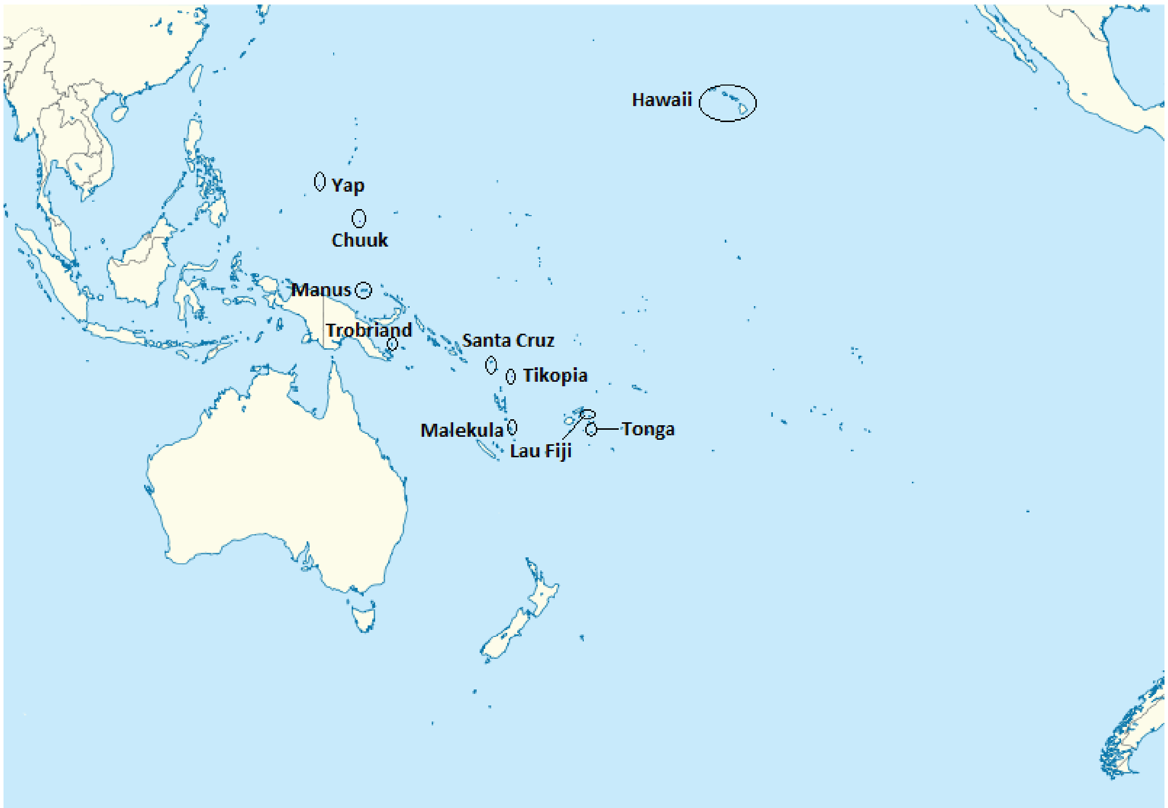
[176] W. Rivers, *Psychology and Ethnology*, (New York: Harcourt, Brace & Co, 1926).

[177] K. Rasmussen, *People of the Polar North*, (London: Kegan, Paul, Trench, Trubner & Co, 1908) and H. Golden, *Kayaks of Greenland*, (Portland: White House Press, 2006).

[178] M. Collard et al., 'Causes of tool kit variation among hunter-gatherers: a test of four competing hypotheses' *Canadian Journal of Archaeology,* (2005) 29: 1–19 and D. Read, 'An interaction model for resource implement complexity based on risk and number of annual moves' (2008) *American Antiquity* 73:599–625.

[179] Michelle Kline and Robert Boyd, 'Population Size Predicts Technological Complexity in Oceania' *Proceedings of the Royal Society B* (2010) 277:2559-2564.

integrated, physically distinct and unique structural configurations that contribute to the form of a finished artefact.[180] Additionally Kline and Boyd calculated the mean of the techno-units in a population. The finding was that the number of tools and the complexity of them are higher in larger well-connected populations.



(**Fig 3.2** Oceania. Blank Map. Labels Inserted. WikiCommons. Retrieved Jan 5 2013: http://commons.wikimedia.org/wiki/File:Oceania_full_blank_map.svg)

Group	Population	Connectivity	Toolkit	Mean of Tool Complexity (TU)
Malekula	1100	low	13	3.2
Tikopia	1500	low	22	4.7
Santa Cruz	3600	low	24	4.0
Yap	4791	high	43	5.0
Lau Fiji	7400	high	33	5.0
Trobriand	8000	high	19	4.0
Chuuk	9200	high	40	3.8
Manus	13,000	low	28	6.6
Tonga	17,500	high	55	5.4
Hawaii	275,000	low	71	6.6

(**Table 3.1** Kline and Boyd, 2009)

[180] W, Oswalt, *An Anthropological Analysis of Food-Getting Technology*, (New York, NY: Wiley, 1976), 38.

Larger island populations had a greater number of potential innovators. The larger populations on this list have a larger repertoire of tools, and are also less dependent on connectivity with the outside, as with the case of Hawaii. In comparison, relatively small populations with a high degree of connectivity were still able to retain a fairly large repertoire and a modest degree of technological complexity. Essentially, small populations that are connected to others are not really 'small populations' since they are tapped into a larger network. Complex tools are particularly prone to loss because it takes more people to retain and teach complex knowledge. Gradual tinkering can improve technology but the number of innovators and the connectivity between them can sometimes be crucial.[181] In the context of collective learning this makes a great deal of sense. In order for innovation to accumulate, you need to have the numbers to facilitate the transmission of those ideas and to encourage further tinkering. When population size and connectivity for ideas remain at a fairly low level, that process is not as rapid and may even stagnate.

It would appear that stagnation is more frequent in small hunter-gatherer communities than in the agrarian or industrial period. This may explain the long stretch of time that passed from the inception of our species in Africa 250,000 years ago and the dawn of agriculture. In this period of the *longue durée* there was a great deal of innovation and technological complexity, but nowhere near the speed of agrarian or industrial numbers and connectivity. Zenobia Jacobs, Bert Roberts, Hilary Deacon, and Lyn Wadley established two Palaeolithic Tasmanian Effects in Africa, at Still Bay 72,000 y/a and Howieson's Poort 64,000 y/a.[182] At Still Bay, humans created highly complex flake technology, including finely shaped,

[181] Kline and Boyd, 3.
[182] Z. Jacobs, R. Roberts, R. Galbraith, H. Deacon, R. Grün, A. Mackay, P. Mitchell, R. Vogelsang, et al. 'Ages for the Middle Stone Age of southern Africa: implications for human behavior and dispersal' *Science* 322 (2008) 5902: 733–5, L. Wadley, T, Hodgskiss, M. Grant, 'Implications for Complex Cognition from the Hafting of Tools with Compound Adhesives in the Middle Stone Age, South Africa' *Proceedings of the National Academy of Sciences* (2009) 106:9590-9594.

bifactually worked spearheads. At Howieson's Poort, humans created composite weapons and stone artifacts, both of which were hafted. These two sites were more innovative than much else in Middle Stone Age Africa, and an increasingly complex social organisation and an increase in population is implied by the use of bone tools, symbols, and personal ornaments. The strange thing is that these two industrious cultures are separated by several thousand years of stagnation and the disappearance of their technologies. And the differences between the way the technologies of Still Bay and Howieson's Poort are constructed implies that when Still Bay disappeared, the innovators of Howieson's Poort started from scratch. Both cultures intriguingly fall within the genetic bottleneck that occurred 80-60,000 years ago.[183] It would appear the relatively low carrying capacity for hunter-gatherers ranging across a territory, the small size of their groups, and their vulnerability to ecological changes and disasters made the disappearance of knowledge more common in the Palaeolithic.

II. The Tasmanian Effect in Agrarian Civilisations

The Tasmanian Effect is not just confined to hunter-gatherer societies, however, though due to the low connectivity and small populations of those societies it may be more common in such societies. The Tasmanian Effect can also occur in agrarian civilisations. We shall now focus on a case study where it occurred in the post-Roman West in the fourth, fifth and sixth centuries AD: In Italy, Gaul, Iberia, and Britain.

a) Population Decline in the Post-Roman West

In honour of Le Roy Ladurie and in a sense of continuity with his work, we shall focus primarily on Gaul. We must make clear, however, that the Western Roman Tasmanian Effect trend was not mirrored in the Roman-Byzantine East, which underwent a different population trend, including growth through the fourth, fifth, and into the sixth century AD:

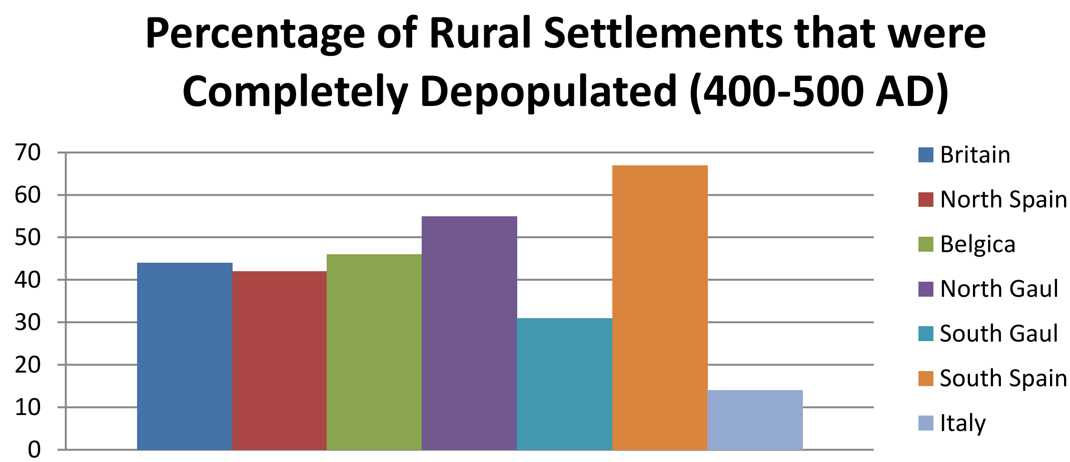
[183] Jacobs, 733.

(**Fig 3.3** Eastern and Western Empires in 395 AD. Utah State University. Retrieved Jan 5 2013: http://www.usu.edu/markdamen/1320Hist&Civ/slides/08romfal/mapEWRomanEmpire.jpg)

The population of Gaul, on the other hand, was already decreasing after 350. Settlement patterns show large-scale abandonment of fifth century farms in Gaul and Belgica to the tune of 30-55% and archaeology shows the deterioration of villas that were not abandoned completely.[184] This statistic is based on the last date of archaeological activity and signs of habitation in rural settlements. Complete abandonment of 30-55% of rural settlements is accompanied by other rural settlements showing signs of contraction, though not complete abandonment. The same phenomenon occurred in other regions of the Roman (and post-Roman) West: South Spain, North Spain, and Britain were particularly depopulated in the fifth century. You do not see the same rates of depopulation in the Byzantine East, however, where the population continued to grow until the mid-sixth century, as reflected in rural settlement

[184] Tamara Lewit, *Agricultural Production in the Roman Economy AD 200-400*, (Oxford: Tempus Reparatum, 1991),.

archaeology.[185] And it is clear that, unlike the West, there was no considerable deterioration of collective learning or technology in the East. There is a clear relationship between loss of technology and population dynamics in these two regions.



(**Fig 3.4** Based on the figures of Lewit 1991)

55% of rural settlements in North Gaul, 46% in Belgica, and 31% in South Gaul were abandoned by 500 AD.[186] The majority of these settlements were abandoned in the fifth century, though some abandonment happened in the fourth century. The sign of settlement abandonment still does not indicate whether depopulation was extreme enough to cause a Tasmanian Effect. However, the slight depopulation of the fourth century, the fifth century Germanic invasions, combined with the Justinianic Plague of the mid-sixth century (that hit both the East and the West), and the civil wars that followed, might have been drastic enough

[185] P. Gatier, 'Villages du Proche-Orient protobyzantin (4ème-7ème s.) Etude régionale,' in Geoffrey King and Averil Cameron, *The Byzantine and Early Islamic Near East: Land Use and Settlement Patterns*, (Princeton: Darwin Press, 1994), 17-48. Susan Alcock, *Graecia Capta: The Landscapes of Roman Greece*, (Cambridge: Cambridge University Press, 1993), 38-48. See also J. Bintliff, 'Forest Cover, Agricultural Intensity and Population Density in Roman Imperial Boeotia, Central Greece,' in Frenzel Burkhard *et al.* (eds) *Evaluation of Land Surfaces Cleared from Forests in the Mediterranean Region during the Time of the Roman Empire*, (Stuttgart: G. Fischer Verlag, 1994), 133-143 and also J. Bintliff, 'Regional Survey, Demography and the Rise of Complex Societies in the Aegean,' *Journal of Field Archaeology*, (1997) 24:8-38. C. Meyer, 'A Byzantine Gold-Mining Town in the Eastern Desert of Egypt: Bir Umm Fawakhir, 1992-93' *Journal of Roman Archaeology* (1995) 8:192-224. Clive Foss, 'Archaeology and the "Twenty Cities" of Byzantine Asia,' *American Journal of Archaeology*, (1977) 81:469-86. For a survey, see Chris Wickham, *Framing the Early Middle Ages: Europe and the Mediterranean, 400-800*, (Oxford: Oxford University Press, 2005), 442-53.

[186] See Lewit 1991.

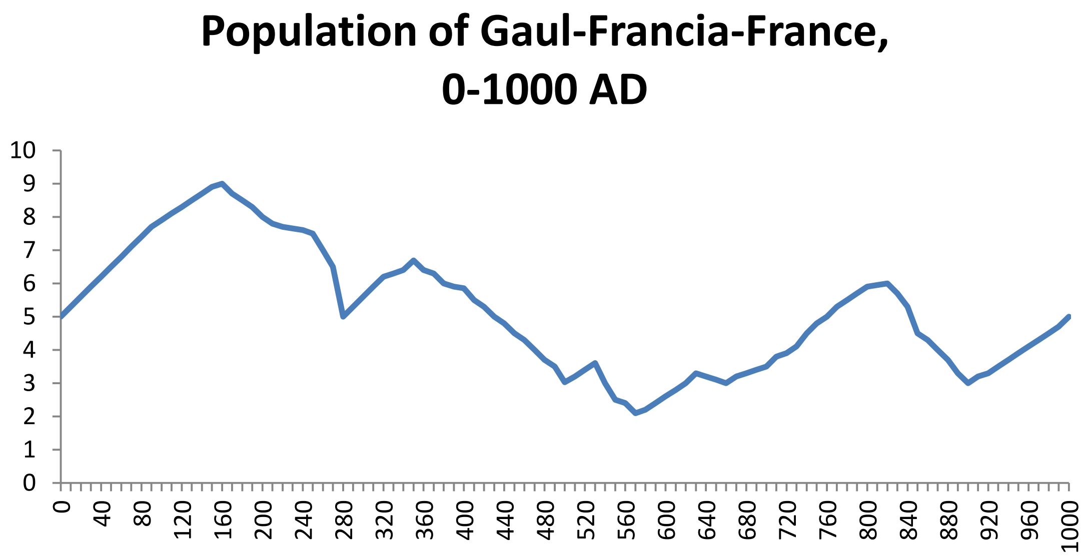
to reduce the population to the extent that collective learning was actually lost and the carrying capacity was lowered. It would then have remained for subsequent centuries to make up the difference.

The estimate of Jacques Dupâquier estimates the population of Gaul in the second century AD, at the height of the growth of the Principate cycle, at 8-9 million people, with an urban rate of around 5%; this figure is the high watermark of the Gallic population, compared to 4-4.5 million Gauls in the time of Julius Caesar.[187] Using the high watermark as an index and the rural settlement figures as a guide, Gaul, after the disintegrative phase of the 200s would have recovered to a population of around 6.69 million, by 300-350. From 350-400, that is to say, before the Germanic invasions, the population probably declined to 5.85 million people, a drop of 840,000 souls. Then from 400-500, the population dropped to 3,030,000 – over the course of the disastrous fifth century; that is a decline of 2.82 million people, giving us a total of 3.66 million since decline began c.350. Over the course of 150 years that is a drop of over one-half of the population. Given what we know of the combined effect of regular secular famine-induced losses, the scale of losses due to elite infighting and foreign invasion (particularly in comparison to similar losses in the medieval and early modern periods, as we shall see) those figures are entirely realistic. The population estimate here also tallies with other estimates that place the reduced population in the vicinity of 3 million by 500 AD.[188] Depending on the rate of recovery between the conquest of Clovis and the Justinianic Plague c.500-540, this number might have been reduced still further by the ravages of the pandemic.

[187] Jacques Dupâquier et al. *Histoire de la Population Française*, 4 vols, (Paris: Presses Universitaires de France, 1988), 68 & 86. See also Braudel, 140. Elisabeth Carpentier and Michel Le Mené, *La France du XIe au XVe siècle: population, société, économie*, (Paris: Presses Universitaires de France, 1996), 6.

[188] J.C. Russell, 'Population in Europe 500-1500' in *The Fontana Economic History of Europe*, ed. Carlo Cipolla, (London: Collins, 1969), 23. See also discussion Marcel Reinhard, André Armengaud, and Jacques Dupâquier, *Histoire générale de la population mondaile*, (Paris: Éditions Montchrestien, 1968), 64.

Either way, we are looking at a severe decline of the Gallic population that was reduced by about one-half and was held low by recurrent losses.



(**Fig 3.5** Estimates based on Dupaquier 1988, Braudel 1990, Reinhard 1968, and Lewit 1991)

The literary evidence also indicates a violent spasm of destruction in the barbarian invasions that were soon followed by periods of peace, before the West was struck by another invasion. It is possible these accounts are just the 'Roman bias' of the people whose lands were being invaded, that they are nothing but 'anti-German' propaganda, and the extreme acts of violence they reported were either exaggerated or fictionalised. Examination of several primary sources indicates that this was not frequently the case. Frequently the focus of the tract is not to denounce the Germans but the decadence and sin of a society that had brought God's wrath down upon Roman citizens such as in the writings of Prosper of Aquitaine, Orosius, Orientius, and Salvian of Marseilles.[189] Mention of slaughter is incidental to the wider narratives and religious rants of those documents. Additionally, many accounts were written by contemporaries and had they claimed vast slaughters that did not occur, they could

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[189] *Carmen de Providentia Dei* (attributed to Prosper of Aquitaine) trans. Michael McHugh, (Washington: Catholic University of America Press, 1964 [c.416], Orosius, *Histories Against the Pagans*, trans. Roy Deferrari, (Washington: CUA Press, 2002[c427]), Salvian of Marseilles, 'De Gubernatione Dei' in *The Writings of Salvian the Presbyter*, trans. Jeremiah O'Sullivan, (New York: CUA Press, 1947 [c.440]), Orientius, *Commonitorium*, trans. Mildred Tobin, (Washington: CUA Press, 1945 [c.406-439]).

easily be contradicted by their contemporaries. One of the most reliable firsthand accounts, Eugippius' *Life of Saint Severinus*, is a piece of religious propaganda to brag up the life and miracles of that saint, who lived from 453-482 in what is today Austria and Slovenia.[190] Eugippius shared many of Severinus' life experiences. Unlike other accounts of the Germanic invasions, no bombastic rhetoric is employed to describe the atrocities that Eugippius witnessed. They are taken as incidental alongside the author's attempt to flatter the memory of his friend. The account is nevertheless riddled with accounts of barbarian raids, abductions, and looting, in patterns very similar to other accounts from other regions and decades. Accounts like Paulinus of Pella (and Gildas of Britain) also take note of the extent of looting and destruction of property that filled the country with refugees.[191] If this habit of raiding and looting was characteristic of the invasions and even remotely systematic, as from other evidence seems to be the case, this would explain settlement abandonment and eventually a lowered carrying capacity. It would seem that depopulation in the early fifth century resulted just as much from starvation as from direct violence on the part of the invaders.

b) The Justinianic Plague

After a nearly two centuries of depopulation, the sixth century Justinianic Plague brought the post-Roman population to its low watermark. Little work has been done in historical scholarship on the Justinianic Plague, particularly for the West, though recent scientific work has confirmed the plague was a strain of *Yersina pestis*, just like its successor, the Black Death.[192] At the time of writing, there is no comprehensive historical study of the Justinianic Plague or a specialist study of the Latin West. The best works on the plague in general and in relation to Gaul are by Robert Sallares, Michael McCormick, Dick Harrison,

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[190] Eugippius, *Life of Saint Severinus*, trans. Ludwig Bieler, (Washington: CUA Press, 1965 [c.483-500].
[191] Paulinus of Pella, 'Eucharisticon' in *Poetae Christiani Minores* (Vienna: F. Tempsky, 1888[459/60)], 291-325, and Gildas, *The Ruin of Britain*, trans. Michael Winterbottom, (London: Phillimore, 1978 [c.540]), 16-26.
[192] David M. Wagner, et al, 'Yersinia pestis and the Plague of Justinian 541–543 AD: a genomic analysis' *The Lancet Infectious Diseases* Early Online Publication 28 January 2014.

Lester Little, and J-N Biraben and Jacques Le Goff. The first three authors, Sallares, McCormick, and Harrison, are extremely valuable for a number of insights into the nature and spread of the disease and the impact upon the Mediterranean world as a whole, and the last two authors Biraben and Le Goff, provide the most comprehensive information on sources with particular attention to Gaul.[193] The anthology compiled by Lester Little in 2007 is by far the most recent and most ambitious study of the Justinianic Plague so far.[194] It covers a variety of regions and topics, though admittedly the West in general and Gaul in particular get a short shrift.[195] A number of other authors are cited in this case study and other works are listed immediately below that have a focus well beyond Gaul, mostly in the East where the source material is more bountiful.[196]

All told, however, it is clear that a population that was already low and isolated (though perhaps recovering) in the beginning of the sixth century was further ravaged by the outbreak of a highly contagious and extremely deadly pathogen. The impact of the Justinianic

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[193] J-N Biraben and Jacques Le Goff, 'The Plague in the Early Middle Ages' *Biology of Man in History*, (Baltimore: Johns Hopkins University Press, 1975).

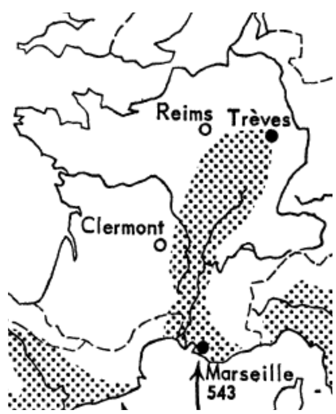
[194] William Rosen, *Justinian's Flea: Plague, Empire, and the Birth of Europe,* (London: Jonathan Cape, 2007) was released around the same time as Little's work and also makes mention of Gaul, but is a work by a non-historian written as a grand tale of the old style. It is full of inaccuracies about dates, makes irrelevant references to nineteenth and twentieth century history, and *all* the citations lack page numbers.

[195] No reference will be made here to the single article of Little's anthology that focuses on Gaul, Alain Stoclet's bizarre and incoherent 'Consilia humana, Ops divina, Superstitio: Seeking Succor and Solace in Times of Plague, with Particular Reference to Gaul in the Early Middle Ages' in *Plague and the End of Antiquity: The Pandemic of 541-750*, ed. Lester Little, (Cambridge: Cambridge University Press, 2007), 135-149, a confused cultural study that draws tenuous connections to literature from completely different periods and does absolutely nothing to shed light on the material impact of the disease on the population.

[196] T. Bratton, 'The Identity of the Plague of Justinian' *Transactions and Studies of the College of Physicians of Philadelphia*, (1981) 5, 3:113-124 & 174-180, L. Conrad, 'Arabic Plague Chronologies and Treaties: Social and Historical Factors in the Formation of a Literary Genre' *Studia Islamica* (1981) 54: 51-93, 'Epidemic Disease in Central Syria in the Late Sixth Century: Some New Insights from the Verse of Hassan ibn Thabit' *Byzantine and Modern Greek Studies* (1994) 18:12-58, 'Die Pest und ihr soziales Umfeld im Nahen Osten des fruhen Mittelalters' *Der Islam* (1996) 73: 81-112, 'Ta'un and Waba: Conceptions of Plauge and Pestilence in Early Islam' *Journal of Economic and Social History of the Orient*, (1982) 25: 268-307, J. Durliat, 'Le peste du VIe siècle: Pour un nouvel examen des sources byzantines' in *Hommes et richesses dans l'empire byzantine*, eds. V. Kravari, C. Morrison, and J. Lefort, (Paris: P. Lethielleux, 1989), 107-119, E. Kislinger and D. Stathakopoulos, 'Pest und Perserkrieg bei Prokop' *Byzantion* (1999) 69:76-98, K. Leven, 'Die "Justinianische" Pest' *Jahrbuch des Instituts fur Geschichte der Medizin der Robert Bosch Stiftung* (1987) 6:137-161, J. Maddicott, 'Plague in Seventh-Century England' *Past and Present* (1997) 156:7-54, D. Rijkels, *Agnosis en Diagnosis: Over Pestilentien in het Romeinse Keizerrijik*, (Leiden: Proefschrift, 2005). Others will be cited within the chapter.

Plague on Western Europe in the sixth century was probably less severe than the Black Death. In Gaul/France, for instance, the population was around 20 million in 1348, when it was likely only 3 or 4 million for the same vast region in 543, when the plague first arrived at Marseille. This did not reduce the death toll of the plague where it did strike, but there is evidence that the sparse and disconnected population prevented its spread into many regions that the Black Death would have no difficulty reaching. This has been established in the case of sixth-century Spain, where population was too sparse for the plague to make significant inroads inland.[197]

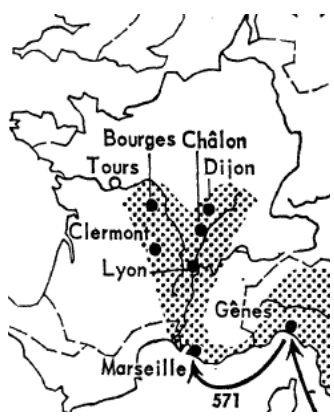
There were two major waves for Gaul in 543 and 571. There was also a succession of smaller waves in the 580s. Thereafter the land area covered by Gallic plagues is negligible. Examination of the primary documents reveals the first wave in 543 came out of Marseilles. It infected Provence, swept up the entire trade route of the Rhône, then sweeping as far north as Trier. It stopped short at Reims, and did not go farther west into Neustria or farther north into Germania. The plague also appeared in patches in the Midi, but stopping short of Clermont-Ferrand, supposedly by a miracle of the local bishop.[198]



(**Fig 3.6** Spread of the Justinianic Plague in Gaul. Biraben & Le Goff 1975: 1500)

[197] Michael Kulikowski, 'Plague in Spanish Late Antiquity', in *Plague and the End of Antiquity: The Pandemic of 541-750*, ed. Lester Little, (Cambridge: Cambridge University Press, 2007), 155.
[198] Gregory of Tours, *Liber Historiae Francorum*, trans. Lewis Thorpe, (London: Penguin Books, 1974), IV:5, .*Liber Vitae Patrum*, trans. Edward James, (Liverpool: Liverpool University Press 1985), VI:6, *Liber in Gloria Martyrum*, trans. Raymond van Dam, (Liverpool: Liverpool University Press, 1988), 50, Gregory of Tours, *Liber in Gloria Confessorum*, trans. Raymond van Dam, (Liverpool: Liverpool University Press 1988), 78, *Vitae Patrum* XVII:4 543,

The miracle of St. Gallus at Clermont is probably not due to the power of the divine but to the haphazard nature of a flea-borne disease, not to mention the relative disconnectedness of the population. Since black rats do not migrate very far on land, they require rapid movement of trade in grain, cloth, or other shipments to carry them.[199] Then the flea needs a cluster of human hosts to find once they are transported to an area. The result is certain patches of land do not see any devastation at all. Casualties would have likely been severe where the plague did strike, though the percentage of the population that was carried off is debatable.[200] Josiah Russell long ago claimed that there was an average loss of 20-25% in the first wave of the plague and a grand total of 50-60%, however these figures are likely exaggerated.[201] He was basing his numbers on the casualties of the Black Death in the fourteenth century, but as Dick Harrison has pointed out, it is impossible to presume a death rate just because it happened that way 800 years later.[202] Nevertheless we are talking about a devastating pandemic that struck a population that was already dangerously low.



(**Fig 3.7** Biraben & Le Goff 1975: 1501)

The second wave in 571 appears to have been just as severe for Gaul, if not worse. The Rhone trade route was once again heavily struck but there is no mention of it spreading any

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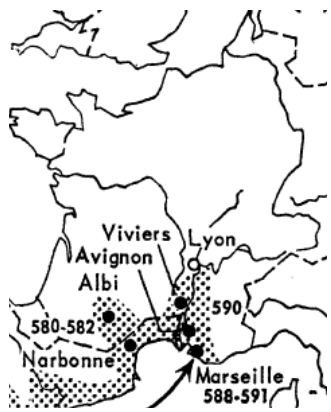
199 Robert Sallares, 'Ecology, Evolution, and Epidemiology of Plague' in *Plague and the End of Antiquity: The Pandemic of 541-750*, ed. Lester Little, (Cambridge: Cambridge University Press, 2007), 259.
200 Harrison, 26-27, is a minimalist who nevertheless concurs with the idea that casualties would have been severe in the region where the plague struck.
201 Josiah Cox Russell, 'That Earlier Plague' *Demography* (1968) 5:180.
202 Harrison, 27.

farther north as in 543. This time we know the Loire region was more heavily affected, with the plague reaching as far as Bourges, but Gregory does not say that it reached as far west as Tours, even though he would become bishop of the town two years later. Lyon, Bourges, Chalon-sur-Saone, Dijon, Clermont are all mentioned by name as being infected.[203] It would appear the populous south was hard struck by the second wave, while the sparsely populated north went unscathed. We know that this wave was particularly bad for southern and eastern Gaul, even worse than the concurrent outbreak in the East. It is possible that the greatest toll on southern Gaul was taken in this year.



(**Fig 3.8** Biraben & Le Goff 1975: 1502)

This brings us to the smaller waves in the 580s. It should be noted in this decade Gregory mentions sociopolitical unrest and food shortages accompanying the epidemics.[204] Definitive reports of plague are confined to Narbonne, on the Mediterranean coast in Septimania and under control of the Visigoths at the time. It only spread inland as far as Albi.[205] The region is said to have been particularly hard struck with recurrent outbreaks or the reintroduction of a new infection happening over the course of these years.

The gaps between infected regions were common to all three stages and got even patchier in the minor waves that persisted into the seventh century. The best explanation for

[203] Gregory of Tours, *Historiae Francorum*, IV:31-33.
[204] Gregory of Tours, *Historiae Francorum*, IX:6-7.
[205] Gregory of Tours, *Historiae Francorum*, VI:14 & 33, VII:1.

this is that the population was already so low and sparsely located that the disease could not easily spread. Michael Kulikowski found the same thing was true for Spain.[206] When the plague did strike it reduced the early medieval population to low levels, and it appears that the combination of fifth and sixth century depopulation spawned a Tasmanian Effect.

c) *The State of Roman & Post-Roman Technology*

Even those scholars who argue for continuity between the Roman and medieval period have grudgingly accepted that there were many cases of technological stagnation and recession in the post-Roman West. The case is confused by the apparent continuation of innovation and technology in the Byzantine East. But technological decline, or 'simplification' as some like to call it, undoubtedly shows up in the archaeological record in the Western Empire. Luke Lavan's overview of technological change between 300 and 650 AD makes a most instructive starting point for this subject.[207] Lavan raises an intriguing point about the previous period, which we would classify as a secular downturn in the Third Century Crisis, 'where a number of technologies appear to have been disrupted or discarded.'[208] The fourth century was characterised by economic and technological recovery. It is possible a Tasmanian Effect occurred even in the tumult and depopulation of the third century. One might hypothesise that this lowered the carrying capacity and this might explain why the Western Empire seems to have hit a demographic wall around 350, rising only to a fraction of the levels it reached c.150.

The crippling weakness of almost all works on Late Roman technology is that they draw no firm distinction between technology found in the Eastern and in the Western Empires, even

[206] Michael Kulikowski, 'Plague in Spanish Late Antiquity', in *Plague and the End of Antiquity: The Pandemic of 541-750*, ed. Lester Little, (Cambridge: Cambridge University Press, 2007), 155.
[207] Luke Lavan 'Explaining Technological Change: Innovation, Stagnation, Recession and Replacement' in *Late Antique Archaeology: Technology in Transition, AD 300-650*, eds. Luke Lavan, Enrico Zanini, and Alexander Sarantis, (Leiden: Koninklijke Brill, 2007), xvi.
[208] Lavan, xviii.

when there are very good demographic reasons for doing so.[209] The Eastern Empire flourished and grew throughout the fifth and into the sixth centuries AD. The Western Empire seems to have gone into decline by the mid-fourth century. It is no surprise that Lavan's section on innovation takes most of its examples from the East. No population decline in the fifth century East and no Tasmanian Effect, would lead to no loss of collective learning, and thus allow innovation to continue unhindered. He mentions the impressive Theodosian Walls of Constantinople, the most powerful fortifications built in Antiquity in terms of scale, depth, and strategic complexity.[210] Lavan mentions the civil monuments built in Rome, but this deals more with the fourth century and the period of elite inflation and conspicuous consumption. Lavan also mentions how these standards of construction were not common, especially in provincial cities.[211] But the architectural innovations of fourth century Rome and those of Hagia Sophia and sixth century Constantinople are mentioned in the same breath. They not only stand two centuries apart but they belong to two separate secular cycles. It is no wonder there is so much confusion on this subject, if technological examples are to be jumbled together like this. The rest of Lavan's section on technological innovation is dominated by the irrigation of Egypt, the screw presses of Tunisia and Tripolitania, the peasant stone houses of Syria, and the invention of lateen sails and frame-first ship construction centred on Palestine. All of this belongs to the East.

Perhaps not surprisingly, the next section on technological 'stagnation' draws more examples from the West. Lavan admits with some understatement that 'the technological profile of Late Antiquity is not entirely positive'.[212] The prime example of 'stagnation' is the low-level maintenance of buildings from the prosperous first and second centuries. In Rome

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[209] Lavan himself blandly dubs the concurrence of innovation and recession as 'one of the most fascinating aspects of the period' xviii-xix.
[210] Lavan, xxii.
[211] Lavan, xxiv.
[212] Lavan, xxviii.

there grew up a culture of repair with ‘a qualitative deterioration of skill’ and the most famous example of recycled friezes being placed on the Arch of Constantine.[213] Lavan’s explanation for this decline is worth noting. He states that professionally trained architects simply disappeared. Lavan says the Tiber Bridge built by Symmachus in Rome in the 380s lacked sufficient expertise and the structure collapsed.[214] This is illuminating. It would once again support the contention that collective learning was already in reverse in the Principate depression of the third century, which might help explain the stunted growth in the Western Empire in the fourth.

Finally, when we come to the section on technological ‘recession’ Lavan states that despite much evidence for continuity and innovation in the fourth to sixth centuries (notably taking most of his examples from the East) ‘one has to admit’ a recession ‘at different times in different places’ between the fifth and seventh century AD.[215] What can only be described as the grudging tone of this admission is symptomatic of the prevailing trend of continuitism: the tendency of some scholars writing on this period to insist on qualitative continuities rather than any sort of civilisational decline. The section on technological recession is also quite brief. Nevertheless the author admits that many Roman craft industries did recede or disappear. Once again, the examples for technological recession are predominantly taken from the West, though not many examples are given at all. Lavan mentions the decline and simplification of the Romano-British corn dryer as his only specific example.[216] This stands in stark contrast to his section on innovation.

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[213] See also Bryan Ward-Perkins, ‘Re-using the Architectural Legacy of the Past, Entre Idéologie et Pragmatisme’ in *The Idea and Ideal of the Town between Late Antiquity and the Early Middle Ages*, eds. Gian Pietro Brogiolo and Bryan Ward-Perkins, (Leiden: Brill, 1999), 227-232.
[214] Lavan, xxx.
[215] Lavan, xxxi.
[216] Lavan, xxxii.

d) A Possible Agrarian Tasmanian Effect

Collective learning is heavily dependent on demographic processes. People produce a variety of ideas and inventions: some are useful, some are failures. The more people there are, the greater the statistical probability that people will produce or preserve useful innovations.[217] The accumulation of knowledge gradually raises the carrying capacity by increasing food production. This produces more people, who in turn produce more ideas, and these in turn raise the carrying capacity. Sheer population size is not the only factor, however. In collective learning, a good idea is only spread and maintained if it is copied. The idea has to be adopted by others in the population. There must be an exchange of ideas. Certain conditions facilitate the exchange of ideas. There must be close-knit interaction between various communities. There must be a consistent and reliable form of language and letters. There must be long-distance exchange. There must be urban centres where large groups of specialists may gather and exchange information. There must be efficient travel between diverse and disparate regions. Language barriers, geographic obstacles, illiteracy, and ultimately depopulation, inhibit the exchange of ideas. These obstacles must be mitigated, overcome, or avoided for collective learning to gain momentum.

In what follows, I will offer evidence that that a relatively mild manifestation of the Tasmanian Effect occurred in Western Europe (Gaul, Italy, Spain, Britain) in the fifth and sixth centuries. The continuous depopulation of the post-350 disintegrative cycle, then the Germanic invasions, then the wars for the domination of Gaul, Italy, Spain, and Britain, then

[217] In this process, collective learning does not differ in the least from Darwinian natural selection and the principles of R.A. Fisher's fundamental theorem. In both collective learning and conventional evolution, one process being memetic and the other genetic, the generation of variations produces change and, occasionally, but not necessarily, improvement. In both collective learning and evolution, a larger population has more variations at play, and this enhances the process. This is particularly true for collective learning because one person in a population can potentially produce literally hundreds of ideas in their lifetime, some good and some bad, whereas in evolution an individual is limited to their genetic code.

the Justinianic Plague, then the numerous civil wars, had lowered the carrying capacity, disrupted exchange networks, and ultimately lost a great deal of knowledge for a variety of trades and crafts – from pottery, to agriculture, to woodworking, to weapons.

There is in fact a wealth of archaeological evidence for technological decline in the West in many areas. Roman animal skin tanning is our first example. Tanning is the processing of animal hides with tannin-rich vegetable infusions, making the leather resistant to water and bacterial decay. Curing is a less stable form of fighting off decay using oils, fats, or minerals. This process is impermanent and vulnerable to water. Roman tanning was introduced into Gaul after Julius Caesar conquered it. Along with tanning, the Romans brought better sewing and a new range of products, the most visible example being hobnailed footwear.[218] Then in the fifth or sixth century, hobnailed footwear disappears. Tanning itself disappears in the sixth century West and does not reappear until the Carolingian period, three hundred years later. This stands in stark contrast to the Eastern Empire, where tanning was used throughout the Roman and medieval period. The decline in tanning cannot be attributed to the invasion of the barbarians proper, because tanning was already faltering in the fourth century. It appears that when the factories that mass-produced tanned leather disappeared, the population at large did not know how to produce it themselves, and the knowledge of tanning technology was lost for three centuries.[219]

A similar pattern can be detected in Roman woodworking. Simple designs like combs were continuous in manufacture and design throughout the Roman and medieval period, probably because the technology is so simple. More complex designs like *pyxides*, small lidded boxes, tell a different story. In the Roman period, they were available to all levels of

[218] Carol van Murray-Driel, ‘Technology Transfer: The Introduction and Loss of Tanning Technology during the Roman Period’ in *L’artisanat romain: évolutions, continuités et ruptures (Italie et provinces occidentals)* ed. Michel Polfer, (Montagnac: Éditions Monique Mergoil, 2001), 56.
[219] Murray-Driel, 64.

society. In the Western Empire in the fourth century, however, the technology of manufacture became simplified and produced a lower quality product. Previously *pyxides* required two tools for manufacture that worked against the grain of the wood the whole time. The simplification was using one tool only, which reduced the amount the box could hold, weakened the structure, and left sharp jagged grooves on the inside from the tool. Then the product disappeared entirely in Gaul, as well as Britain, somewhere during the fifth century.[220]

Another mass-produced commodity that went into decline was the clay roof tile. Roof tiling was common throughout the Roman period. Even the lower classes had roof tiles. Tiles take quite a great deal of expertise to make. It would appear in the fifth century that expertise disappeared. 'Cultural choice' is an unlikely explanation for this disappearance. Clay roof tiles are better than thatch or wood shingles. They last longer and are much less prone to leaking. A well constructed tiled roof can last hundreds of years. A thatched roof has to be remade every few decades.[221] Once the knowledge for mass-manufacturing tiles disappeared in the fifth century, so did the tiles.

In fifth century Britain and parts of Spain, pottery was no longer made with a wheel and lacked quality and decoration. In Britain, even the kings of Northumbria used pottery of a deplorable quality, hand-shaped from badly processed clay, inadequately fired, and easily broken. In Italy, the range of jugs, plates, bowls, serving dishes, mixing and grinding bowls, casseroles, lids, and amphorae was reduced to a simple bulbous cooking pot.[222] There was a

[220] Paola Pugsley, 'Trends in Roman Domestic Woodwork: Bright Ideas and Dead Ends' in *L'artisanat romain: évolutions, continuités et ruptures (Italie et provinces occidentals)* ed. Michel Polfer, (Montagnac: Éditions Monique Mergoil, 2001), 112-115.
[221] Ward-Perkins, *Fall of Rome*, 96.
[222] Ward-Perkins, *Fall of Rome*, 104-106.

disappearance of large ceramic factories that engaged in inter-regional trade, a decrease in the variety of types, and the manufacture became course and slovenly.[223]

The same technological decline in the 400s and 500s affected other techniques. The production of tableware in Western Europe was vastly reduced. There was a complete disappearance of the technique of coating crockery with varnish. The large scale exploitation of marble quarries ended. The Roman construction technique of *opus quadratum*, which allowed building without the use of mortar, disappeared.[224] These things only resumed in the Middle Ages in the West, though they never really stopped in the East. Instead normal masonry was either done with *opus mixtum* or *petit appareil* (little coursed blocks, sloppily squared and irregularly laid), which both employ mortar.[225] Wine production in the sixth century Western Empire went into decline, and while the East began to innovate with the new and efficient screw press, the West was still using old winch-operated lever presses.[226]

In the fifth and sixth centuries, production techniques became simplified in a way that was easier to learn.[227] After a generation or two, more complex knowledge that is not used or recorded is lost. When mass-production ended, demand for complex products ended, as did the capacity to produce them. Artisans who survived population losses and who were not forced to give up their trade altogether might have to set up smaller factories with simplified methods and a reduced trading area. After a generation of complete disuse and further depopulation, the knowledge of how to make more complex items would have simply disappeared.

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[223] Paul Arthur, 'Form, Function, and Technology in Pottery Production from Late Antiquity to the Early Middle Ages' in *Late Antique Archaeology: Technology in Transition, AD 300-650,* eds. Luke Lavan, Enrico Zanini, and Alexander Sarantis, (Leiden: Koninklijke Brill, 2007), 181.

[224] Tiziano Mannoni, 'The Transmission of Craft Techniques According to the Principles of Material Culture: Continuity and Rupture' in *Late Antique Archaeology: Technology in Transition, AD 300-650,* eds. Luke Lavan, Enrico Zanini, and Alexander Sarantis, (Leiden: Koninklijke Brill, 2007), xlv-xlvii.

[225] Jeremy Knight, *The End of Antiquity: Archaeology, Society, and Religion AD 235-700,* 2nd edition, (Stroud: Tempus, 2007), 100.

[226] Jeremy Rossiter, 'Wine-Making after Pliny: Viticulture and Farming Technology in Late Antique Italy' in *Late Antique Archaeology: Technology in Transition, AD 300-650*, eds. Luke Lavan, Enrico Zanini, and Alexander Sarantis, (Leiden: Koninklijke Brill, 2007), 115.

[227] Mannoni, xlviii.

It is possible the decline of collective learning also influenced arms production, though precisely how is not clear. The dramatic shift in weaponry and armour coincides with the Third Century Crisis and Principate depression phase. The *spatha* sword replaced the old standard *gladius*, and *lorica segmentata* plate armour became increasingly rare as the third century progressed, helms changed in style, and the circular shield replaced the rectangular one.[228] It is impossible to decisively argue that these new features were less well made or less effective than the legionary kit of the first and second centuries, however. A more solid case can be made for the decline in the quality of military equipment in the fourth century. The Dominate in the fourth century has few finds of metallic armour. Monuments of the Tetrarchy, Constantine, and the house of Theodosius show mainly unarmoured troops or men in scale. Roman writer Vegetius asserts helmets and armour were rarely worn by the infantry from the time of Gratian (376-83). This claim has been hotly disputed, since it may refer to the state of the forces in the aftermath of the Battle of Adrianople. However, Gratian was the Western emperor and the scholarly consensus is that Vegetius was also from the West. It is therefore unclear why the pure conjecture that Vegetius is referring to an equipment shortage specifically around 378 in the Eastern Empire is the most likely explanation. Regardless, given the lack of archaeological finds and the representations of unarmoured men, a decline in the use of armour appears to be the dominant trend.[229]

This cannot be decisively attributed to loss of collective learning, though it may in fact be the case. It could easily be explained by the shift to mass-produced weaponry in the Dominate. There were twenty factories producing shields, swords, and, if the case is valid, armour in Italy and Gaul. This is a reflection of Diocletian’s impulse to mass produce and centralise.[230]

[228] M. Bishop and J. Coulston, *Roman Military Equipment from the Punic Wars to the Fall of Rome*, (London: B.T. Batsford, 1993), 122-149.
[229] Bishop and Coulston, 167.
[230] Bishop and Coulston, 186.

However, once these regions were overrun in the Germanic invasions, it would have had the same result for weaponry as the disappearance of factories for popular goods. There is some suggestion that higher technical manufacturing skills were lost, like the knowledge that allowed the production of torsion artillery.[231] The loss of the factories made salvage of older weapons extremely vital, and weapons themselves became scarce. For early medieval armour, a smith would be lucky to have a few pieces of steel, but mostly they had to use bloomery iron with pieces of steel in it. A lot of armour used in the fifth century was just reused armour that was mass produced in the fourth. Mail shirts were rare and reused to the point that very little has survived of them in this period.[232] The best way to gain an idea of the decline of weapons and armour is achieved by comparing a picture of a first or second century Roman infantryman, with his plate armour and solid helm, with that of a fourth or fifth century infantryman, unarmoured and in a tunic with helmet segments held together by leather. There is no question of which military kit had the finer quality and the greater effectiveness in battle. Most technology and organisational doctrines slowly disappeared in the fifth and sixth centuries, only to be revived in the Renaissance.[233]

The loss of collective learning also led to a decline in the functional quality of architecture. The shift away from Roman grandeur was obviously not just a ‘cultural choice’. The knowledge to reproduce such grandeur was forgotten and not recovered until the Renaissance. This is no better illustrated than by Filippo Brunelleschi (1377-1446) travelling to Rome several times to survey the construction principles of the surviving Roman ruins and devising a way to do the impossible: to erect a dome over the Santa Maria del Fiore in Florence 138 feet across. Medieval methods were insufficient; there was no way to construct a timber frame

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[231] John Coulston, ‘Arms and Armour of the Late Roman Army’ in *A Companion to Medieval Arms and Armour*, ed. David Nicolle, (Woodbridge: Boydell Press, 2002), 23.
[232] Alan Williams, ‘The Metallurgy of Medieval Arms and Armour’ in *A Companion to Medieval Arms and Armour*, ed. David Nicolle, (Woodbridge: Boydell Press, 2002), 45-49.
[233] Coulston, ‘Arms and Armour’ 24.

for the dome, since there were no trees large enough to bridge the gap.[234] The Pantheon, which Hadrian built in the second century AD, spanned 142 feet across, a little wider than the Santa Maria. Yet Brunelleschi was amazed that the Pantheon displayed no signs of visible support.[235] The knowledge needed to construct such a dome was forgotten and it took direct study of a Roman building to revive it. This is only one example of knowledge lost in the early medieval period that was revived by studying antiquity in the Renaissance. This does not denigrate the magnificent buildings of the Carolingian or the Gothic periods. There is no need to judge the various architectural styles qualitatively. The important point is that the dome of the Santa Maria del Fiore represents a specific piece of knowledge that was lost as a direct result of a decline in collective learning. In the early medieval period it was one of the casualties of the Tasmanian Effect.

Even in technologies that do not completely disappear, the Tasmanian Effect can lead to the simplification of technologies, as with the simplified tool kits of Oceania. Such a simplification happened in heavy industry in Gaul: the mass-production of Argonne and Mayen pottery. First, let us review the state of Gaul after the onrush of the Germanic invasions. The scale of economic decline in the fifth century corresponds to the magnitude of the population loss. South Gaul accordingly shows signs of more economic vibrancy than North Gaul. The North, which suffered a much larger population collapse, appears to have been in serious decline.[236] Apart from Metz and Trier and other strong points that could serve as a defensible redoubt against raids, most other towns were abandoned. North of the Seine towns that remained ecclesiastical centres were so heavily depopulated that they scarcely deserved to be called urban. Paris and the rest of the towns between the Seine and the Loire

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[234] Peter Murray, *The Architecture of the Italian Renaissance*, (London: Thames and Hudson, 1986), 31-32.
[235] Ross King, *Brunelleschi's Dome: The Story of the Great Cathedral in Florence*, (London: Pimlico, 2001), 26-28.
[236] Guy Halsall, *Barbarian Migrations and the Roman West, 376-568*, (Cambridge: Cambridge University Press, 2007), 347-8.

survived somewhat better, though archaeology shows they were occupied over a very much reduced area.[237] Between the Loire and the Seine it would appear that the culture centred on the Roman villa collapsed around 450. North of the Seine it would appear the deterioration of the villas began almost immediately after the 406/7 invasion.

The Gaul of the fifth century was clearly demarcated into two economic zones: south of the Loire, which continued to trade pottery with Africa and Spain, and North Gaul which produced its own pottery. This was Argonne ware, the largest trade network in the West and indeed in the Roman world north of Syria. Mayen pottery also had a smaller but no less substantial trade radius for the times. Trade in this line continued to flourish and be widespread over North Gaul. The decline in Argonne and Mayen pottery can hardly be measured in decline of trade. The mass-production of these wares continued well into the Dark Ages and the radius of their distribution contracted only slightly. However, almost immediately upon the onset of invasion there was a significant decline in these two forms of pottery in terms of *technological simplification* that I would hypothesise was the result of a Tasmanian Effect from massive depopulation. The number of forms and decorations declined to an absolute minimum as shown below. Furthermore it would appear the widespread demand for these simplified and unsophisticated pots indicates that local production centres were unable to produce them.[238] This implies an even more severe technological simplification at the local level.

First, let us examine Argonne ware. This was the larger of the two mass-production industries in the early medieval period and it had the larger radius. As stated above, Argonne ware was the largest scale production industry in the Western Empire. Until the 1960s it was

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[237] A. Dierkens and P. Périn, 'Les sedes regiae mérpvomgoemmes emtre Seine et Loire' in *Sedes Regiae*, eds. G. Ripoll and J.M. Gurt, (Barcelona: Royal Academy of Fine Arts, 2000), 247-9.
[238] Halsall, 349-350.

believed that Argonne production had ceased with the invasions of 406/7.[239] Then more recent archaeological finds revealed that Argonne pottery continued throughout the fifth century and well into the sixth before dying out.[240] Nevertheless, it would appear there was an immense change in quality and sophistication. Didier Bayard has divided the production of Argonne pottery into four broad phases of similarity in style with a number of sub-phases. The borders between each phase are blurred and can only be determined within around ten years, give or take. The Late Roman phase of Argonne pottery beginning c.350 ended around c.400-410 with an 'intermediate' sub-phase in styles between phases one and two probably corresponding to the years of the grand invasion of 406/7 and the installation of the Burgundians in the Rhine valley in 411.[241]

The 406/7 invasion did not destroy the infrastructure that allowed the diffusion of Argonne pottery, and it was distributed over the radius of 300km, though exports to Britain came to an end.[242] Neither did technological simplification coincide with the invasion period of 410, nor would one expect to see that happen. The loss of accumulated knowledge happens after depopulation has taken place, not at the same time. First, a generation must be depopulated. This causes demand for a product to decline by sheer numbers. This causes a simplification in the products being made. And finally, if the demand remains low, knowledge

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[239] For example, G. Chenet, *La céramique Gallo-Romain d'Argonne du IVe Siècle et la terre sigillée décorée à la Molette Macon,* (Macon: Protat Printers, 1941).

[240] W. Hubener, 'Eine studie zur spatromische Radchensigillata(Argonnesigillata)' *Bonner Jahrbucher* (1968) 168:240-98. For more recent works see D. Bayard 'L'ensemble du Grand Amphithéâtre de Metz et la sigillée dÁrgonne au Ve Siècle' *Gallia* 47:271-319, M. Tuffreau-Libre and A. Jacques, 'Le céramique gallo-romaine du Bas-Empire à Arras' *Gallia* (1992) 49 271-319, Bayard, 'La céramique dans le Nord de la Gaule à la fin de l'Antiquité' in *La Céramique du Ve au Xe siècle dans l'Europe du Nord-Ouest*, ed. Daniel Piton, (Pas-de-Calais: Groupe de Recherches et d'Etudes sur la Céramique dans le Nord, 1993) and 'Le fin de la domination romaine dans le nord de la Gaule: l'apport de la sigillée d'Argonne' in *L'Armée Romaine et les Barbares du IIIe au VIIe Siècle*, eds. F. Vallet and M. Kazanski, (Paris: Association française d'archéologie mérovingienne, 1993), P. van Ossel,'Einen Überblick über die Verbreitung dieser spätantiken Keramik in Nordgallien bietet' *Alba Regia* (1994) 25:221-230, and Bayard, 'La Sigillée d'Argonne, un Paramètre Essentiel pour l'Établissement de la Chronologie du Ve Siècle dans le Nord de la Gaule' in *La Datation des Structures et des Objets du Haut Moyen Âge: Méthodes et Résultats,* eds. Xavier Delestre et Patrick Périn, (Saint-Germaine en Laye: Association française d'archéologie mérovingienne, 1998).

[241] Bayard, 'La céramique', 109.

[242] Bayard, 'La céramique', 111.

of the more complex designs is forgotten. As it was, phase 2 (c.410-440) followed the Germanic invasions with not an overall simplification, but just a mild change in design: new decorations and the addition of a few new forms, like a jar with the lid attached to the collar. Nothing, however, really distinguishes phase 2 pottery from the decorations of previous phases.[243] Bayard states that phase 2 ended either with the bloody campaigns of Aetius and the Huns against the Burgundians in 436, or their relocation in 443, or, as Bayard deems more likely, even beyond the departure of the Burgundians as late as c.455.[244]

Then approximately half a century after the initial invasions, something radical happens. Even though the depopulation attested by the rural settlement abandonment and the literary sources was well underway, it is only at this point that we see a radical shift in Argonne production. Phase 3 is characterised by a dozen wheel-spun designs that appear indiscriminately on a few vases of fine classical design and also on a great many pots and dishes of mediocre quality, one of the most widely dispersed of which was a simple common dish.[245] Phase 3, however different in style from the phases that preceded it, did not last very long. Within twenty years, there was another radical change in style. Phase 4 began in 475 and lasted until 530. By this time the radius of distribution had shrunk to a 100 km, well within the Seine and the Rhine.[246] The design appears very different from phase 3. Examples clearly datable to phase 4 yielded very few rouletted designs and virtually no decorations. It is quite possible that c.470-500 Argonne ceramics became very simple and plain, with no decoration whatsoever.[247] Argonne pottery begins to make the shift from fineware to predominantly coarseware, a great many examples of which are no longer wheel-spun but handmade.[248] At

[243] Bayard, ‘La Sigillée’, 8.
[244] Bayard, ‘La céramique’, 109.
[245] Bayard, ‘La céramique’, 109.
[246] Bayard, ‘La céramique’, 118.
[247] Bayard, ‘La Sigillée’, 9-11.
[248] Knight, 150.

the dawn of the sixth century, Argonne production had shrunk to such a point that 60-75% of all ceramics were being locally produced, and were less fired and of an extremely poor quality.[249] After c.530-540, possibly coinciding with the Justinianic Plague, Argonne persists in the form of simply pots and a smooth dish until a little before 600. For the most part, plain pottery only appears in military graves in the 500s and then stops at the end of the century.[250] Demand for mass-produced pottery had dropped as a result of the invasions and depopulation of the first half of the fifth century. When demand did not recover for several decades, production was simplified. Only plain, low quality pottery was produced on a gradually declining scale. At the end of the sixth century, the knowledge of more elaborate manufacture was forgotten and not revived for many years.

In Mayen pottery, distributed from the Eifel highland zone along the Rhine, there is longer continuity. Simple designs like cooking pots and lid-seated jars remain from the Late Roman to Carolingian period. Fifth century ware was of reasonable quality and came in a vast range of types, including bowls, dishes, field-flashes, and bottles. Sixth century Mayen pottery continued to be wheel-turned though the quality showed growing incidence of irregular fracture. The same design grew poorer in quality by 600, though with an attempt to mimic similar decorative designs. Within the 600s, however, Mayen pottery demonstrates the same pattern that Argonne exhibited a century earlier. Red-painted ware that appears on the archaeological record between 650 and 750 are weakly painted, generally oxidised, with a very limited range of forms – mostly of globular vessels. The same goes for seventh century stoneware where simple globular pots form nearly 80% of all types from production sites. If you combine this with globular pitchers with spouts this percentage rises to 93%. This period

[249] Bayard, 'La céramique', 119.
[250] Bayard, 'La Sigillée', 9-11.

marks a shift toward more utilitarian designs, with a reduction both in type and decoration.[251] It is quite likely that the geographic location of Mayen production fell outside of areas that were depopulated in the fifth century, and it was not until the sixth century plague and civil wars shifted the focus farther north and east that depopulation led to a similar decline in production and a simplification in design, and ultimately a decline in accumulated knowledge.

e) General Trends in the Post-Roman Tasmanian Effect

The loss of knowledge was by no means uniform across all trades, nor was knowledge lost uniformly over all regions in the former Roman Empire. However, the increasing isolation of Gallic localities due to the breakdown of infrastructure, the reduction of long distance trade, and the gradual rise of illiteracy at the local level, exacerbated a loss of collective learning that population decline was already causing. Different technologies did not decline at the same rates, nor was decline in any particular technology uniform across all regions. Due to the sedentary nature of agrarian centres and the tenuous communications between them, the loss of collective learning can only be measured at the local level. This makes sense, since we are measuring the state of learning within individual populations of villages and counties, rather than a confederation of them. Different pieces of information were lost depending on the demographic decline of the region, the industries of the region, the state of communication between that region and its neighbours, and which specialists and literature were eliminated and which survived.

It would appear in circumstances of extreme population decline, a craftsman may be killed and unable to pass on his knowledge through apprentices or writing. Even if he is not killed, a severe population decline reduces the demand for his goods. Accordingly, we see the severest decline in technologies that create mass-produced, low-cost, everyday goods rather than

[251] Mark Redknap, 'Medieval Pottery Production at Mayen: Recent Advances, Current Problems' in *Zur Keramik des Mittelatters und der Beginnenden Neuzeit im Rheinland*, eds. David Gaimster, Mark Redknap, and Hans Helmut, (Oxford: BAR International Series, 1988), 13-17.

luxury goods for the elite. If demand shrinks and remains low for several generations, the incentive to retain the knowledge of the craft diminishes and eventually is discarded. Lastly, population decline, especially brought about by violent means like war and pillage, reduces the material wealth of a community. Even if demand for a product remains substantial, the resources with which an artisan could produce those goods are no longer available. Once again, if production is impossible for several years, the knowledge for doing so can be forgotten, especially if it does not survive in literature. A mixture of these various dynamics seems responsible for the occurrence of a Tasmanian Effect over the course of a prolonged population decline.

The massive decline in rural settlements combined with shipping, iron and lead production, and urban centres (that we shall discuss in the next chapter) is fairly conclusive evidence of an overall population decline in the fifth century. The scale implied is enormous. We are talking about marked population decline in provinces like Gaul that were already thinly populated compared to the East. This decline was protracted for over a century. Thus we are talking about the disappearance of thousands of people from several generations. With the disappearance of these individuals inevitably came the disappearance of knowledge. With the isolation of those who remained, no longer connected by the vast network of the Roman Empire, came a hindrance of the exchange of ideas. The decline of a population leads to the decline in the number of ideas being produced. The decline of a unified network of exchange leads to the decline in the number of ideas floating in from elsewhere. Finally, without a vast expansion of literature saving ideas when the population declines, there are fewer minds to retain those ideas and pass them on to future generations. This is how the Tasmanian Effect strikes at cultural evolution. It is the rare but devastating loss of more information with each generation than is passed on to the next that inevitably reduces the standard of living, the carrying capacity, and the general complexity of a society.

The Tasmanian Effect in the post-Roman west, however, remains more of an anomaly in the era of agrarian civilisations than it does in hunter-gatherer societies. I have yet to find another convincing instance where collective learning was lost and took centuries to recover. While other examples of Tasmanian Effects may exist in agrarian history, it is quite clear that such things are rare in a period where humans are much more numerous and better connected than in foraging communities. Even then, it is clear that a loss of accumulated knowledge is still possible. Like a mass extinction event in biological evolution, a cultural extinction event wipes out variations and it can take years for a society to recover to the same level of technological proficiency. It is relevant though highly speculative to ponder what catastrophic conditions would be required to achieve a Tasmanian Effect in modern society. But that goes beyond the remit of this work. It suffices to say that if Tasmanian Effects are rarer in agrarian civilisations than in hunter-gatherer societies, they must be rarer still once we approach the globally interconnected system of modernity.

In this section we surveyed how decline in population and connectivity does not only reduce the speed of collective learning, it can also reverse the process. In Tasmania, Oceania, and Palaeolithic Africa, populations were adversely affected by small populations and low connectivity. Even in the era of agrarian civilisations, a decline in population and connectivity could eliminate knowledge and reduce technological complexity. The study on post-Roman Gaul is unique in that it is one of the first historical surveys of the Tasmanian Effect in an agrarian civilisation. There remains the question of why Tasmanian Effects occur. It is very closely tied to the phenomena Le Roy Ladurie studied in the *longue durée.* A drastic population downturn can cause technological retrogression, sometimes this is caused naturally, and sometimes it is caused by manmade crisis. The latter is a frequent occurrence in the demographic cycles examined by Ladurie. When the population declines, manmade violence can hold the population low, destroy infrastructure, cut off communication networks, and when compounded with disease and famine, a Tasmanian Effect can result. The loss of the knowledge accumulated in previous generations by collective learning is the worst-case scenario for the population declines of the agrarian cycles we shall examine in the next chapter.

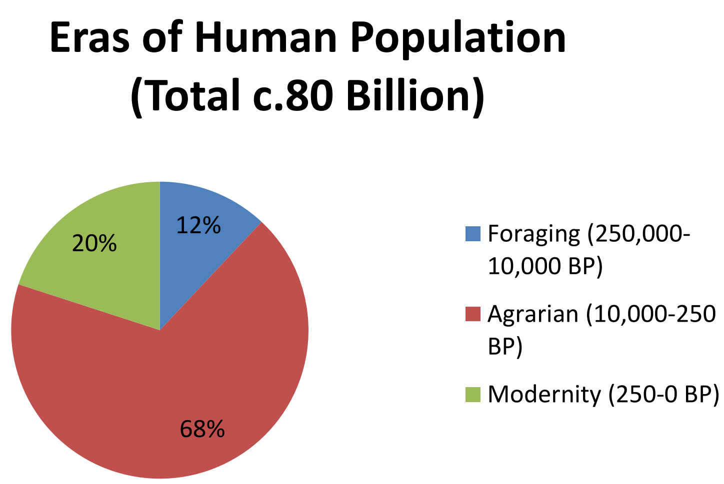
Chapter Four: Longue Durée Cycles in the Agrarian Era

This chapter will explore the relationship between population s-curves in the agrarian period and the rise and fall of sociopolitical instability. Generally speaking, periods of population growth result in a higher frequency of political stability, and periods of population decline result in the severest periods of upheaval in the historical record. Most strikingly, in all cases that have been studied, the initial ecological decline or stagnation of a population seems to be followed by a period of intensified internal conflict – a manmade crisis that holds the population low. The stalling effect of manmade crisis on population cycles is the most significant way that human population cycles differ from most s-curves in the non-human biological realm. Non-human species usually recover without a large-scale population depression caused by intra-species violence. Because of the peculiar attributes of our species, most notably our societal complexity, our tangled competition for resources within convoluted class systems, and also our enhanced capacity for organised violence, human populations enter an additional phase of manmade crisis. This period of infighting and imperial collapse seems to be triggered by ecological causes, primarily the slow rise of the carrying capacity and the slower pace of technological innovation relative to population growth in the agrarian era. In this sense, the demographic-structural model of these ecological s-curves can be seen as part of a set of larger hypotheses that extend beyond the workings of agrarian societies and even into the non-human realm.

We will sample works on s-curves in several regions and time periods. The first is Amerindian Pueblo society in southwest Colorado 700-1300 AD, which seems to conform to the predictions of population decline and internal instability, except when external warfare and invasion intervene. The second is a look at England 1150-1700 AD that notes two major cycles, the first in the medieval period where there is a clear connection between population fluctuations, living standards, the rise and fall of elite incomes, and sociopolitical instability, while the second is slightly obscured by the inception of the ‘agricultural revolution’ of the sixteenth and seventeenth centuries, while some symptoms of s-curves still remain. The third is a case study of Russia, 1460-1620, which also seems to conform to the inverse relationship between population and levels of instability. The fourth is a combined case study of the Ottoman Empire and Chinese Ming dynasty, which underwent cycles at roughly the same time, and exhibit markedly similar traits. The fifth case study is Rome in the Republican and Principate eras, between 350 BC and 285 AD, which also seem to undergo two major cycles of population growth, decline, and instability. This sampling brings us to the in-depth case studies of our own work, first, on the Roman Dominate (285-600 AD) where population fluctuations and instability can be split between the Eastern and Western Roman Empires. In the East, the population grew into the sixth century and experienced low instability. In the West, the population recovered from the Third Century Crisis until around 350 AD, when the population again entered a decline that seems largely connected with continued manmade crisis. The second case study, placed in a separate chapter due to its length, deals with Le Roy Ladurie’s old stomping ground of medieval and early modern France. In this period, France underwent two major cycles, one in the medieval period seeing growth from 1000 until 1300, then ecological crisis followed by manmade disaster until 1450. Recovery and another conventional cycle of growth 1450-1550 resulted, followed by another period of instability 1550-1730. In this second cycle, no exogenous variable as powerful as the Black Death intervened, and in the seventeenth century we witness three mini-waves of population growth and decline, each of which seem to accord with periods of instability. Chapter 5 closes with some general conclusions about the nature of s-curves in the agrarian era.

I. The Broad View of Human Population Dynamics

First let us take a broad view of human population dynamics. Approximately 80 billion human beings have lived and died on the surface of the Earth since the inception of our species. Roughly a fifth of them have lived since the Industrial Revolution.[252] Nevertheless, over two-thirds of all humans who have ever lived have drawn breath in the agrarian era from c.10,000 to 200 years ago: the realm of most traditional history. The temples of Greece, and the imposing citadel at Persepolis, and the magnificent halls of Versailles were surely the result of a higher level of complexity than the mere 9.6 billion humans who lived in the long stretch of the Palaeolithic from 250,000 to 10,000 years ago.[253] It is no coincidence that the agrarian period is where most of historical study operates. Traditional history is not dwarfed by the grand narrative of 13.8 billion years. Simply more people were alive during this time and a great many pulsations of complexity were occurring. There is, as a consequence, a great deal of intricacy for historians to study. This complexity is heavily influenced by population numbers and the number of ready minds to innovate and accumulate culture.



(**4.1** Population of all humans who have lived, by era, Livi-Bacci 1992)

[252] Livi-Bacci, 31 & 33.
[253] Ibid.

A dominant trend in agrarian history appears to be a combination of the demographic and the structural. In waves lasting a few centuries, with many variations, populations ebb and flow, empires rise and fall, and the story of agrarian civilisation is one of struggle against scarcity and against the violent passions that animate a society when it is starving. When populations are low relative to the carrying capacity, there is plenty of food and a shortage of labour. This occurs in all the examples cited in this chapter. As a result, the vast bulk of the population (c.80-90%) enjoys a high standard of living. Bread is cheap, land is plentiful, and relatively high disposable income allows for modest luxuries: regular consumption of meat, expansion of the farm, investment in trade. The population grows as a result. Then after a few generations, the population begins to strain the carrying capacity, prices of essential goods rise, wages shrink because there is an oversupply of labour, and as a result the cushion of wealth of those at the margins disappears. Land allotments shrink and cannot support a family, increasing numbers of peasants are forced off their land and become wage labourers, shortages of grain become more common, crop failures caused by foul weather become more devastating, and things get very unpleasant for the vast majority of the common population. On the other hand, the low wages and higher rents profit the wealthier sections of society – the rich get richer and the poor get poorer. The elite population gets wealthier and more numerous. Then the common population starts dying. The rich also suffer, since their incomes shrink as there are fewer people to pay rents, to pay high prices for goods, or to scrabble for their low wages in exchange for labour. Almost overnight the situation is reversed. The common population can experience better conditions and is ready to rebound. Unfortunately, the elite population often prevents this with a manmade crisis that holds back population recovery for decades.

Competition for increasingly scarce resources between numerous elites, leads to faction, instability, and civil war. Competition exists not only between elites but also between elites and the government. And here is the crucial process that the *annalistes* like Ladurie missed. The rise in violence in society in the aftermath of population decline is what keeps the population low for decades upon decades, when ecologically one would expect the ranks of humanity to immediately swell forth once again. This is what Ladurie and Postan could not explain in the Brenner debate. The situation is exacerbated by the growing destructive power of which a human civilisation is capable, and this is a negative feedback effect of collective learning. What might have been a scrap between a few tribes in the Palaeolithic becomes a cataclysm that can claim millions of lives. It is here, and not simply by starvation, that the worst declines can happen. The Malthusian crisis is followed by a manmade one that is often incomparably worse, sociopolitical violence holding the population low decades after the initial drop. Here is the hard grim reality that adds detail to the overall 'shape' of human history that we have been building in this work.

II. Main Drivers of Longue Durée Cycles

It goes without saying that foremost of the drivers of the patterns surveyed in this chapter is population growth. Human reproduction in the agrarian era had a tendency to outstrip the carrying capacity every few centuries. Population influenced the availability of land and the amount of basic food goods that were available for sustenance. It also influenced the distribution of land. When overpopulation took hold, peasant holdings became increasingly fragmented to the point that they could not support a family. Often these small properties were bought up by large landowners, which flung a large number of peasants into the labour market. Eventually overpopulation gets so severe that it makes famines, when they strike, more devastating than crop shortages in years when the population is well below the carrying capacity. So, population is undoubtedly the main driver of the ‘natural’ crisis caused by the game of ecology.

Another driver is the number of elites relative to the total size of the population and the size of their incomes relative to each other. Elites are always stratified into the very rich, middling, and low level magnates. But when the elite numbers grow in times of population strain (profiting from the low labour and sale of peasant holdings) this can set up future difficulties. When populations stagnate or go into decline, elite incomes can drop. For those middling and poorer elites this can significantly reduce their incomes. It is in this period that we see the rise of inter-elite competition and also competition against the government. Here is the main driver behind the manmade crisis. However, this notion has to be qualified. It would degenerate to mono-causalism to attribute an entire internal conflict to the decline of elite incomes. Nevertheless, in an ecological sense, it constitutes motive and opportunity. And this trend is a frequent enough occurrence in the history of agrarian civilisations to constitute a regular pattern that is worth exploring.

Another driver of these cycles is the policy of the government itself. Once faction and political difficulties mount up, and the tax base decreases due to depopulation, many governments succumb. However there is an element of human agency that can exist in good policy that can ease the symptoms of crisis – at least temporarily. Two instances of this may be Louis XIV of France at the end of a disintegrative cycle and Elizabeth I of England at the beginning of population strain in the 1590s. Yet against the monstrous force of nature, wise government can only proceed so far, until, either the carrying capacity is raised sparing disaster (as seen in eighteenth century France) or a less competent administration succeeds, exacerbating the disaster (as seen in the seventeenth century Stuart dynasty).

Elements that are more ‘external’ to the demographic-structural model cannot be discounted. By ‘external’ I mean variables that are not directly tied to internal population dynamics or the relative social cohesion of a society. External war, as with the Pueblo societies, seems to account for periods of violence when the internal population is still on the rise. External wars of conquest are not the result of the same demographic-structural factors as internal sociopolitical instability, since the xenophobia, tribalism, war-mongering, and desire for plunder seem to be perennial and fairly engrained in the character of the human primate and human culture. They can occur at any point of the cycle and reduce a population well before it reaches the carrying capacity sustained by its agriculture. Similarly, devastating epidemics, do not arise because of overpopulation or depopulation, but they arise from the biological sphere and evolution of pathogens. They can, however, be quite devastating to a population already suffering from malnutrition and hugely exacerbate population declines that are already underway. As will be noted in the case of England and France, the Black Death was preceded by a period of more ‘natural’ population decline starting at the beginning of the 1300s. Another external variable is land clearance, where populations in a region clear forests or drain marshes to raise the carrying capacity. Obviously, the ability of a human population to raise its local carrying capacity depends on the availability of such uncleared land. Some populations exploited this variable, such as in Western Europe in the tenth to thirteenth centuries. But once that land is cleared, the land then has to be used more efficiently to raise the carrying capacity once again. This can only be done by innovation. Land clearance might, perhaps, be considered a form of ‘innovation’ within the framework of collective learning. However, it is not absolutely necessary for humans to develop a new tool or technology for such a land clearance to take place.

Another variable to consider is climate. In a society whose carrying capacity is highly dependent on agriculture, it follows that a society should be profoundly influenced by fluctuations in the global climate. These fluctuations were influenced by Earth's orbital changes and volcanic eruptions which altered the average temperature of the Earth by several degrees every few centuries. It is also possible that from very early on that greenhouse gas emissions and the clearing of forests by humans (to fluctuating degrees depending on population levels) also influenced whether the Earth's temperature rose or fell.[254] The medieval warm period 800-1300 AD may have played a role in the expansion of agriculture and the land clearances of many parts of the world in that time period, along with a notable increase in the carrying capacity of the European and East Asian populations (as we shall see in this chapter). Conversely, the Little Ice Age from 1350-1850 may have exacerbated crop failures and put pressure on the carrying capacity, even while agricultural innovations via collective learning tended to increase it.

Another main driver is the carrying capacity of the human population. In the agrarian era it was 'sluggish' in rising compared to population growth. If the carrying capacity had risen faster, civilisations would have been spared the s-curves that created so many sociopolitical problems that afflicted them. While the carrying capacity was gradually raised between 10,000 and 200 years ago (and arguably 250,000 and 10,000 years ago), the carrying capacity did not keep pace with the exponential power of human breeding. The driver that eventually raised the carrying capacity was the form of cultural evolution known as collective learning.

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[254] See William Ruddiman, *Plows, Plagues, and Petroleum: How Humans Took Control of Climate*, (Princeton: Princeton University Press, 2005), and *Earth's Climate: Past and Future*, (New York: W.H. Freeman, 2008), for the 'early anthropocene hypothesis' that states that humans may have started influencing the climate as early as 8000 years ago with the intensification of human agriculture.

Each human innovator is capable of producing a number of variations, tinkering with inherited ideas, and occasionally improving upon them. It was this process that ensured that the turmoil of s-curves did not have to be eternal. Human innovation increasingly managed to harness more energy to sustain larger numbers of people, who eventually produced more and more variations of culture and ideas. The complexity of human societies gradually increased as the agrarian era progressed. Ultimately, it is the carrying capacity that is the connection between the conventional *longue* and the Darwinian *plus longue durées*. And it is here that we find the lynchpin of the human and cosmic stories.

III. Case Studies

a) Demographic Fluctuations and Instability in Mesa Verde (600-1300 AD)

While most of the work on agrarian cycles has been done by the theory's primary advocates, Turchin, Nefedov, and Goldstone, authors Timothy Kohler, Sarah Cole, and Stanca Cuipe took their model and decided to test it on the Mesa Verde Pueblo societies in southwest Colorado in the pre-Columbian era. Their intention was to determine to what extent population decline corresponded with sociopolitical instability. 'Pueblo' societies or 'Anasazi' were various Amerindian farming civilisations that inhabited a circle of land comprising northeast Arizona, northwest New Mexico, southern Utah, and southwest Colorado between 7000 BC and 1600 AD.[255] Kohler et al.'s study area comprised of a set of communities that thrived c.600 AD to 1300 AD in rural settlements covering an area of 1800 km² around Mesa Verde. These Pueblo societies were bordered to the south by another powerful Pueblo society called the Chacoans, who briefly led an invasion and conquest into the study area. We shall discuss how that impacted Pueblo agrarian cycles later. Kohler et al.'s main interest was to determine

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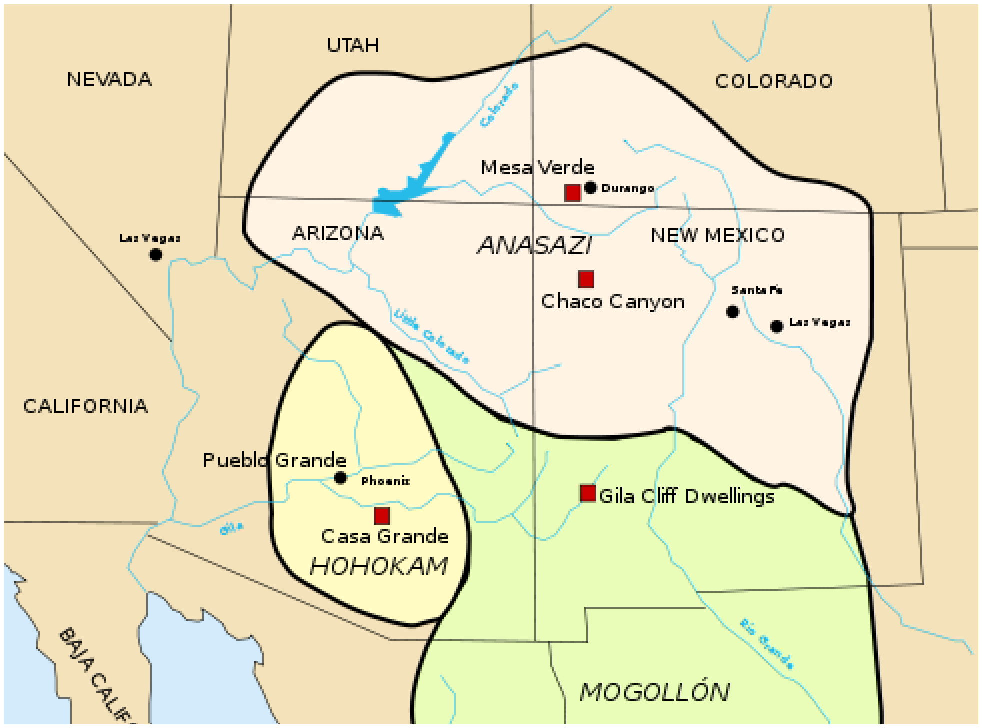
[255] Some of the best surveys of Pueblo civilisation are made by Linda Cordell, *Ancient Pueblo Peoples*, (Washington: St. Remy Press, 1994), Brian Fagan, *Ancient North America: The Archaeology of a Continent (Part 5)*, (New York: Thames and Hudson, 1991), and Stephen Plog, *Ancient Peoples of the American Southwest*, (New York: Thames and Hudson, 1996).

how accurate Turchin's model was in explaining the population and state dynamics that the Pueblo communities underwent in that time.[256] They found that in the absence of external warfare, Turchin's model predicting the decline of population to cause a rise of sociopolitical instability proved fairly accurate.



(**Fig 4.2** Map of Anasazi and Neighbouring Settlements. WikiCommons. Retrieved Jan 5 2013: http://commons.wikimedia.org/wiki/File:Anasazi-en.svg)

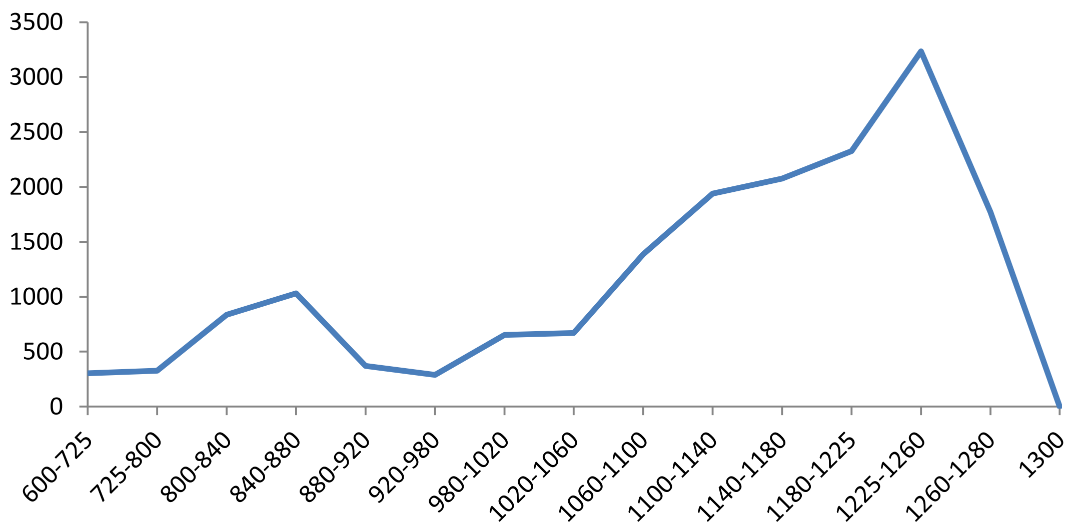
The virtue of Kohler et al.'s test, as they point out, is that the 700 year time series (600-1300 AD) represents one of the most accurate data sets on population for any prehistoric society. This is largely due to the thorough archaeological work to uncover rural settlements and when they were occupied or abandoned. Farmers arrived in the study area in south-western Colorado in 600, continued to grow in number, and by the late 700s the earliest dated villages arose.[257] During this period, the population tended to increase in a climate of little violence. The population continued to increase in size until the region experienced a spell of

[256] Timothy Kohler, Sarah Cole, and Stanca Cuipe, 'Population and Warfare: A Test of the Turchin Model in Pueblo Societies' in Stephan Shennan (ed) *Pattern and Process in Cultural Evolution*, (Berkeley: University of California Press, 2009), 277-278.
[257] D. Breternitz, C. Robinson, and G. Gross, *Dolores Archaeological Program: Final Synthetic Report*, (Denver: USDI Bureau of Reclamation, Engineering, and Research, 1986), 1-3.

cold and dry conditions c.850-900. This constitutes our first population cycle in the southwest Colorado Pueblo society.

Period (AD)	Number of Households	Change
600-725	304	--
725-800	326	22
800-840	836	510
840-880	1030	194
880-920	370	-660
920-980	289	-81
980-1020	653	364
1020-1060	671	18
1060-1100	1385	714
1100-1140	1940	555
1140-1180	2077	137
1180-1225	2326	249
1225-1260	3234	908
1260-1280	1770	-1464
1300	0	-1770

(**Table 4.1** From Kohler et al. 281)



(**Fig 4.3** From Kohler et al. 281)

Kohler et al. measured the incidence of violence, sociopolitical violence or external warfare, by looking at finds of mass graves where skeletal trauma was inflicted. They managed to rule out skeletal trauma that was done by accident, for example through a fall. Those fractures that were inflicted by violence bear a special appearance. The study also includes instances of mutilation or cannibalism, both of which were common practice in

Pueblo culture at the time.[258] Taking an increased death toll due to violence as signs of increased warfare and/or instability, the authors found that fighting peaked in four periods: c.900-950, c.1080-1100, c.1140-1200, and c.1260-1280. The first and last peaks of violence seem to fit with Turchin's model. The middle two fell at the same time as a Chacoan invasion, annexation, and overthrow. This may explain why the population fell in the former group but maintained a steady, if stagnated, rise of population in the latter group.[259]

The authors find, as our model predicts, that in the 800s and 900s populations declined while violence increased, while the preceding period of growth was relatively peaceful. Kohler et al. claim that it appears that exogenous factors were 'weak'. The rise and fall of the population in this period and the frequency of sociopolitical instability is explained by the model.[260] The population rose from 600-880, strained the carrying capacity, fell in accord with a rise in violence in the 900s, and was held low by manmade crisis long after the population had already descended. Insofar as Turchin's model goes, the authors found it fits the situation with a high degree of accuracy. Internal warfare undoubtedly played a role in the population decline in the eighth and ninth centuries. Kohler et al. conclude that part of this decline was due to direct death. But they also cite the presence of female infanticide that may have been related to breeding more male warriors, as was practice in Pueblo societies, which held the potential to depress the population in the long-term by a third.[261] Disease also arises in the group aggregation and moving armies that are associated with warfare. Finally, dislocation to other regions unable to feed everyone, the authors conclude, may also have played a role in the decline of population.

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[258] Steven LeBlanc, *Prehistoric Warfare in the American Southwest,* (Salt Lake City: University of Utah Press, 1999), 174.
[259] Kohler et al., 285-286.
[260] Kohler et al., 288.
[261] W. Divale and M. Harris, 'Population, Warfare, and the Male Supremacist Complex' *American Anthropologist* (1976) 80:379-386 and Kohler et al., 288.

Pueblo societies subsisted on farming maize and hunting deer, rabbit and hare. However, when the population began to recover for the next cycle c.960-1020, we see the adoption of domesticated turkey farming, to compensate for the decline in the deer population.[262] Turkey farming was another widespread characteristic of Pueblo societies.[263] Population growth then maintains itself, with many faltering points, until 1260. Unlike the close fit to Turchin's model of 800-960, the period 960-1260 requires closer examination, taking careful consideration of exogenous factors. We see another slight rise in the incidence of mass graves, violent fractures, and signs of mutilation and cannibalism in the late 900s and early 1000s. This was before the appearance of grand Chacoan architecture that heralded their conquest of the region. The Pueblo population also increased concurrent with this violence. Kohler et al. conclude this slight increase in violence probably was due to the first incursions of the Chacoan armies. The period 1060-1100 sees the first successful Chacoan invasion and migration into the region, with a peak in violence around 1080. This migration was probably responsible for much of the continued rise of the population. The collapse of the Chacoan system in the mid-1100s brought another peak of violence, this time at unprecedented levels. Interestingly enough, the collapse of the Chacoans coincided with a population decline in their own region, even while the population of the study area continued to rise.[264] Kohler et al. attribute the violence of this period to external warfare, which Turchin's model also considers exogenous. It is possible that the continued growth of the Pueblo population in defiance of the model may be explained by this exogenous variable.

Finally, in the first half of the 1200s, there was very little violence and signs of fractures, cannibalism, and mutilations. The population grew even more rapidly than in the

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[262] Kohler et al. 282.

[263] Camilla Speller, Brian Kemp, Scott Wyatt, Cara Monroe, William Lipe, Ursula Arndt, and Dongya Yang, 'Ancient Mitochondrial DNA Analysis Reveals Complexity of North American Turkey Domestication' *Proceedings of the National Academy of Sciences* (2010) 107:2807-2812.

[264] Kohler et al., 289.

previous period of conflict with the Chacoans, and there is evidence of growing political stability.[265] By all accounts, this appears to be the beginning of a new cycle of peace and easily maintained population growth. The Pueblo population grew to unprecedented levels. Unfortunately recurring violence c.1260-1280 witnessed population decline and settlement abandonment. By 1300 the Pueblo people had disappeared from the area, through a mixture of death and migration.[266] Kohler et al. conclude that Turchin's model holds for situations that are more straightforward and isolated from exogenous variables. It identifies a simple set of relationships between demography and sociopolitical instability that has explanatory power when conditions for the model are met. While the poor fit of the model during the Chacoan period is not unanticipated, the authors say, the model may be limited to situations where exogenous factors are of little import – something that is rare in agrarian civilisations.[267]

This case study remains unique in that it is a test of Turchin's model by anthropologists who are not biased advocates of his demographic-structural theory. It is also unique in that it is the only case study taken in the Americas. One thing is clear, however, that in cases of population decline in agrarian civilisations we often see the rise of violence in a population whose numbers have been declining steeply that can reduce a population even further and perhaps even hold it low for several decades before a demographic recovery. We see this in the period 880-960 and 1260-1300. Conversely, periods of the most robust population growth are accompanied by a relatively low level of internal violence, as shown in the periods 600-880 and 1180-1260. However, if this were just an isolated case of the relationship between population dynamics and sociopolitical instability, it would not tell us

[265] Kohler et al., 290-291.
[266] For details of this decline and disappearance, W. Lipe, M. Varien, and R. Wilshushen, *Colorado Prehistory: A Context for the Southern Colorado River Basin*, (Denver: Colorado Council of Professional Archaeologists, 1999), 242-289, and M. Varien, S. Ortman, T. Kohler, D. Glowacki, and C. Johnson, 'Historical Ecology in the Mesa Verde Region: Results from the Village Project' *American Antiquity* (2002) 72: 273-299.
[267] Kohler et al., 291.

much about the operation of the *longue durée* in agrarian civilisations. Nor does the case study deal with the dynamics between elites and non-elites because of the lack of written records. So the best one can really say of this example is it is compatible with the demographic-structural model, not that it really supports it. However, the case of the Pueblo peoples in southwest Colorado is also mirrored by the same trend in many other regions and time periods.

b) Reflection

Pueblo societies illustrate how s-curves may have impacted an ‘early stage’ agrarian society, before the development of much surplus, specialisation, writing, or monumental architecture. And while chronologically the Pueblo society falls quite late, in the first and second millennium AD, it may be an indication that the same trends of overpopulation and sociopolitical instability occurred in the similarly constructed agrarian societies that existed 10,000-5000 years ago, after the dawn of agriculture but before the construction of the first ‘agrarian civilisations’ in Mesopotamia. However, this is speculative and it is possible that more recent factors, perhaps influence from the agrarian civilisations to the south, precipitated the relationship between overpopulation and sociopolitical instability in the Pueblo society. Additionally, while the population decline of this society was severe, there is no indication or archaeological evidence to establish whether there was a Tasmanian Effect. None of the archaeology shows a simplification or loss of knowledge, although perhaps because the society was so simple to begin with such losses may be more difficult to discern than for an agrarian civilisation.

At any rate, the Colorado Pueblo society is an example of how collective learning did not raise the carrying capacity fast enough in an early-stage agrarian society. Cultural variations did not arise fast enough in this small population that did not possess an accelerant to collective learning like writing or complex trade. Without a great deal of cultural variation and innovation, humans cannot increase the level of exploitation of the environment around them, restricting energy flows. Due to the slower pace of variation and selection, the complexity of the society in terms of free energy rate density remains at lower levels relative to agrarian civilisations, to speak nothing of the level that is harnessed by modern society. The result is population decline and manmade crisis, which threatens to destroy learning, or, in this case, to bring about the total dissolution of the society in question. That is how the Darwinian algorithm can influence the 'life or death' of a human society.

c) S-curves in Medieval & Early Modern England

The work of Peter Turchin has identified two major population cycles in England after 1,000 CE, the first 1150-1485 and the second 1485-1730. The first cycle, the medieval one, conforms to the relationship the *annalistes* established between population levels and the real wage and also the relationship between population, elite numbers and incomes, and sociopolitical instability postulated in this chapter. The English population enjoyed a period of growth in the twelfth and thirteenth centuries. Populations peaked around 1300 and went into a slight decline even before the Black Death. The 'real wage' fell accordingly. In this period landholders, nobles, and other elites profited greatly from an oversupply of labour, shortage of land, and increased rents. Their wealth increased as did their numbers. During the slight decline of the early fourteenth century, however, and especially after the devastation of the Black Death, elite incomes plummeted and they entered a state of increased competition and violence that held the population low long after a purely Malthusian model would expect it to rebound. It was not until c.1500 that elite numbers were reduced, their average incomes were restored, and the population began to rebound and enjoy an enhanced living standard once again. The early sixteenth century witnessed a conventional population recovery as seen in other regions, but the agrarian revolution, higher crop yields, and a higher carrying capacity intervened. In the seventeenth century, we still see a declining living standards, elite overpopulation and competition. We also see the lost of 190,000 people in the various waves of the Civil War – approximately 4% of the contemporary population (twice the proportional losses of the First World War) and a marked stagnation of the population.[268] The population decline is somewhat masked by a rising carrying capacity due to the fledgling 'agricultural revolution' in the seventeenth century. It is possible early modern England had already escaped the ecological tyranny of the *longue durée* and was already progressing beyond agrarian s-curves into the new era of the Anthropocene.

The English medieval cycle is the closest fit to the model of population pressure and sociopolitical instability. The statistics of the English population 1086-1500 are very well traversed and confirmed.[269] With the possible interruption of the Anarchy under Stephen 1138-1153, the population grew to a peak around 1300, declined slightly 1300-1348, was devastated by the Black Death, and then entered a manmade crisis that held the English population low, when in a strictly Malthusian model you would expect a recovery. The Domesday Book (1086) indicates 275,000 adult males or heads of households, minus four northern counties, two major cities, and the masses of subtenants and vagrants. Extrapolating from these figures scholars have put the population of England shortly after the Norman conquest at 1.75-2.25 million people.[270] After years of expansion of arable cropland and a high

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[268] Charles Carlton, *Going to the Wars: The Experience of the British Civil Wars, 1638-1651*, (London: Routledge, 1992), 211.
[269] J. Hatcher, *Plague, Population and the English Economy:1348-1530*, (London: Macmillan, 1977), H. Hallam, 'Population Movements in England, 1086-1350' in J. Thirsk (ed) *The Agrarian History of England and Wales*, vol 2, (Cambridge: Cambridge University Press, 1988), 508-93, J. Hatcher and M. Bailey, *Modelling the Middle Ages: The History and Theory of England's Economic Development,* (Oxford: Oxford University Press, 2001), C. Dyer, *Making a Living in the Middle Ages: The People of Britain 850-1520*, (New Haven: Yale University Press, 2002).
[270] Hatcher, 68, S. Harvey, 'Domesday England' in J. Thirsk (ed) *The Agrarian History of England and Wales*, vol 2, (Cambridge: Cambridge University Press, 1988), 48, see also earlier estimates of J. Russell, *British Medieval Population*, (Albuquerque: University of New Mexico Press, 1948) and M. Postan, *Essays on Medieval Agriculture and General Problems of the Medieval Economy*, (Cambridge: Cambridge University Press, 1973), 252.

birth rate, estimates place the peak of the English population at 4.5-6.5 million around 1300. The vast bulk of scholarly work on the subject accords with these figures.[271] Estimates for the period 1300-1348 indicate a mild decline of population on the order of half a million, from 6.5-6 million.[272] In a state of population strain, the harvest failures and famines of 1315-1316 and the cattle epidemics of 1319-1321, hit people at the margins hard and there was a significant decline in the English population.[273] As we shall see, this same phenomenon also occurred at the same time in France. On the other side of the Black Death pandemic and its aftershocks, a 1377 poll tax indicates a population of 2 or 2.5 million, in accordance with what we know of the Black Death reducing the population by 40-50%.[274] The English population was held low at this level throughout the late fourteenth and fifteenth centuries, when a strict Malthusian model would predict a recovery at some point. In fact, even in the early sixteenth century, tax rolls show that England still hovered around the population of 2.25-2.75 million.[275] This is only slightly higher than we saw in the Domesday survey. Recovery then began in earnest in the late sixteenth century, eventually restoring the English population to the peak fourteenth century level in the 1600s.

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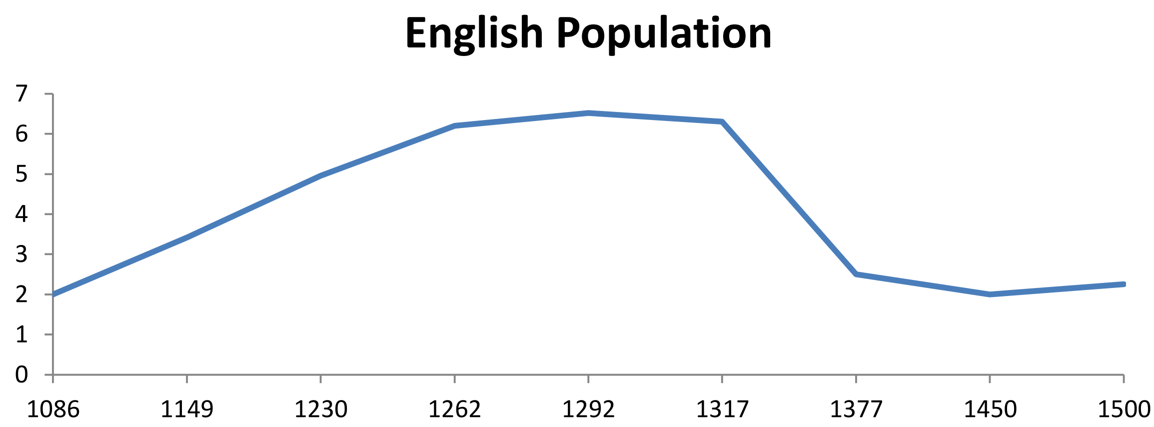
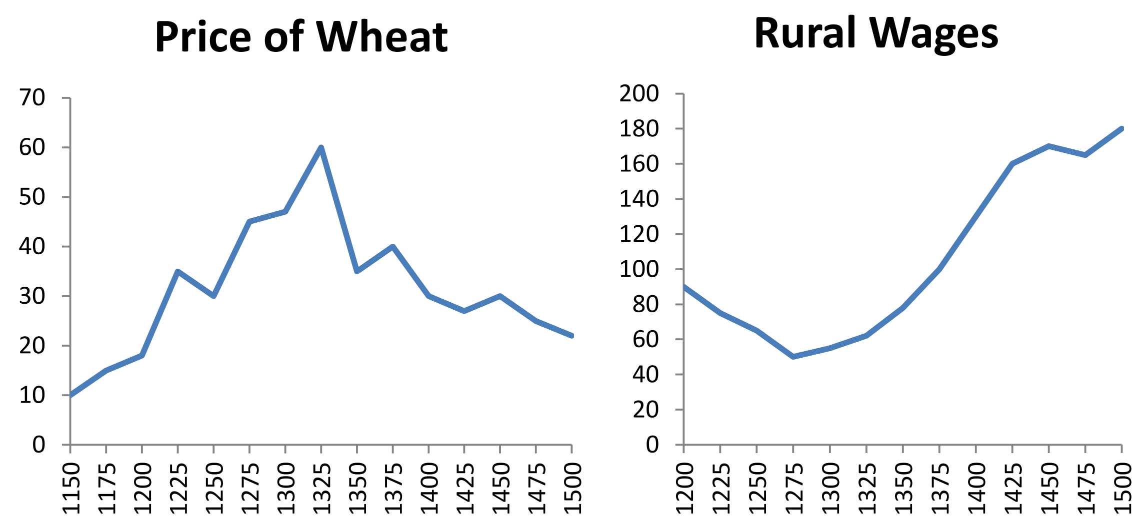
[271] Hatcher, 68, Turchin and Nefedov, 36, Postan, *Essays*, 276, and J. Langdon and J. Masschaele, 'Commercial Activity and Population Growth in Medieval England' *Past and Present* (2006), 190: 63.
[272] Hallam, 537.
[273] E. Miller and J. Hatcher, *Medieval England: Rural Society and Economic Change, 1086-1348,* (London: Longman, 1978), 60.
[274] Hatcher, 68.
[275] Hatcher, 69.



(**Fig. 4.4** Data from Hallam 1988, Hatcher, 1977, Langdon and Masschaele 2006, Turchin 2009)

The flaw of Turchin's population analysis of the medieval period resides mostly with where he dates the start of the cycle: 1150. It is clear that England enjoyed some moderate population growth between 1086 and 1149, to the tune of 1.4 million. Turchin leaves some ambiguity about whether the population may have declined during the reign of St. Stephen, during the so-called Anarchy, and the extent of this decline, if it occurred at all, is unconfirmed. Interestingly, the loyalty of the majority of the barons in this conflict seemed to rest with whoever appeared to be the victor at the time, and there is not the same degree of division and factionalism that we see in later periods, or the brutality, or the same level of civilian unrest. The ties of the Anarchy to external warfare and dynastic rivalries in northern France, to which the English dynasty was tied and in regions where the enemies of the Crown found haven, may explain this factor. Nevertheless, Turchin classifies the Anarchy as sociopolitical instability even with these external ties and without clear indication of any significant population decline in this period. As a result, perhaps the cycle ought to be better classified to begin in the eleventh century rather than c.1150. The Anarchy was undoubtedly the result of external warfare and desires for conquest that are endemic to the human primate in all seasons, rather than the sociopolitical instability that arises in cases of clear population decline.



(**Fig 4.5** Price of wheat in grams of silver per 100 kg from Farmer 1988, Farmer 1991, Turchin 2009 and wages of rural labourers using 1375 as an index of 100 from Turchin 2009)

Unlike the study of Pueblo societies, which left no literary records, here we have documentation of prices and wages that allow us to measure standard of living in addition to population levels and sociopolitical instability. However, in using the language of 'prices and wages' in a pre-Industrial age, something that was inherited as far back as Abel, Turchin may be guilty of misleading his audience with a slight anachronism. Prices and wages as we consider them today did not apply in exactly the same way in the period of agrarian civilisations. For one thing, many commoners subsisted on a system of payment in kind, not currency. As Karl Polanyi pointed out, while the market has played a role in human society since the beginning of the agrarian era, it did not assume its central and vital role until the modern era.[276] However, in the agrarian era price movements still do give us an indication of the abundance of food among the common population because in every case the shrinking of the real wage coordinates with population decline, and it is supplemented by statistics on the percentage of bread and meat in their diets. High prices, even when adjusting for inflation, always coincide with periods of population pressure and ecological strain. Furthermore, wages

[276] Karl Polanyi, *The Great Transformation: The Political and Economic Origins of Our Time*, (Boston: Beacon Press, 1957), 59-71.

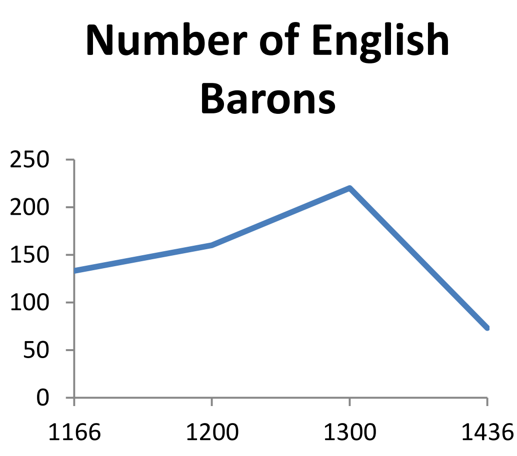
of rural labourers tell us how much of the household income or the takings from the field, either in currency or kind, were devoted to basic subsistence and how much was spent on other items. Combining prices and wages into a ‘real wage’ allows us to estimate how many people were close to the margins as the population peak was reached. Indeed we see the real wage decline in medieval England in the 1200s and reach critical levels in the starving years of 1300-1348, when the population declined slightly. When ecological disaster strikes, whether in the form of harvest failures or livestock epidemics, a swelling number of people at the margins are harder hit than in years of plenty – in this sense calculating a ‘real wage’ is quite useful. The margin for error is also suitably small, since at no point do we see a thriving standard of living for commoners in periods of high population pressure, which would run contrary to most demographic models. As it stands, in early medieval England, the real wage maintains a fairly consistent inverse relationship with population dynamics.

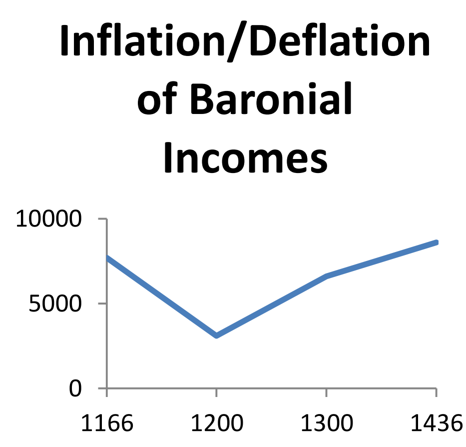
In addition to the decline in real wages, i.e. the amount a common household had to meet their subsistence requirements, there was a shift in meat consumption. As the population swelled c.1250-1300, meat formed a very small part of the diet of harvest workers at Sedgeford in Norfolk, with nearly half their diet consisting of bread. However, after the population collapse of the Black Death, the share of bread dwindles to 15% and meat to roughly 30% of the diet in the late fourteenth and fifteenth centuries.[277] Also, average peasant subsistence holdings shrank from 1250 to 1300 due to overpopulation, by which time 33% of the population on a survey of multiple English landholdings held less than a hectare of land when the estimated amount of land required for the subsistence of a family is 4.5-6 hectares.[278] This meant that more people were thrown into alternatives to feed themselves, principal among which was working as a rural labourer. Once population pressure was relieved, the

[277] C. Dyer, *Everyday Life in Medieval England*, (London: Hambledon and London, 2000), 82.
[278] D. Grigg, *Population Growth and Agrarian Change*, (Cambridge: Cambridge University Press, 1980), 68.

commoners enjoyed an increased standard of living again. However, the population was held low until the end of the 1400s. Sociopolitical instability may help us understand why.

During the most vigorous population growth from 1200-1300, the number of elites increased, as did the average size of their incomes.[279] This occurred at the same time as the common population was reaching its peak and encountering shrinking real wages. Instrumental in this divergence was the increasing abundance of largely landless agricultural labourers, and the oversupply reduced the amount of payment the landholding class had to pay for their services. Landholders were also able to increase their rents by exorbitant amounts between 1200 and 1300, with the average rent per acre being between 2-6 *d* in 1251, and increasing to 12.5-28 *d.* per acre by c. 1300.[280] The overexploitation of the peasantry, well documented by Marxist historians, profited baronial families, seeing the average income triple between 1200 and 1300. At the same time their numbers increased. The same goes for knights and the gentry. Without question the last years of population growth was the best time for the elite classes, as predicted by the model.





(**Fig 4.6** Number of high ranking barons and their average incomes, adjusted for inflation and expressed in hectolitres of grain, from Painter 1943, Given-Wilson 1987, and Turchin 2009)

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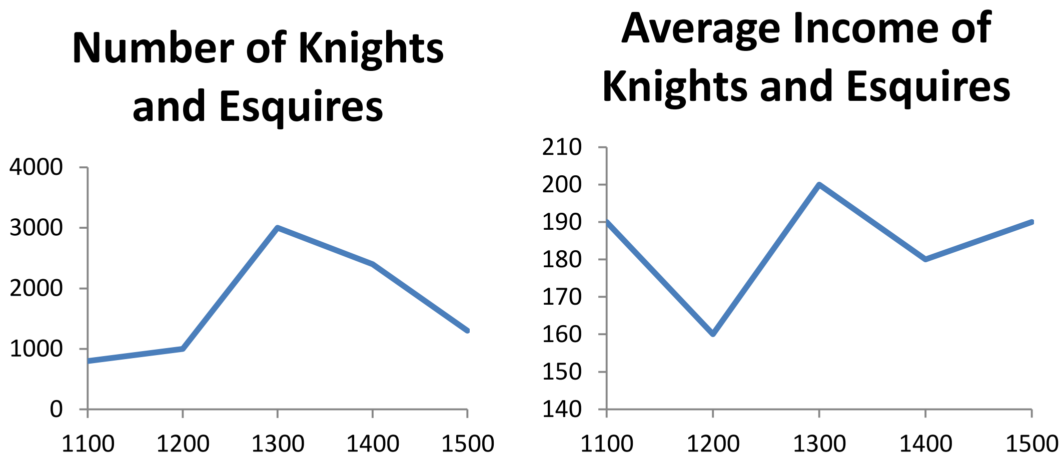
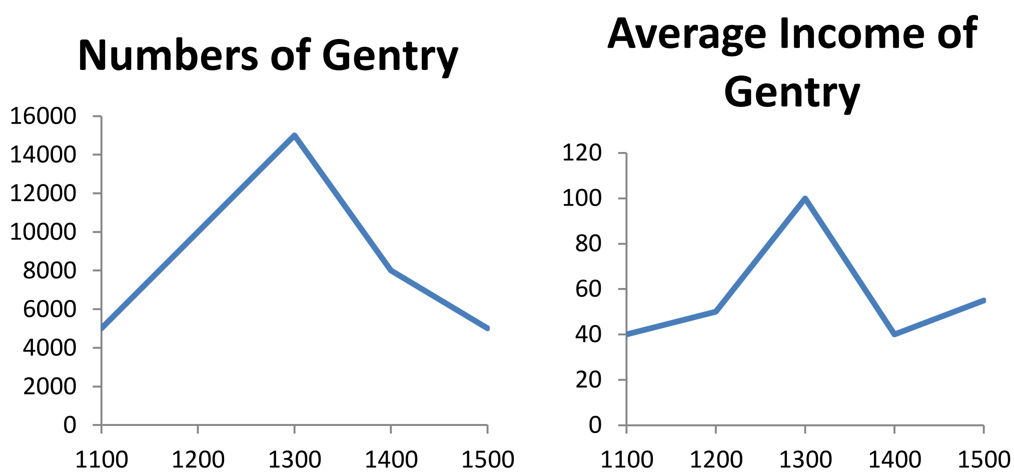
[279] S. Painter, *Studies in the History of the English Feudal Barony,* (Baltimore: Johns Hopkins University Press, 1943), 173 and C. Given-Wilson, *The English Nobility in the Late Middle Ages: The Fourteenth Century Political Community*, (London: Routledge and Kegan Paul, 1987), 188.

[280] J.L. Bolton, *The Medieval English Economy:1150-1500*, (Totowa: Rowman and Littlefield, 1980),187, Miller and Hatcher, 45, Dyer, *Making a Living*, 72-73, Miller and Hatcher, 45.



(**Fig 4.7** Numbers of knights and incomes expressed in hectolitres of grain, from Dyer 2002, Given-Wilson 1987, Denholm-Young 1969, Mingay 1976, and Pugh 1972)



(**Fig 4.8** Numbers of middling elites and incomes expressed in hectolitres of grain, from Dyer 2002, Given-Wilson 1987, Denholm-Young 1969, Mingay 1976, and Pugh 1972)

However, once ecological crisis struck the commoners after 1300, and especially after the Black Death, elites did not die at the same rate. The shrinkage of the elite population during the famines of the early fourteenth century was negligible, and even in the Black Death casualty rates were lower for gentry and barons. Peasant numbers shrank at the rate of 40-50%, but the number of gentry declined only by about 27% and the number of great barons only by 8-18%.[281] The result was an extremely top-heavy social pyramid by the mid-fourteenth century. The reduction of peasant numbers suddenly produced a shortage of labour

281 K. McFarlane, *The Nobility in Later Medieval England,* (Oxford: Clarendon Press, 1973), 170, Russell, 216-28, Hatcher, 22-25.

and reduced the number of people paying rent. The labour shortage reduced elite incomes, particularly of the gentry, who tried to cope by restricting high wages on the peasantry, prompting the peasant revolt in 1381.[282] Regardless of their attempts to cope, the more numerous elites began to compete for revenues, spurring an era of sociopolitical instability.

In the thirteenth century, baronial rebellions were not as protracted and intense as in the 1300s and 1400s.[283] Internal warfare after the decline of the English population took on a much more violent and insidious character. The amount of overthrow and regicide also increased, claiming Edward II (1372), Richard II (1400), Henry VI (1471), Edward V (1483), and Richard III (1485). The preceding period is devoid of such brutality. Sociopolitical instability included three major rebellions in the eleventh and twelfth centuries, compared to the private wars in 1315, civil war 1321-1322, the rebellion of Isabella and Mortimer and Edward II's murder 1326-27, the coup d'état of Edward III against Mortimer in 1330, the Peasants Revolt in 1381 against overexploitation by the elites to sustain their revenues, the insurrection of the Lords Appellant in 1387-1388, the overthrow of Richard II in 1391, his overthrow and murder 1399-1400, the Glyn Dwr rebellion 1400-1408, the Lollard plot against Henry V in 1414, unrest under Henry VI and armed factionalism 1448-51 paralysing the government, Jack Cade's rebellion 1450, and finally the War of the Roses in four major phases 1455-1485.[284] At the core of this shift from stability to rampant instability was a shift in elite numbers and average incomes. It was only when elite numbers were reduced and their high incomes restored (see figs 4.4-6) that we see a relaxation of inter-elite competition around 1500. It is at this point that the population began to recover.

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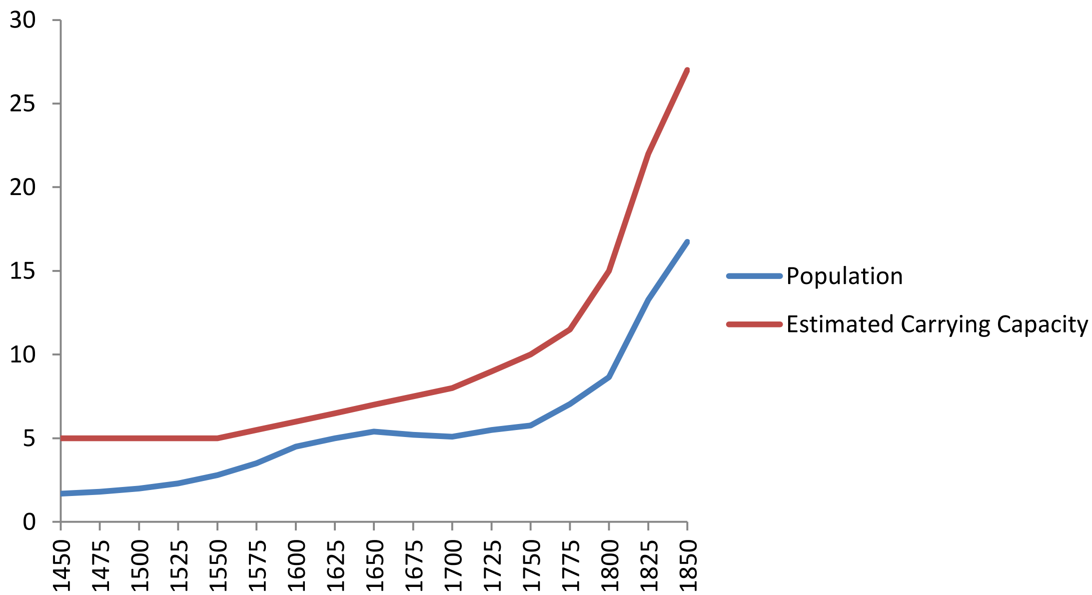
[282] E. Fryde, 'Peasant Rebellion and Peasant Discontents' in E. Miller (ed) *The Agrarian History of England and Wales*, vol 3, (Cambridge: Cambridge University Press, 1991), 755-760.
[283] R. Bartlett, *England under the Norman and Angevin Kings: 1075-1225*, (Oxford: Clarendon Press, 2000), 60
[284] Turchin and Nefedov, 48-49.

The *annaliste* interpretation of this cycle holds insofar as the inverse relationship between population numbers and the real wage is concerned. However, where it falls short is explaining why the common population did not immediately rebound after the Black Death. The answer is a manmade crisis that followed the ecological one. Generally speaking, medieval England tends to conform to the Turchinite model, however, certain exogenous factors did intervene, most notably the plague. Nevertheless, the population figures and strain evident from 1300-1347 illustrate that the decline was already underway and that the Black Death exaggerated the fluctuations of the cycle. As we shall see, the same thing occurred in medieval France (see section III). However, it is interesting to note how population cycles work in situations that are devoid of both harsh epidemics and external warfare on home soil. In those cases, as we will see, a less dramatic rise and decline and shorter periods of instability are the norm. Generally speaking though, the relationship between population pressure, the real wage, elite incomes, and sociopolitical instability is maintained in the case of medieval England.

The population cycle in early modern England, however, conforms less to the Turchinite model due to the gradual onset of the 'agricultural revolution' that employed legumes, used a better crop rotation system, and increased yields. This was the result of collective learning that originated in the fourteenth century Low Countries, spread to England, and then from there to the rest of the European continent in the eighteenth century. The slow spread of these ideas is testament to how much slower collective learning lags behind population growth: we are not just waiting for collective learning to produce innovations but for those processes to spread and be selected through cultural evolution.

We shall discuss this in further detail in chapter five. Suffice it to say, however, that the rising carrying capacity of the English population in the late sixteenth and seventeenth centuries obscures the period of population strain and does not show any dramatic dips like we see in the medieval period, though we do see a significant dip in Civil War, during which England lost approximately 190,000 people or nearly 4% of its population of c.5 million.[285] And there was a long period of population stagnation and population decline due to famine c.1600-1730 which is worth exploring. It is undeniable, however, that these population downturns are masked by a quick recovery from a slowly rising carrying capacity. It was not until the mid-eighteenth century that agrarian reforms were widespread and the carrying capacity truly took off.



(**Fig 4.9** Estimated population of England from Hatcher 1977, Britnell 1997, Cornwall 1970, Wrigley and Schofield 1981, Overton 1996, and estimated carrying capacity from increasing wheat yields, bushels per acre, from Overton 1996 and Turchin 2009)

As we can see, early modern England, unlike many case studies in this chapter, never fully surpassed its carrying capacity, which was raised by agricultural improvements. What we are witnessing is the start of modernity, the emergence from the agrarian era with a slowly rising carrying capacity and freeing the population from the Malthusian tyranny of population s-curves. This stands in stark contrast to the case study of France later in this chapter, because

[285] Carlton, *Going to the Wars*, 211.

modernity did not start as soon, with many agricultural improvements not spreading to France through cultural evolution until the eighteenth century and holding the carrying capacity relatively low. One would almost think that early modern England escaped the Malthusian dynamics of the agrarian era, and it certainly frustrates analysis. However, as mentioned above, agricultural innovations did not bear aggressive results until after 1750, and the population stagnated 1590-1650 – the period of increasing sociopolitical instability and civil war. As England approached the carrying capacity in the seventeenth century it still did suffer ecological strain, a shrinking real wage, the overproduction of elites, and a period of sociopolitical instability. The only thing that is absent is a dramatic drop of the population (excluding the 4% lost during the elite-infighting of the 'depression' phase). Thus early modern England presents us with a more awkward fit to Turchin's model than its medieval counterpart. You have strain but not sustained population drop, and yet population strain seems to have been enough because it still kick-started the rise of sociopolitical instability, lowered elite incomes, and caused faction and civil war.

From 1500-1540, England enjoyed a modest amount of population growth reaching from just over 2 million to approximately 3 million c.1540 and crossing the 4 million mark in the early 1590s.[286] Then in the final years of Elizabeth's reign, stagnation and population strain began to set in, culminating in the famines of 1594-1597.[287] In the long stretch of the seventeenth century, the English population grew by only another million and stayed at those levels. Turchin attributes this stagnation to, first, the death toll in pre-modern cities that grew as a result of enclosure and increased urbanisation, two, the increased strain on real wages of the peasantry, and third, the worsening of the climate, which resulted in numerous crop

[286] J. Cornwall, 'English Population in the Early Sixteenth Century' *Economic History Review* (1970) 23: 32-44, E. Wrigley and R. Schofield, *The Population History of England, 1541-1871: A Reconstruction*, (Cambridge: Harvard University Press, 1981), 566.
[287] C. Clay, *Economic Expansion and Social Change: England 1500-1700*, vol. 2, (Cambridge: Cambridge University Press, 1984), 19.

failures and famines.[288] Beyond that immigration to the Americas and the increase in violence in the seventeenth century may have played their role in the prolonged stagnation even while the carrying capacity climbed. Even though we do not see sustained population decline, however, we do see the telltale signs of strain and sociopolitical instability in this period. It appears that population strain was enough to destabilise society in this part of the cycle. It is possible that in *longue durée* s-curves sociopolitical instability can result from either population strain or crash.

Peasant landholdings shrank. In 1560 57% of holdings were one acre or more, and in 1620 this decreased to 36%, while the percentage of peasants with only a small cottage garden increased from 11% to 40%.[289] The price of grain increased nearly five times in the same period while real wages declined by 40%.[290] Meanwhile between 1540 and 1640, the elite grew from 6300 to 18,500 aristocratic families, growing from 60 lords to 160, 1300 knights and esquires to 4400, and the gentry from 5000 to 15,000.[291] We do not see the same population decline that reduced elite incomes as it did in the medieval period. However, the increased number of elites while the population remained more stagnant and strained seems to have provoked elite competition for resources. However, the precise connection between the stagnating population and the sparks of elite violence is not adequately explained in Turchin's treatment of early modern England.

In conclusion, while there is much to suggest a connection between population strain, elite numbers and incomes, and the rise of sociopolitical instability in the medieval period, the interruption of the agricultural improvements in the seventeenth century obscures the second

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[288] Turchin and Nefedov, 101-102.

[289] A. Everitt, 'Farm Labourers' in J. Thirsk (ed) *The Agrarian History of England and Wales*, vol. 4, (Cambridge: Cambridge University Press, 1988), 402.

[290] D. Fischer, *The Great Wave: Price Revolutions and the Rhythm of History*, (Oxford: Oxford University Press, 1996), 74, R. Allen, 'The Great Divergence in European Wages and Prices from the Middle Ages to the First World War' *Explorations in Economic History* (2001) 38:411-47.

[291] L. Stone, *The Causes of the English Revolution: 1529-1642*, (New York: Harper and Row, 1972), 72.

English population cycle in the early modern era. These glimmerings of modernity, the acceleration of collective learning, and the rise of the carrying capacity defy the population trends that had ruled agrarian civilisations. The agrarian revolution expanded into the industrial one. We shall discuss this more in chapter six.

Once nation-states began to escape the ecological tyranny of the agrarian era and the conventional *longue durée* an entirely new set of variables come into play. The agricultural improvements of the Early Modern era were followed by the industrial innovations that raised the carrying capacity dramatically in the nineteenth century. It is an era that witnesses the ever-mounting rise of complexity, cultural innovations, the ability of human beings to harness energy, the unification of the major world zones, and the future danger of exhausting the Earth's resources in the same way that agrarian civilisations exhausted the resources of the field. At any rate, before the agrarian revolution began in England, its population and levels sociopolitical instability obeyed the same trends seen in other agrarian states in our survey.

d) Reflection

Medieval England's population hit the carrying capacity, felt strain, declined, and was held low by an elongated period of manmade crisis. In contrast to the Pueblo society, which may serve as an example of how the relationship between overpopulation and sociopolitical instability may have been present in early agrarian societies, medieval England is an example of how they strike a fully fledged agrarian civilisation. There is, however, no sign of a Tasmanian Effect, despite the massive losses inflicted by the Black Death, and learning was retained throughout the period where the number of potential innovators declined. And collective learning continued to build up right into the next recovery. However, no major variations or innovations in agriculture were selected to raise the carrying capacity and early modern England hit a similar carrying capacity to the one hit in 1300.

Certain innovations from the Low Countries were gradually adopted, starting with a sparse few examples of selection in the sixteenth century, gaining pace in the seventeenth century, and reaching fever pitch in the eighteenth century, raising the carrying capacity and the number of potential innovators in the English population. Shortly thereafter, variations and innovations in steam, iron, and mechanised production set off an explosion of productivity that began the Industrial Revolution and raised the free energy rate density of English society in the nineteenth century. That process has continued to the present, where the amount of free energy rate density of modern society constitutes roughly 4 million times the free energy rate density of a galaxy and the most complex entity we know of in the Universe. Collective learning may have been slower than population growth in the majority of the era of agrarian civilisations, but once the right cultural innovations are produced and combined in a human society it can have profound effects similar to the rise of agriculture in the first place or the Cambrian explosion that released a torrent of new forms of life. The Darwinian algorithm of random variation and non-random selection continues to foster complexity.

e) Agrarian S-curves in Russia, c.1460-1620

Much work has been done on the agrarian cycles in Russia by Sergei Nefedov. Russia may have undergone a cycle of population decline and sociopolitical instability 1250-1460, as Nefedov suggests, but prior to the Novgorod scribe books of the mid-fifteenth century, we do not have sufficient data to confirm it. The Mongol invasions of the 1240s ended a period of population decline in what is now Russia. Sustained population growth occurred through the fourteenth century, despite casualties of the Black Death that were nowhere as high as in Western Europe. Growth continued until c.1400, there are signs of overpopulation and famine in the northwest, which had a severe climate and poor soils. The central districts of Russia (the area around Moscow) carried on for longer until the mid-fifteenth century when Moscow underwent a bitter civil war. Population strain may have preceded this burst of sociopolitical instability, though there is no way of confirming, but famine and disease did strike concurrent with it. By 1460, 20% of all villages in the Moscow Principality were deserted, the grain price dropped 50%, the wage of labourers increased to the equivalent of 24kg of grain per day, and Russia began another phase of population growth.[292] This is the point when we have a much better idea about population growth, the standard of living, and elite incomes, though the data on total elite numbers is fairly limited and requires estimates drawn from the number of gentry serving in the Muscovite army.

The average peasant family of eight members and two adult men c.1500 worked 18 *desyatins* or 19.6 hectares, with three of those *desyatins* being worked to give crops to the local lord. The rest of the harvest, according to the calculations of Nefedov, amounted to 425kg per person, with the subsistence amount being pegged at 250kg.[293] This bountiful period is in keeping with what we know of population expansion periods. Over the next hundred years, the population moved out into new lands, and two censuses between the 1480s and 1500 in the Novgorod region tell us the population grew by 14% in that time.[294] Furthermore the entire population of Russia is estimated to have grown from 6 million to 9 or 10 million by 1550.[295] However rapid growth soon outstripped available land and caused a shrinking standard of living. The price of grain rose from 10 *dengas* per quarter (6 g of silver) c.1520 to 22 *dengas* in 1532 and 35-40 *dengas* in 1543-44.[296] Like in the previous cycle 1250-1460, overpopulation and a declining standard of living first appeared in the northwest before

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[292] Sergei Nefedov, 'On Demographic Cycles in the History of Medieval Russia' *Klio* (2002) 3:193-203, A. Yusko, *The Moscow Land in the Ninth through the Fourteenth Centuries* (Moscow: Nauka, 1991), 52-53.
[293] Turchin and Nefedov, 242.
[294] AHNWR, *Agrarian History of Northwest Russia from the Second Half of the Fifteenth Century to the Beginning of the Sixteenth Century*, (Leningrad: Nauka, 1971), vol. 1, 48-50.
[295] A. Kopanev, 'The Population of the Russian State in the XVI Century' *Istoricheskie Zapiski* (1959) 64:237-244.
[296] AHNWR, vol. 1, 21-22, and A. Man'kov, *Prices and their Movements in the Russian State during the XVI Century*, (Moscow: Academy of Sciences of the USSR, 1951), 104.

hitting the central region. In places where landlords made heavy exactions form their tenants, like the Vodskaya and Derevskaya regions, peasants had already fallen below subsistence level, keeping 180kg per person from a harvest, compared to the minimum of 250kg. This made the population in the northwest extremely vulnerable to famine and by 1500-1540, the population had declined by 13 to 17%. This was unusual, however, and in most regions of Russia before 1540, the population increased by 27-45% in various regions.[297] Around 1550, however, central regions also began to feel the pinch. An average of three peasant families farmed the land that was populated by one family a century prior (19.6 hectares) and in some districts there was not enough food to last until the next harvest.[298] Overpopulation also caused many small farms to go bankrupt and forced them over to the foremost creditors of the time, the Russian Orthodox Church, so that by 1550 they owned 33% of the land in Russia.[299] This threw an influx of landless rural labourers into the countryside. The first major famine struck in 1547, the worst in over a century of population growth and plenty. Nefedov tells us that the demographic crisis really took hold in the north, northwest, and Volga region in the 1550s, with severe famines and migration, depopulating some regions by as much as 40%. The central region around Moscow was a decade later, with severe famines occurring 1560-1561 and skyrocketing grain prices to 50-60 *dengas*. In 1568, day labourers were earning a third of what they were earning in 1520 and could not support a family of three.[300]

During the period of population growth Ivan III (1462-1505) and Basil III (1505-1533) enjoyed fairly stable reigns. The regency of Ivan IV was then a period of increasing

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[297] AHNWR, vol 3, 178 and vol. 2, 290-91.
[298] E. Kolycheva, *Agrarian Formation of Russia in the Sixteenth Century*, (Moscow: Nauka, 1987), 64, and L. Prokop'eva, 'The Grain Budget of a Peasant Household in Belozersky Region in the Middle of the Sixteenth Century' in N. Nosov (ed), *The Peasantry and Class Struggle in Feudal Russia*, (Leningrad: Nauka, 1967), 102.
[299] A. Zimin, *The Reforms of Ivan the Terrible*, (Moscow: Izdatel'stvo Socialno-Ekonomicheskoi Literaturi, 1960), 80.
[300] Turchin and Nefedov, 245-246.

factionalism, government coups, and assassinations.[301] External warfare starting in 1557, raised taxation and turned the screws on the peasantry even further, who after government taxes and rents were left with an average of 60kg per capita. Famine was the result. By 1560, population decline was universal throughout Russia. During this time Ivan IV began his reign of terror, recruiting one elite faction into the *oprichnina* and turned them against the boyars. By 1572, he turned on the *oprichnina*. This is Nefedov's example of sociopolitical instability in the immediate aftermath of the population crisis. In fact the worst of the ecological crisis was still to come. Crop failure in 1567 on an already strained peasantry without grain reserves caused a major famine. The following year it grew worse and then was followed by the plague. By the 1570s, Derevskaya in the northwest had one-third of farms deserted, mostly due to famine and plague, in Bezhetskaya the decline was 40%. Percentages in the central region around Moscow were often even higher, sometimes reaching 90%.[302]

This dramatic drop of the population had two consequences. One, the living standards of peasant families gradually improved in the 1570s due to a shortage of people to work the land. The real wages of labourers of Vologda were 2.5 times higher than in the 1560s. On gentry estates, rents fell to a third, on government estates they fell by half, and the requirements of peasants to work the land for the lord fell to half or a third also.[303] The other consequence was a correlating decline of the income of the elite. The gentry were particularly impoverished, with roughly half of the gentry having to abandon their estates completely.[304] By the 1580s the social pyramid was extremely top heavy. Nefedov calculates the increase in

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[301] N. Riazanovsky, *A History of Russia*, (Oxford: Oxford University Press, 2000), 145.
[302] Sergei Nefedov, 'On the Feasibility of Applying the Demographic-Structural Theory to the Study of Russian History during the Sixteenth Century' *Otechestvenaya Istoriya* (2003) 5:63-72.
[303] Turchin and Nefedov, 254.
[304] R. Skrynnikov, *Russia at the Beginning of the Seventeenth Century: The Time of Troubles*, (Moscow: Mysl, 1988), 13.

the gentry's cavalry officers that their numbers in 1580 were three times the size in 1530.[305] Once again shortage of data hampers our ability to view things more precisely than this, but an increased number of elites when the population had severely declined implies that there was less wealth derived from the land for the elite to absorb. To cope with this problem the 1590s and early 1600s, the government began imposing harsh forms of serfdom upon the peasants, in which a fleeing serf would be forcibly returned. This allowed the elite to impose harsher rents and dues. For example, the landlord's share of the harvest had doubled on many church lands by 1600.[306] This had a deleterious effect on peasants already at the margins. Arguably this attempt of elites to cope with their declining incomes with overexploitation rather than just inter-elite competition and civil war might qualify as another phase of the manmade crisis keeping the population low.

Unfortunately the imposition of harsh serfdom to overexploit the peasantry backfired upon the elite. In 1601, the harvest suffered due to bad weather and damaged the seeds for 1602. A major famine continued until 1603, even though there was reasonably clement weather that year. The rate of starvation reduced the peasant population even further, impoverishing the elite to the point that many lower gentry had to sell themselves into slavery or become bandits. No fewer than 20,000 elites chose the latter.[307] This second population crisis was prelude to the Time of Troubles, a period characterised by numerous pretenders to the throne, boyar factions, and predation by bandits and Cossacks. The turmoil of this period was marked by a lack of any sufficient population growth, despite the resumption of regular harvests. Internal infighting continued until 1613, when Nefedov's estimates based on the military data of Chernov show that the elite had been reduced in number from 80,000 gentry

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[305] Turchin and Nefedov, 255.
[306] Ibid.
[307] C. Dunning, *A Short History of Russia's First Civil War*, (Philadelphia: Pennsylvania State University Press, 2004), 69 &72.

officers in the 1580s to 15,000 by 1630.[308] If taken as proportional for the elite as a whole, after a period of prolonged and bloody civil war, the elite were reduced, the manmade crisis ended, allowing another period of population growth and stability. Russia emerged from the cycle with a population of 4.5 or 5 million, reduced to half the population levels at the high watermark of 1550. Only after the Time of Troubles did vigorous population growth resume. By 1678, the population had increased to 8.6 million.[309] The following period of growth, decline, and sociopolitical instability is, like England, clouded by improvements in agriculture and the timid beginnings of Russian industrialisation in the late nineteenth century. However, the relationship between increasing populations, a declining standard of living, and an ecological crisis followed by a manmade crisis that holds population low seems to hold firm, at the very least for this second wave of sociopolitical instability in the Time of Troubles.

Nefedov concludes that from 1450-1500, there were high consumption levels by the peasantry, a high real wage, a flourishing standard of living, and great deal of political stability. Strain from overpopulation hit the northwest region centred on Novgorod in the early sixteenth century, with the central region around Moscow falling prey to the same symptoms by 1550. The average ratio of the peasantry to the land shrank, grain prices skyrocketed, wages declined, the amount that average tenants had to live on decreased below the per capita subsistence level of 250kg, and there was a return of severe famines and epidemics. In the 1560s and 1570s, the population began to decline, and Nefedov argues that we get our first taste of sociopolitical instability from Ivan IV's division of the elite, turning one group upon the other. After the population collapsed, elites tried to cope with their declining incomes by enforcing serfdom and raising peasant dues and rents. However, this kept the population low and squeezed the peasantry to the breaking point, causing a major three year famine after the

[308] Turchin and Nefedov, 248 and Cerhnov 1954:125.
[309] Y. Vodarski, *The Population of Russia from the End of the 17th Century to the Beginning of the 18th Century*, (Moscow: Nauka, 1974), 26-28.

crop failure of 1601. The elite had no choice to make recourse to competition with each other and the government resulting in the protracted civil war of the Time of Troubles.[310] For the most part, Nefedov's account seems to hold firm to phenomena we see in other agrarian cycles, with the most important factor being how manmade crisis held the population low after the ecological collapse.

f) Reflection

Early modern Russia represents another example of how demographic-structural trends can operate in an agrarian civilisation, influencing the course of historical events. Once again we have periods of overpopulation, strain, decline, and manmade crisis. Once again collective learning was not able to raise the carrying capacity fast enough to keep pace with population growth. There is no discernible Tasmanian Effect in this case, and it appears that learning was retained despite population decline and knowledge continued to accumulate. David Christian informs me there may have been a temporary decline of artisanal and architectural quality after the Mongol invasions of the 1240s, but only for 50 years or so, and we are both agreed that this does not constitute a loss of learning but a period of economic deterioration. Accumulation of knowledge despite periods where the number of potential innovators declines seems to be the typical course of cultural evolution in the era of agrarian civilisations. But it seems that only gradually are successful variations generated by potential innovators to raise the carrying capacity, stave off periods of strain, and gradually increase the human ability to increase their control over energy flows. As fast as cultural evolution is compared to other processes in the Darwinian algorithm, it is often not fast enough for population growth.

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[310] Turchin and Nefedov, 258-259.

g) *Agrarian Cycles in the Ottoman & Chinese Empires (c.1500-1650)*

The work of Jack Goldstone included a study of agrarian cycles in the Ottoman Empire and the Ming dynasty.[311] Both polities underwent cycles along a similar timeframe. Between 1450 and 1590, both polities underwent a period of demographic growth, and then a spell of crisis between 1590 and 1650. Afterward the demographic situation stabilised and both the Ottomans and Chinese enjoyed another period of stability and even expansion, until 1780, when demographic strain and instability occur once again.[312] This correlation is not so unusual, since as Victor Lieberman has pointed out, polities across Eurasia underwent concurrent phases of demographic growth and political stability and then demographic decline and instability.[313] The Black Death in the fourteenth century and the population decline that resulted set both the Ottomans and Chinese on similarly timed ecological trajectories. At the end of the fourteenth century, both the Ottomans and Chinese territories saw incipient growth began. In the sixteenth century, population growth accelerated, and between 1520 and 1580, the population of Asia Minor increased by an estimated 50-70%, while the Chinese population increased from 65 million around 1400 and peaking at 175 million around 1600.[314] After 1600, the Chinese population went into clear population decline to about 140 million, whereas it is unclear whether the Ottoman Empire suffered population decline (the Empire lost 4 million 1600-1700) or just stagnated (Anatolia's population only grew by 500,000 people 1600-1700, as opposed to 1.5 million in the previous century).[315]

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[311] Jack Goldstone, *Revolution and Rebellion in the Early Modern World*, (Berkeley: University of California Press, 1991). 349-415.
[312] Goldstone, 350.
[313] Victor Lieberman, *Strange Parallels: Southeast Asia in Global Context, c.800-1830*, vol 1., (Cambridge: Cambridge University Press, 2003), 2.
[314] Ö. Barkan, 'Research on the Ottoman Fiscal Surveys' in M. Cook (ed) *Studies in the Economic History of the Middle East*, (Oxford: Oxford University Press, 1970), 163-171.
[315] Colin McEvedy and Richard Jones, *Atlas of World Population History*, (London: Penguin, 1978), 133, 137, & 166.

Like with England and Russia, as population growth increased pace in the sixteenth century, the strain began to show before outright population decline. Even though the Ottomans gained 50-70% more population, the new land brought under production only increased by 20% and near the end of the sixteenth century grain needed to be imported from the Balkans to Asia Minor.[316] The price of rice, wheat, and barley in Asia Minor increased four times between 1489 and 1616.[317] In China new land brought under production did not match population growth either, though new crops from the Americas, including maize and sweet potatoes, but with a reduced nutrition level.[318] The price of rice meanwhile tripled between 1500 and 1650.[319] Once again, overpopulation caused the average peasant landholding to shrink below substance levels and many peasants in both Asia Minor and China were forced to become landless labourers. In the sixteenth century, their lands were gradually bought up and concentrated into the hands of the few. These landholders formed part of an increasingly large and increasingly wealthy elite. The trend holds for both China and the Ottoman Empire, and is in accord with what we see in other agrarian civilisations.[320]

Elite dynamics took on a more individual character in each polity with some core similarities. In the Ottoman Empire, *timars*, who were landholders who made up the Ottoman cavalry, had their stipends given to them by the sultan and incomes at fixed rates. Due to inflation in the late sixteenth century, many timars could not afford to equip themselves for war, thus breaching their contract and causing the confiscation and redistribution of their land. In 1560, there were 87,000 timars in the Ottoman army, and by 1630 there were 8000. The

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[316] M. Cook, *Population Pressure in Rural Anatolia, 1450-1600,* (Oxford: Oxford University Press, 1972), 13-14 and B. McGowan, *Economic Life in Ottoman Europe*, (Cambridge: Cambridge University Press, 1981), 12-13 & 25.
[317] Ö Barkan, 'The Price Revolution of the Sixteenth Century: A Turning Point in the Economic History of the Near East' *International Journal of Middle East Studies* (1975) 6:11.
[318] Goldstone, 358.
[319] M. Cartier, 'Les importations de metaux monétaires: essai sur la conjoncture chinoise' *Annales* (1981) 36:464 and James Geiss, *Peking under the Ming, 1368-1644,* (Princeton: University Microfilms, 1972), 159-164.
[320] Goldstone, 363.

sultan meanwhile compensated with janissaries and sipahis, who became the new predominant elite, whose stipends were not fixed, and grew from 12,900 in 1527 to 67,500 in 1669, with their salaries increasing by a factor of ten in the same period.[321] From the 1580s onward, many of these pay rises were the result of janissaries using violent revolt to extort money from the government. The decay of the timar system led to a number of janissaries being posted in the provinces, where they intermarried and used their influence to acquire local estates. Tax farming was handed out on a massive scale to commoners who further added to the number of wealthy landowners.[322] The period of Ottoman population decline, or at least stagnation, was characterised by an increase in elite competition. Fighting surrounded the holding of government office, and competition was the source of much intrigue and assassination. Between 1568 and 1573, 43% of district commanders stayed in office for 3 years or more, but by 1632-1641, this number had been reduced to 11%, with many elites being kept out of office for several years.[323] This led to a series of revolts by local officials, landowners, and the elite forces of the army, demanding more money and power from the sultan. These revolts became particularly acute after 1590, with the worst revolts being in 1622-28, 1631-32, and 1657-58. At various points the government's grip grew so weak that they frequently lost control of Iraq, Syria, the Crimea, and even Eastern Asia Minor. The period is also characterised by the assassination of numerous viziers and sultans.[324]

Ming China in the 1400s underwent a period of high social mobility in which wealthy peasantry and merchants could rise to the increasingly numerous and influential gentry class. However, throughout the 1600s, price inflation saw the fortunes of this middling class shrink.

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[321] Barkan, 'Price Revolution', 20.
[322] K. Karpat, 'The Stages of Ottoman History: A Structural Comparative Approach' in Karpat (ed) *The Ottoman State and its Place in World History*, (Leiden: Brill, 1974), 91.
[323] I. Kunt, *The Sultan's Servants: The Transformation of Ottoman Provincial Government, 1550-1650*, (New York: Columbia University Press, 1983), 70-72.
[324] Goldstone, 378-379.

Goldstone levels fairly vigorous argument that much of this inflation had little to do with the importation of Spanish silver, but rather was the result of population increase. As we know, such inflation in periods of population growth is not unusual in other agrarian cycles. Some gentry succumbed, while some managed to accrue large landholdings at the expense of their peers, with an increasingly numerous landless peasantry working these great estates. The population continued to increase, and land became concentrated into the hands of the few by the late sixteenth century. The increase of highly wealthy magnates is best measured by the government posts that their offices won them. Between 1400 and 1600, the number of first level officials increased by twenty times. Meanwhile factionalism was increasingly present, splitting the elite into the Donglin party and Restoration society, among others.[325] Faction intensified after the population declined after 1600, and ruined the careers of otherwise competent ministers and generals, simply by virtue of picking the wrong side. Those elites who lost political battles in the 1600s, eventually wound up supporting the north and northwest revolts that toppled the Ming dynasty in the 1640s.[326]

In the case of both the Ottomans and Chinese, the mid-seventeenth century proved a turning point, with the elite shrinking once again, making the social pyramid less top-heavy and with the general population increasing once again. In China after the Manchu (Qing) conquest, the number of officials from new families 1685-1780 was half that of 1500-1684.[327] The Chinese population increased to 270 million by 1770, with the amount of agricultural land being farmed increasing by 50% and new strains of rice and crops from the Americas further raising the carrying capacity.[328] The Ottoman population either peaked or stagnated at 28

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[325] J. McDermot, ‘Bond Servants during the Late Ming’ *Journal of Asian Studies* (1981) 40:700 and Goldstone, 380-382.
[326] F. Wakeman, *The Great Enterprise: The Manchu Reconstruction of Imperial Order in Seventeenth Century China*, (Berkeley: University of California Press, 1985), 229-237.
[327] W. Eberhard, *Social Mobility in Traditional China*, (Leiden: Brill, 1962), 29.
[328] G. Wang, ‘The Chinese Urge to Civilise: Reflections on Change’ *Journal of Asian History* (1984) 18:7.

million by 1600, and did not match that level until 1800. In both cases between 1650 and 1780, the Ottomans and Qing enjoyed a period of relative political stability and population growth. Only when populations began to approach their limit again around c.1780, do we see the resumption of severe crisis in both polities: the White Lotus, Nian, and Taiping rebellions in China and the revolts of Muhammad Ali in Egypt, continued uprisings and assassinations of the janissaries, and the Ottoman's slow loss of influence over localities in their wider empire.[329] One thing that is less clear about this study is the relationship of population decline to declining elite incomes. There is everything to indicate that elite competition increased in the Ming dynasty after the Chinese population declined c.1600, but Goldstone does not present much evidence to suggest elites were suffering a general decline of incomes. On the other hand, there certainly was a large faction of alienated gentry whose financial misfortunes may have been just as adverse as their political ones. With the Ottomans the case is even more unclear. Goldstone does not paint a clear correlation between population decline and the rise of elite conflict. We know the population of the Empire probably dropped, from both casualties of violence and loss of territory, while the Anatolian population simply stagnated.[330] Like with early modern England it remains to be seen whether stagnation and elite overpopulation is enough to strain elite incomes or whether an actual population decline is needed. The clearest thing from the survey of both the Ming and Ottomans is that once again a period of growth and stability is followed by one of overpopulation and instability. At no point in our case studies have we seen the severest internal fighting happen when the general population was still thriving. It seems only when the ecological pinch happens that sociopolitical instability rears its ugly head. Furthermore, it seems many cycles endure similar

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[329] Goldstone, 395-401.
[330] McEvedy and Jones, 133 &137.

and even concurrent timeframes in which the cycle from growth, to crisis, to infighting, to recovery takes place.

h) Reflection

The Ottoman and Chinese Empires are notable, first, for being far ahead of Western Europe in terms of innovations and the carrying capacity, at least as far back as the Tasmanian Effect and the lost of knowledge in the post-Roman West. They are also notable for the fact that after 1650 they entered a period of recovery, but a century and a half later encountered a period of strain and decline as is 'typical' of a normal cycle. This decline occurred at the end of the eighteenth century and the beginning of the nineteenth just as many regions of Western Europe were beginning to escape the tyranny of secular cycles and defy the trends of the past 5000 years of agrarian civilisations. More will be said on what elements of collective learning created this divergence in chapter 5, but for now it is enough to say that the accumulation of learning that led to the Industrial Revolution, the harnessing of more amounts of energy, and greater exploitation of the environment had great bearing on the sociopolitical environment that emerged in the nineteenth century. Only when successful variations that were already selected in the West were adopted in the East did the gap start to close and societies of a newly unified global network begin to approach the high free energy rate density of modernity – which is higher than anything else that humans know of in the Universe. That is how the Darwinian algorithm reaches into early modern and modern history, the ebb and flow of sociopolitical instability, historical events, and the conventional *longue durée.*

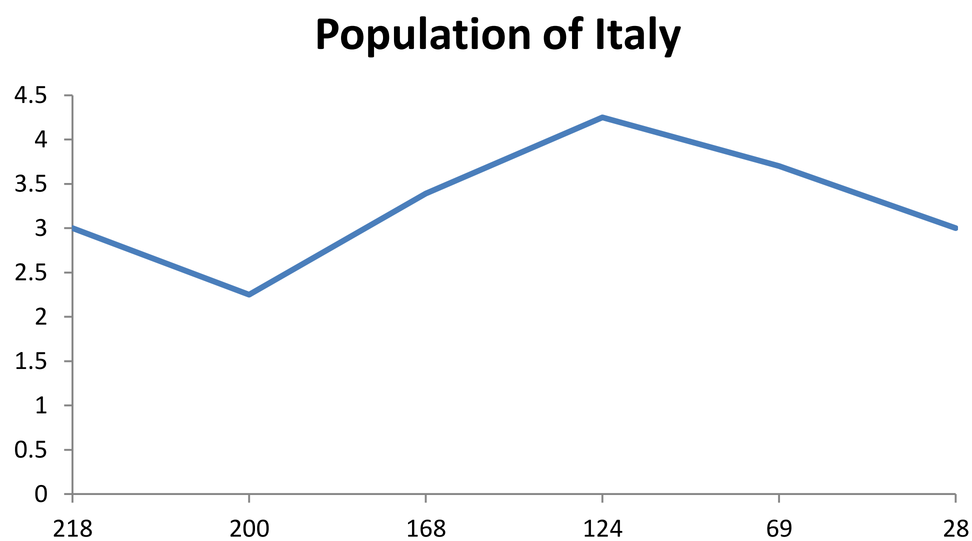
i) Agrarian Cycles in the Roman Republic & Principate (c.350 BC – 285 AD)

Rome underwent two demographic cycles that have been examined by Peter Turchin. There is even a theoretical case to be made for an even earlier cycle spanning 650 to 350 BC, seeing expansion and stagflation for the first 150 years, and crisis and depression falling around the overthrow of Tarquin the Proud and the establishment of the Republic. However, evidence is far too sparse and fragmentary to know for sure. The Republican Cycle appears to be an expansion phase during which Rome established hegemony over the Italian peninsula from c.350 onward. The population losses of the Second Punic War (218-201), an exogenous variable, might explain the elongated duration of the Republican cycle. Stagflation set in around 180, and a disintegrative trend began somewhere between 133 and 90, more likely the latter, and lasted through the wars of Sulla, Caesar, and the Triumvirate until around 30 BC.[331] The following period, the Principate cycle (30 BC-285 AD), precedes our case study on the Roman Dominate (section II). The Roman Empire experienced growth in the first and second centuries AD, crisis following the Antonine Plague in 165 and lasting until 197, and a secular 'depression' of elite infighting in the Third Century Crisis (197-285).

The Republican period saw population growth from 350 BC to the First and Second Punic Wars 265-201, when external warfare and especially the predations of Hannibal on peninsular Italy in the Second Punic War (218-201). Turchin insists that this may have been responsible for the unusually long period of overall growth and political stability until c.180 BC. The figures for 350 BC to the sharp declines of the Punic Wars can be taken from the number of Roman citizens in Toynbee, which increased from c.150,000 to just under 300,000 by 264 BC.[332] By and large this demonstrates a general population increase. After that, better data becomes available and the post-Punic growth in population can be derived from the number from censuses of free adult males in peninsular Italy c.200- 69 BC. Working with the figures of Brunt and Hopkins, Turchin compiled a set of estimates that indicate a growth of

[331] Turchin and Nefedov, 176-210.
[332] A. Toynbee, *Hannibal's Legacy: The Hannibalic War's Effects on Roman Life*, (Oxford: Oxford University Press, 1965), 438-39.

44% from 2.35 to 3.39 million by 168, and the increase to 4.25 million in 124.[333] After that the Italian population declined to 3.7 million by 69 BC and 3 million by 28 BC.[334]



(**Fig. 4.10** Derived from censuses of adult males, Turchin 2009)

The low point of 200 BC was the result of the external warfare of the Second Punic War, particularly Hannibal's predations on Italy. So there does not appear to have been a rise of sociopolitical instability or internal manmade crisis that held the population low. Instead, the Romans seemed to have enjoyed an immediate period of population growth in the post war recovery. Between 180 and 128 BC, overpopulation seems to have reduced the amount of land held by the peasantry. Middling and small landowners (*assidui*) outnumbered the number of landless labourers c. 200 at a ratio of 5:1 or even 10:1, but by c.130, the number of landowners declined and the growth of labourers increased by leaps and bounds.[335] Meanwhile the

[333] Turchin and Nefedov, 180-181, see also P. Brunt, *Italian Manpower: 225 BC-AD 14*, (Oxford: Clarendon Press, 1971) and K. Hopkins, *Conquerors and Slaves: Sociological Studies in Roman History*, (Cambridge: Cambridge University Press, 1978).
[334] Brunt, 97, and W. Scheidel, 'Human Mobility in Roman Italy: The Human Population' *Journal of Roman Studies* (2004) 94:9.
[335] Turchin and Nefedov, 189 & 192.

numbers and wealth of Roman elites also increased and senators became increasingly rich, with fortunes of over 100 million tons of silver.[336]

After population decline set in around 124 BC we begin to see the rise of elite competition and faction with the assassination of Tiberius Gracchus and 300 of his followers in the forum and the emergence of the *populares* and *optimates* factions. However, the bitterest fighting didn't begin until c.91 with the Social War, then the civil war between Marius and Sulla, the rebellion of Marcus Lepidus, the Catiline conspiracy, civil war between Caesar and Pompey, the assassination of Caesar, the Proscriptions of the Second Triumvirate, civil war between Brutus and Cassius and Octavian and Marc Antony, and then the latter turning on each other. It is another case where population decline preceded a manmade crisis. There is a problem with Turchin's analysis, however, in that he cannot adequately gauge whether there was a decline in elite incomes after 124 BC that might have prompted more elite competition, due to lack of data. However, the increase of factionalism and violent struggles for power certainly seem to be symptoms of such an increase in competition.

The Principate period witnessed an increase from 25 million in the Latin West in 14 AD to 42 million by 164 AD.[337] After that the population of the Roman West declined by approximately 32% after the Antonine Plagues and the Third Century Crisis. Economic data is sparse for this period outside Egypt, but there the price of wheat remained low at 90g of silver per quintal 18-47 AD and increased by a third by 165 AD when the first population decline struck.[338] The average land rent in Egypt increased by approximately 26.6% between 100 AD

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[336] I. Shatzman, *Senatorial Wealth and Roman Politics*, (Brussels: Latomus, 1975), 35.
[337] Turchin and Nefedov, 212, see also B. Frier, 'Demography' in A. Bowman, P. Garnsey, and D. Rathbone (eds) *The Cambridge Ancient History*, 2nd ed., vol.11, (Cambridge: Cambridge University Press, 2000), 787-816, and C. McEvedy and R. Jones, *Atlas of World Population History*, (New York: Facts on File, 1978).
[338] R. Duncan-Jones, *Structure and Scale in the Roman Economy*, (Cambridge: Cambridge University Press, 1990), 151-155.

and 165 AD.[339] After the population crisis struck, grain prices in the same region plummeted by 64.5% and rents dropped 37.2% to a lower level than in the Principate expansion phase.[340] Once again we are bereft of statistics for how this affected the state of elite incomes. We do know, however, that sociopolitical instability exploded after the population decline c.165-190 AD. Compared to a reasonably stable period, the Third Century crisis saw a succession of coups and assassinations and even the partition of the Roman Empire into three separate entities, the Gallic, Roman, and Palmyrene Empires. After 268, the rate of violence begins to decline and by 285, Diocletian had resolved the last of the fighting in the Roman Empire, and the population seemed to recover (see our case study on the Dominate).

In general I am in agreement with Turchin's findings for the Principate period, excepting one caveat. Turchin states that the expansion phase (27 BC-96 AD), which according to the theory should have been stable, was 'somewhat marred' by political instability in the ruling class. He is referring to the violent overthrow of Caligula, Nero, Galba, Otho, Vitellus, and Domitian. He dismisses them as mere 'palace coups'. He then plays down the severity of the civil war following Nero's death, 68-69.[341] All this might be taken by some historians of the period as a slight understatement and perhaps a hasty dismissal of something that might expose a weakness in the theory or necessitate a refinement of the notion of elite dynamics. At any rate, the presence of such sustained elite conflict, to speak nothing of the rising tension at the end of the reign of Tiberius, is too glaring a variable to be quickly passed over. It merits thorough examination in a future study.

Sociopolitical Instability in Roman Empire, 0-100 AD

Year	*Event*
15	Disturbances at Rome

[339] W. Scheidel, 'A Model of Demographic Growth and Economic Change in Roman Egypt after the Antonine Plague' *Journal of Roman Archaeology* (2002) 15:97-114, table 1.
[340] Duncan-Jones, 151-155 and Scheidel 'Demographic Growth', table 1.
[341] Turchin and Nefedfov, 211.

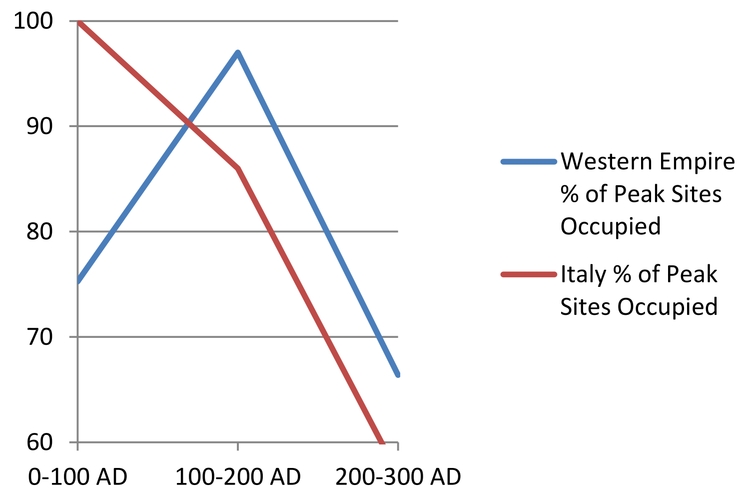
16	Revolt of Legions in Pannonia and Germania
19	Alleged murder of a rival Germanicus by Piso, supposed acolyte of Tiberius
23	Mysterious death of Drusus, who had shared tribunician power with Tiberius
24	Rebellion of the slaves in southern Italy
29	First minister Sejanus begins purging senatorial class of all opponents
30	Sejanus exiles members of imperial family, some of whom die mysteriously
31	Sejanus falls from favour and is executed
37	Tiberius dies having become unpopular for his informers and treason trials
37	After a brief period of popularity, Caligula begins persecuting nobles
38	Caligula executes people without full trial
39	Famine strikes, Caligula seizes property of the wealthy, executes senators
41	Assassination of Caligula; proclamation of Claudius, stability returns
42	Conspiracy at Rome (Scribonianus)
55	Nero allegedly murdered Britannicus, a rival to the throne
59	Disturbances at Pompeii, Nero orders the murder of his mother
60-61	British revolt
62	Nero executes his ex-wife, Octavia
62-63	Persecution of senators for treason
64	Fire of Rome and disturbances
65	Conspiracy at Rome (Piso)
66-70	Jewish revolt
68	Uprising against Nero (Vindex & Galba), flight and forced suicide of Nero
69	Civil war. Galba destroys several towns, executes senators and knights without trial, murdered by army, Otho succeeds, is beaten by Vitellius, and commits suicide, Vitellius conducts a series of tortures and executions, and is killed by Vespasian's men while attempting to flee
70	Uprisings in Egypt, Gaul, and Germania
70-79	Alleged string of 'false Neros' and conspiracies against Vespasian
79-80	Rebellion of Terentius Maximus
89	Revolt of Saturninus
93-96	Sharp rise in persecution of dissidents
95	Conspiracy at Rome
96	Murder of Domitian, accession of Nerva

(**Table 4.2** From Turchin and Nefedov, 2009, 222, but a decidedly more expanded list)

Yet such a dismissal of first century unrest is unnecessary even within the theory. Rural settlement patterns show the population in Italy peaked in the first century AD, unlike most other provinces of the Empire, which continued to flourish until the second. In the second century, while Britain, Belgica, Gaul, and Spain continued to grow, the population of Italy actually fell by 14%.[342] Even Turchin acknowledges this fact in his examination. There is no reason why this fact cannot account for the growing tension among Italian elites at the end

[342] See Fig. 4.9.

of the reign of Tiberius, during the reign of Caligula, and also the periods of violence in the late sixties, and above all the localised nature of a great deal of the first century unrest within Italy.



(**Fig. 4.11**. Data from Lewit 1991)

Nor should Italy's first century peak come as a surprise. Unlike the Social War and the wars between Marius and Sulla in the Republican cycle, the majority of the most brutal campaigning under Caesar, Pompey and later Octavian and Marc Antony, was held outside of Italy, in Spain, Africa, and above all in Greece. Although Italy undoubtedly experienced depopulation, not to mention the elite proscriptions of the second triumvirate, the ravages of actual military campaigning fell elsewhere in the Empire. In 49 BC, Caesar took Rome with ease and hounded Pompey out of Italy, while the most decisive battles of this latter part of the Republican cycle: Pharsalus, Philippi, and Actium took place in Greece. The shortness of Italy's period of expansion (27 BC-c.60 AD) as opposed to the flourishing of the Empire (27 BC-165 AD) might therefore be explained by the fact that the later campaigning of the Republican crisis (49-30 BC) largely spared Italy, unlike the earlier part of the crisis (91-70 BC). Thus it is conceivable that the Italian population might have recovered earlier than the rest of the Roman Empire.

Furthermore the mass concentration of elites in Italy in the first century AD also played a negative role in the Dominate cycle. It would appear that the gravitation of so many elites in such a vast empire to one region, namely around Rome, was detrimental to the state's ability to recover from secular depressions and get out of periods of elite infighting. Rome was the empire's historical capital and political hub, but in reality there was hardly anything economic or demographic that made it an ideal place to house vast numbers of elite. In the meantime, the excessive number of elites in the West and their perpetual infighting in the fourth century bore down upon the recovering Western provinces, which were least capable of enduring such a burden. In the Dominate cycle the presence of many hyper-rich elites in the West while the richest and most populous provinces lay to the East may have strangled growth in the fourth century. It is therefore possible elite dynamics also prematurely arrested growth in Italy in the first century. In spite of this possible flaw, it is quite clear that Turchin's treatment is fairly accurate and that the theory of secular cycles conforms generally to the historical evidence. Our own case study will deal with the succeeding period of agrarian cycles in the Roman Empire.

j) Reflection

Turchin's study is notable for being one of the few studies of the relationship between overpopulation and sociopolitical instability that does not emanate from the second millennium AD and the conventional *longue durée*. Yet despite the numerous challenges of gathering population data it would appear that classical civilisations in the first centuries BC and AD also encountered the ecological and social effects of later agrarian cycles. It would be interesting to push these studies further back into other ancient civilisations to see if these demographic-structural cycles are universal to the age of agrarian civilisations. Combined with the Pueblo example of an early agrarian civilisation it is also possible that these cycles are ubiquitous throughout the agrarian era. This would make sense in the context that, from what we know of agriculture, collective learning did not raise the carrying capacity fast enough to keep pace with population growth. Cultural variations may arise in a sea of potential innovators, but those potential innovators emerge faster – and they need to be fed.

In the previous chapter, we established a possible Tasmanian Effect in post-Roman Western Europe. No such loss or simplification of learning has been established in the Republican or Principate cycles. Yet further investigation seems vital to discerning whether Tasmanian Effects become more common the further back in the agrarian era we look, just as they appear more common in hunter-gatherer societies. It is possible that the slow rise of the world population and unification of the world zones may make this process more difficult. But as of now we have only established one Tasmanian Effect in the era of agrarian civilisations. It is possible that the greatest likelihood of finding another is in the ancient period rather than in the contemporary *longue durée*. At any rate, in this study we see a fairly typical relationship between population cycles and the slow growth of the human ability to harness more energy flows and raise the carrying capacity. In our next case study we shall survey a period where population crisis was so severe that the carrying capacity was lowered and the human ability to harness energy flows declined. Like a mass extinction event in the evolutionary epic, many variations were lost, and it took Western Europe many centuries to regain the collective learning that had previously filled niches in its 'cultural ecosystem'.

IV. Agrarian Cycles in the Roman Dominate (285-500 AD)

The great difficulty with examining population figures for the Dominate cycle is that we do not have clear census figures. Recourse must be made to several forms of archaeological evidence, but, as we shall see a reasonably adequate idea of population levels can be established. We shall look at rural settlement patterns, levels of metal production, fluctuations in maritime activity, the state of Roman villas that remained occupied, and palaeopathology. In the Dominate cycle, the Roman population in the Western Empire recovered in 285 after the previous cycle, increasing by an average of 17% between 285 and 350. Then the population dropped again 350-400 in many provinces, by a range of 4-19%, and it stagnates in others. The recovery from the previous downturn was cut short by conflict amongst the elite population, then devastated by foreign invasion, and then obliterated by pathogens, resulting in a Tasmanian Effect that lowered the carrying capacity for several centuries, setting back the process of gradual accumulation of cultural complexity. Incidentally, population ecology sheds light on the age old conundrum of what caused the decline and fall of the Western Roman Empire.

a) *The Population Cycle of the Eastern Empire*

The Dominate cycle can be split in two. Archaeological evidence of the past three decades has made it perfectly clear that the Eastern Empire after 285 enjoyed a fruitful period of demographic growth and economic prosperity throughout the fourth and fifth centuries, continuing until the Justinianic plague struck in the mid-sixth. It seems quite clear that the expansion and stagflation phases of the Eastern Empire were in the years 285-540 AD. The evidence for this is both demographic and economic. Settlement patterns in northern Syria show the population flourished to a peak around 540, then stagnated and declined into the eighth century. East of Antioch, villages sprang up in the first century AD, there was a decline during the Third Century Crisis, and afterward there was growth in small-scale farming and the development of new fields. Growth came to an end around 550, after which sites were abandoned.[343]

[343] P. Gatier, 'Villages du Proche-Orient protobyzantin (4ème-7ème s.) Etude régionale,' in Geoffrey King and Averil Cameron, *The Byzantine and Early Islamic Near East: Land Use and Settlement Patterns*, (Princeton: Darwin Press, 1994), 17-48.

(**Fig 4.12** Eastern and Western Empires in 395 AD. Utah State University. Retrieved Jan 5 2013: http://www.usu.edu/markdamen/1320Hist&Civ/slides/08romfal/mapEWRomanEmpire.jpg)

In Greece, there was growth in rural settlements between c.300-600 AD. This trend is seen in surveys in Attica and Boeotia. At Corinth in the same period, there was a demographic recovery to a level which had not been seen since the time of Alexander the Great in the fourth century BC. The same pattern can be seen in Methana, which saw nine sites occupied for the first time around 300 AD, and thereafter site numbers continued to grow.[344] In the eastern desert of Egypt, at Bir Umm Fawakhir, a Byzantine gold mining town developed in the 400s and was occupied for many years until it was completely abandoned at the end of the 500s.[345]

[344] Susan Alcock, *Graecia Capta: The Landscapes of Roman Greece*, (Cambridge: Cambridge University Press, 1993), 38-48. See also J. Bintliff, 'Forest Cover, Agricultural Intensity and Population Density in Roman Imperial Boeotia, Central Greece,' in Frenzel Burkhard *et al.* (eds) *Evaluation of Land Surfaces Cleared from Forests in the Mediterranean Region during the Time of the Roman Empire*, (Stuttgart: G. Fischer Verlag, 1994), 133-143 and also J. Bintliff, 'Regional Survey, Demography and the Rise of Complex Societies in the Aegean,' *Journal of Field Archaeology*, (1997) 24:8-38.
[345] C. Meyer, 'A Byzantine Gold-Mining Town in the Eastern Desert of Egypt: Bir Umm Fawakhir, 1992-93' *Journal of Roman Archaeology* (1995) 8:192-224.

At Ephesus, many parts of the city were being redeveloped in the fifth century. All signs point to new buildings being erected as late as 600. Wealthy households on Embolos street were exquisitely decorated during the late 300s or early 400s. In 614, a fire destroyed these buildings. It is telling that they were not rebuilt.[346] Similar trends can be found all over the Eastern Mediterranean.[347] The archaeological evidence seems conclusive enough to state that the provinces of the East enjoyed an integrative phase from the fourth to the mid-sixth century.

It is less clear if the Eastern Empire was still growing when the Justinianic plague descended upon the Mediterranean world in 541. It is possible that population decline had already begun prior to the outbreak, in the same fashion as Western Europe in the fourteenth century before the Black Death.[348] Unfortunately, most archaeological surveys are unable to determine if growth stopped before or after 541. Pottery is unable to date a settlement that specifically. Architectural styles do not allow us to say whether an urban building was constructed before or after the 540s. Disasters also mitigate our ability assign a precise date to growth in the sixth century. The buildings of Antioch were damaged by an earthquake in 526 and a Persian invasion in 540. Apamea was largely spared in 526 and 540, but was sacked in 573. Much of the decline could be attributed to that. However, at Apamea it seems that no new houses for the rich were built between 540 and 600. No shops near the cathedral had coins dated after the reign of Justin I (518-527), but many archaeologists find coins insufficient by themselves to establish a date. Fuller information can be found at Scythopolis. Civic architecture persists into the 500s, with inscriptions dated 506, 515, and 521. The baths were inscribed 534-535. No public works can be found after that date, but once again there is

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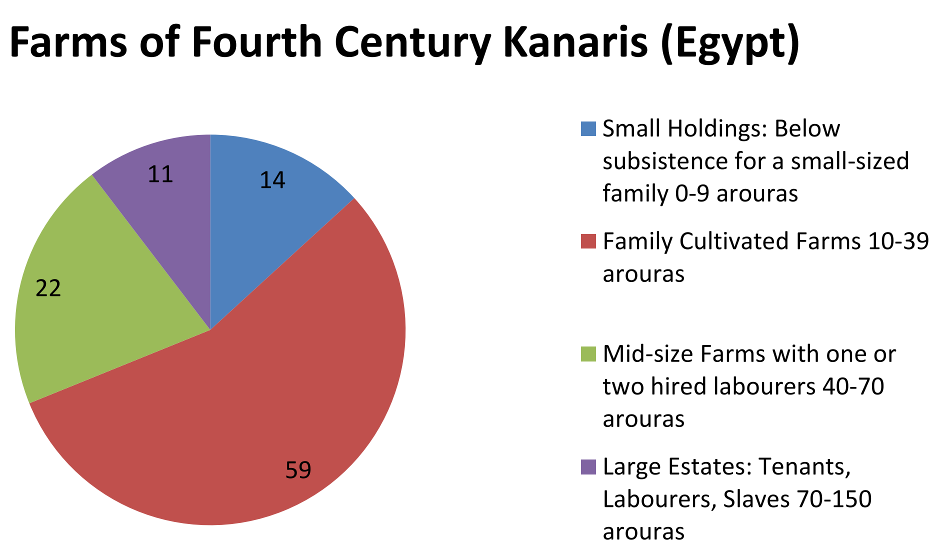
[346] Clive Foss, 'Archaeology and the "Twenty Cities" of Byzantine Asia,' *American Journal of Archaeology*, (1977) 81:469-86.

[347] For a survey, see Chris Wickham, *Framing the Early Middle Ages: Europe and the Mediterranean, 400-800*, (Oxford: Oxford University Press, 2005), 442-53.

[348] See Guy Bois, *Crise du feudalisme: économie rurale et démographie en Normandie orientale du débat du 14e siècle au millieu du 16e siècle*, (Paris: Presses de la Fondation nationale des sciences politiques, 1976).

nothing to indicate whether the decline happened before or after the plague.[349] Whether the Eastern secular cycle was experiencing stagflation or crisis in 541 remains an open question for future studies.

What is more certain is that the Eastern Empire had passed into a period of stagflation by the late fifth or early sixth century. Previously, in the prosperous fourth century, there was more equality among elites and very few hyper-rich landowners. Most Eastern senators were elites on a provincial level, but could not yet threaten the emperor.[350] The 300s were clearly an expansion period. Archaeological evidence from Northern Syria shows there were many small landholders and very few large estates.[351] In Egypt tenant leases were short, peasant landholders were numerous, wage labourers experienced high wages and low prices, and there were no attempts by fourth-century Egyptian landholders to tie their peasants to the land.[352]



(**Fig. 4.13** Data from Bagnall 1993)

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[349] For survey of the mentioned sites in relation to the plague, see Hugh Kennedy, 'Justinianic Plague in Syria and the Archaeological Evidence' in Lester Little (ed), *Plague and the End of Antiquity: The Pandemic of 541-750*, (Cambridge: Cambridge University Press, 2007), 90-92.
[350] Chris Wickham, *The Inheritance of Rome: A History of Europe from 400 to 1000*, (London: Allen Lane, 2009), 37.
[351] G. Tate, *Les campagnes de la Syrie du Nord du IIe au VIIe siècle*, vol.I, (Paris: Librarie orientaliste Paul Geuthner, 1992).
[352] R. Bagnall, *Egypt in Late Antiquity*, (Princeton: Princeton University Press, 1993), 110-23 & 148-53.

However, in the 400s one begins to see growth in the number and size of large estates in the East. Landholders began to acquire trans-regional property, rather than holdings in just one province.[353] This prosperity was the classic result of an increase in the availability of labour, a decrease of wages that landholders had to pay, a rise in food prices, and consequently a rise in the incomes of landholders. In the fifth century, the East began to acquire more elites at a time when the West was already glutted with the hyper-rich. Suffice it to say, in the Eastern Empire elite numbers grew rapidly in the 400s. An increase in elite production and the size of their wealth is a symptom of stagflation. The senatorial order expanded rapidly during the fifth century, particularly in the reign of Marcian (450-457). Stratification and inequality also became a problem. The stratification culminated with the highest ranking elites, the *illustres*, gradually excluding the less wealthy elites, the *spectabiles* and *clarissimi*, from the senate altogether by the reign of Justinian I (527-565).[354]

The problem of elite overproduction is reflected in Byzantine history after the death of Marcian in 457. The reign of his successor, Leo I (457-474), was marked by increased tension between the old Byzantine elite and the Isaurian faction, whose new and disproportionate influence they resented. While the reign was generally stable, it was marked by a number of assassination plots flung between the two camps. Leo I nevertheless ruled for a long time and died of natural causes at a ripe old age. The same could not be said of his grandson, Leo II (474). He ruled for less than a year before dying under suspicious circumstances. His father, Zeno, an Isaurian who had married into the dynasty, became emperor, but was actually overthrown by a revolt that slaughtered many of his Isaurian officers. Zeno fought his way back to the throne, but elite revolts persisted – in stark contrast to the stable fourth and early

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[353] Peter Sarris, 'Rehabilitating the Great Estate: Aristocratic Property and Economic Growth in the Late Antique East,' in William Bowden *et al*. (eds) *Late Antique Archaeology: Recent Research on the Late Antique Coutryside*, (Leiden: Koninklijke Brill, 2004), 55-72.
[354] John Haldon, 'Economy and Administration: How Did the Empire Work?' in Michael Maas (ed) *The Cambridge Companion to the Age of Justinian*, (Cambridge: Cambridge University Press, 2005), 39.

fifth centuries. Elite competition exploded into open conflict in the 490s.[355] The reigns of Anastasius (491-518), Justin (518-527) and Justinian (527-565) sustained a precarious equilibrium fraught with many court intrigues and noble plots, where the emperor had to consistently remain on his guard. Even the glorious reign of Justinian was witness to the Nika Revolts in 532, in which the senators were heavily involved. Several changes to the senatorial order followed the revolt. Sons of 'full' senators, the *illustres*, inherited the rank of *clarissimus* only. The emperor had to be petitioned for higher rank.[356] This was an attempt to restrain elite overproduction and to come to grips with the 'over-mighty subject'. As the table below shows, very little severe sociopolitical instability and elite infighting occurred in the Eastern Empire in the fourth century, with a marked increase as population strain set in thereafter.

Sociopolitical Instability in the Eastern Empire, 285-700 AD

Year	*Event*
306-309	Galerius tries to intervene in Western infighting with limited success
311-313	Galerius dies, Maximin and Licinius compete for control of East
316-317	Licinius fights Constantine, peace and compromise
324-325	Licinius fights Constantine again, surrenders and later is killed
351-353	After a series of civil wars and coups in the West, Eastern emperor Constantius II goes to war and wins the entire empire
353	Gallus, Caesar of the East, is executed for irresponsible governance
364	Empire is split once again, Valens rules East
365-366	Revolt of Procopius
378	Valens killed at Adrianople
387-395	Theodosius I intervenes in Western infighting
450	Pulcheria and Marcian openly dispute succession with Chrysaphius
471	Zeno and the Isaurian faction displace the king-maker, Aspar
474	Leo II allegedly poisoned by Isaurian faction
475	Riots force Zeno to flee Constantinople, usurpers fight amongst themselves
476	Zeno besieges Constantinople
479	Revolt of Marcian the Younger
484	Revolt of the Samaritans
484-488	Revolt of Illus
492-497	The Isaurian War
512-515	Balkan Rebellion
532	Nika Riots

[355] Stephen Williams and Gerard Friell, *The Rome that did not Fall: the Survival of the East in the Fifth Century*, (London: Routledge, 1999), 171-184.
[356] Haldon, 39.

565	Clandestine succession engineered by Callinicus
574	Abdication of Justin II due to insanity
582	Alleged poisoning of Tiberius II
588	Mutiny on the Persian front
602	Mutiny on the Danube and murder of Maurice by Phocas
608-610	Civil war and murder of Phocas by Heraclius
602-628	Persian-Byzantine Wars
634-718	Arab Conquests

(**Table 4.3** Data from Williams and Friell 1999)

Nevertheless, the wealthy upper orders of *illustres* continued to multiply and proliferate. The lower *spectabiles* lost a lot of their military and administrative positions to the ever-growing horde of *illustres*. The late 530s saw the creation of ranks higher than that of *illustris*, those of *magnificus*, *gloriosus*, and later, the superlative *gloriossisimus*. The title of *illustris* was further devalued by being held by provincial elites.[357] These events did not reduce elite numbers. Nor did it reduce the contents of their coffers. Nor did it prevent the decline of the Byzantine population.

In general, it appears that the Eastern Empire from 285-700 experienced a secular cycle that fits well with the basic model. There was expansion in the fourth century, stagflation somewhere in the fifth, crisis after the mid-sixth century, and depression and disaster in the upheavals of the seventh. Possible questions may be raised about Justinian's reign which fell at the end of stagflation but is known for prosperity and the reconquest of Western territories. Yet accounts of prosperity may have been inspired by the strictly elite 'golden age' which is a symptom of stagflation. Another symptom can be increased external aggression.[358] It is also revealing that the re-conquests did not last. At any rate, a great deal of refining remains to be done on the basis of quantitative data, along with mapping the next cycle in what remained of the Byzantine Empire after the Arab Conquests. However, it is becoming increasingly clear that the survival of the Eastern Empire was no mere accident. The

[357] Haldon, 40.
[358] Turchin and Nefedov, *Secular Cycles*, 33-34.

different timing of the population cycles goes far in explaining the endurance and flourishing of the Eastern Empire at a time when an altogether different story was unfolding in the West.

b) The Population Cycle of the Western Empire

In the Western Roman Empire, the population recovered c.285-350 from the losses of the population downturn of the Antonine plague and then the manmade infighting of the Third Century Crisis that succeeded it. The Roman Empire enjoyed a period of relative political stability under Diocletian and Constantine. Then all growth stagnated, elite infighting persisted, and things slowly declined until they dropped catastrophically in the Germanic invasions of the fifth century. A useful survey of settlement abandonment was devised by Tamara Lewit.[359] Lewit looked at two hundred rural sites from several regions in the West and determined when they were occupied. She then gave the proportions for each half-century in the form of a percentage of the highest level of occupation. In the same fashion, Lewit also determined the percentage of the other sites that were still expanding or 'remaining prosperous'. Lewit's survey remains one of the best quantitative works on rural settlements, even two decades later.[360] A re-examination of her numbers reveals an interesting pattern. In Lewit's presentation, the settlement abandonment percentages were taken from a peak index, whenever the peak occurred, whether it was the first century, as it was for Italy, the second century, where most regional peaks occurred, or the fourth century, where South Gaul and South Spain evidently peaked. These multiple indexes unfortunately detract from the clarity of

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[359] Tamara Lewit, *Agricultural Production in the Roman Economy AD 200-400*, (Oxford: Tempus Reparatum, 1991).

[360] Nevertheless, Lewit herself is a staunch advocate of continuity. Lewit's presentation of the percentages downplays the idea of gradual but severe decline in the late fourth century, even though some of the regions seem to indicate it. She is incredulous at depopulation after 400. She advances an array of arguments to explain where all the people went and how continuity was maintained. Of course, if there was a more gradual decline from 350, it defeats necessity of such explanations. Subsequent works of Lewit follow the same theme of continuity. Tamara Lewit, 'Pigs, Presses, and Pastoralism: Farming in the Fifth and Sixth Centuries AD' *Early Medieval Europe* (2009) 17:77-91 and '"Vanishing Villas" ": What happened to elite rural habitation in the West in the fifth and sixth centuries?' *Journal of Roman Archaeology* (2003) 16:260-274. For a critique of this article see A. Bowes and A. Gutteridge 'Debate: Rethinking the Later Roman Landscape' *Journal of Roman Archaeology* (2005) 18:405-413.

the presentation. Accordingly I will use a second century index for all regions. The two of the seven regions that exceeded their second century levels will simply score over 100.

Region	*200–250*	*250–300*	*300–350*	*350–400*	*400–500*
Britain	98	94	98	79	47
Belgica	91	43	55	36	19
North Gaul	82	45	64	55	9
South Gaul	94	73	104	104	73
North Spain	96	61	93	96	54
South Spain	109	100	109	100.5	67
Italy	90	71	85	81	71

(**Table 4.4** Index of rural settlements occupied by region and by period (2nd Century Index); Data from Lewit 1991)

The period 200–250 CE shows a decline from the second century peak, probably due to the Antonine Plague that initiated the crisis phase of the Principate. The period 250–300 CE clearly reflects a deep decline of the worst infighting of the Third Century Crisis and secular depression phase. It is interesting to note that a region like Britain, which avoided the bulk of the fighting of this phase, only declines modestly, more like a mild recoil from the carrying capacity than a severe decline from a manmade crisis. The period 300–350 CE witnesses a universal period of growth and recovery, which heralds the beginning of the Dominate expansion phase. Then in the period 350–400 CE this growth is dramatically cut off, in contrast to what we know of settlements in the Eastern Empire. In Britain, Belgica, North Gaul, and Italy there is slight or even considerable decline well before the Germanic invasions. There are, of course, regional variations. South Gaul evidently sees no growth but only stagnation, while Spain sees stagnation or even mild growth. Lewit's figures for South Spain were inflated, based on only one study where 25 percent of sites surveyed in the Guadalquivir valley possessed no earlier pottery. This contrasts dramatically with the drop in the fifth century. So instead an average between the two periods is taken. Also Lewit inflates the figures for Britain by 8 points after 350 because she does not accept the absence of post-350 coins as conclusive, and so counts them all as occupied. Here the original figure of 79 is upheld. Either way it demonstrates decline from the previous period *well before the Germanic invasions*.

It is important to note that the occupation index includes those settlements that declined, but were not totally abandoned after the second century. Lewit also gave figures for settlements that were expanding or were ‘remaining prosperous’ in each fifty year period. The combination of these two categories defines the percentage of settlements which were neither expanding nor stagnating, that is, contracting: either showing signs of decline, partial abandonment, or destruction. The fourth century figures for Britain, Belgica, and North Gaul are worth noting.

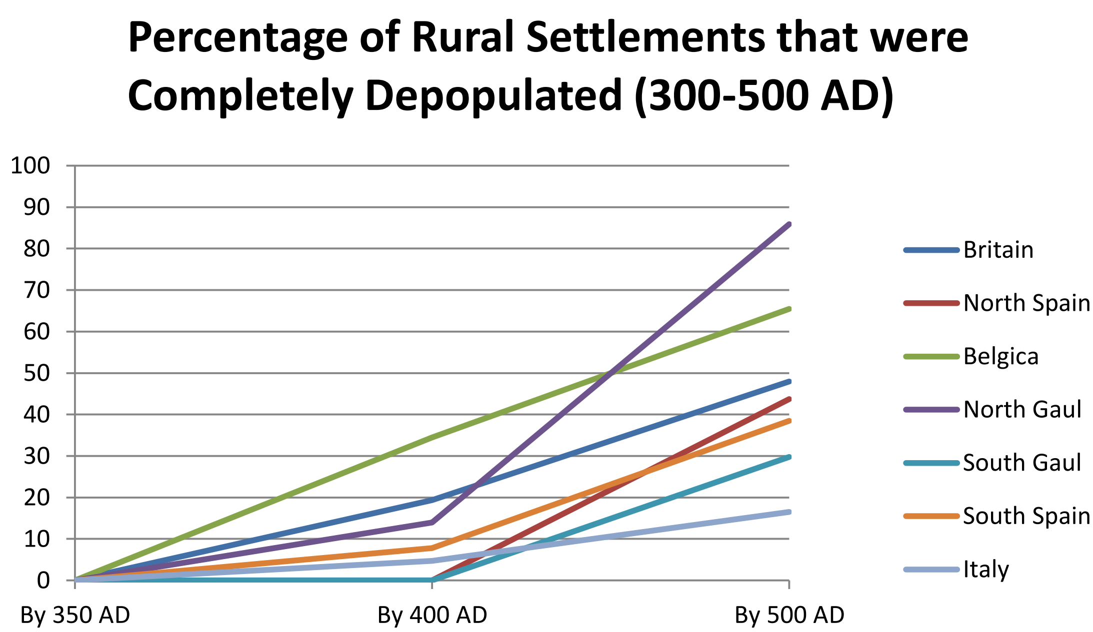
Region	*200–250*	*250–300*	*300–350*	*350–400*	*400–500*
Britain	8	20	16	38	N/A
Belgica	18	57	45	64	N/A
North Gaul	10	60	37	44	N/A
South Gaul	19	29	0	12	N/A
North Spain	3	40	4	11	N/A
South Spain	3	20	9	0	N/A
Italy	N/A	N/A	N/A	N/A	N/A

(**Table 4.5** Percentage of occupied but contracting rural settlements; data from Lewit 1991)

Lewit states that it is startling that the 400s saw such a rapid decline because: (1) it followed a period of continued occupation, which is only partly true, (2) it contrasts sharply with archaeological signs of growth in 300–350 in the Eastern Empire, and (3) it would require a massive depopulation surpassing the devastation of the Black Death to ‘account for the abandonment of nearly every farm [*sic*] in North-West Europe within the space of about twenty years.’[361] Fortunately, the presence of s-curves in the agrarian era may help resolve these difficulties. First, the third and fourth centuries were not periods of continued occupation but of fluctuating population levels due to the rise and fall of secular cycles, as shown in Lewit’s own graphs. Second, the prosperity of the Eastern Empire does not dictate a similar

[361] Lewit, *Agricultural*, 37-38.

pattern in the West, since it is becoming increasingly clear that the Dominate cycle evolved differently in the East. The reasons for this difference are dealt with below: a lowered carrying capacity and the East-West disparity in elite dynamics. Third, no holocaust like the Black Death would have been necessary, if the decline in the West had begun earlier than 400, as has been demonstrated with Lewit's own figures. The demographic theory presents an alternative, more gradual, and therefore more conceivable, explanation for depopulation and the decline of the Western Roman Empire.



(**Fig. 4.14** Showing losses from peak levels c.350, see table 4.x)

The gradual downturn of population is accompanied by other forms of evidence. After a brief period of recovery in the 300s, the Western economy apparently fell to a nadir point that was lower than anything seen in the disintegrative phase of the previous century. Iron production may have recovered c.300–350, but it fell to an all-time low by the year 400. Thus, only one-tenth of iron sites in Britain survived.[362] A study of mines in the Iberian Peninsula shows that of 173 Roman mines in Spain, fewer than 21 were operating in the late 300s, and

[362] B. Jones and D. Mattingly, *An Atlas of Roman Britain*, 2nd Edition, (Oxford: Oxbow Books, 2002), 180-196.

this number shrank again to only two in the 400s.[363] An impressive group of iron forges in southwest Gaul, which began recovering as early as the third century, did not make it out of the fourth.[364] In eastern Gaul, another iron production site shows the same pattern. It was active between the first and fourth centuries, but charcoal dated by radiocarbon fails to show any operation past 400.[365] Gold mines follow a similar pattern. The coins at Tharsis in Iberia are dated no later than 350, while at Vipasca there is only evidence of dwindling occupation in the fourth century with nothing beyond. At Rio Tinto, a small settlement had coins from the reign of Honorius possibly dating as late as the 420s, but no later. In Britain gold mines were active until c.383. In Dalmatia, mining halted during the Third Century Crisis, revived on a small scale in the fourth century, but by 400 these mining operations had ceased altogether.[366]

Last Known Mining and Smelting Activity in the Western Empire (West to East)

Year	*Location*
300s	Lusitania, North Hispania
300s	Forest of Dean, Britannia
300s	Weald, Britannia
Early 300s	Les Martyrs, Southwest Gaul
417	Bituriges, Central Gaul
By 400	Autun, East Gaul
417	Sardinia
417	Noricum
By 400	Illyricum
360	Dalmatia

(**Table 4.6** From Jones, Domergue, Mangin, Cauuet, Edmondson)

Last Known Mining and Smelting Activity in the Eastern Empire (West to East)

Year	*Location*
By 550	Attica, Greece
By 550	Pangaios, Greece

[363] Claude Domergue, *Les Mines de la Péninsule Ibérique dans l'Antiquité Romaine.* (Paris: École Française de Rome, 1990), 215-224.
[364] B. Cauuet, *et al*. *Un centre sidérurgique romain de la montagne noire: le domaine des forges, Les Martys, Aude.*Paris: CNRS editions, 1993), 68-9 & 123-5.
[365] Michel Mangin, *Mines et métallurgie chez les Éduens: le district sidérurgique antique et médiéval du Morvan-Auxois*, (Besançon: Université de Besançon, 1992), 222-242.
[366] J.C. Edmondson, 'Mining in the Later Roman Empire and Beyond: Continuity or Disruption?' *Journal of Roman Studies* (1989) 84-102. While the research plainly shows the closure of most Western mines by 400, the author stresses a fifth-century 'restructuring' to 'small-scale' production for 'local economies'. It is revealing that no such 'restructuring' happened anywhere in the East, see page 92.

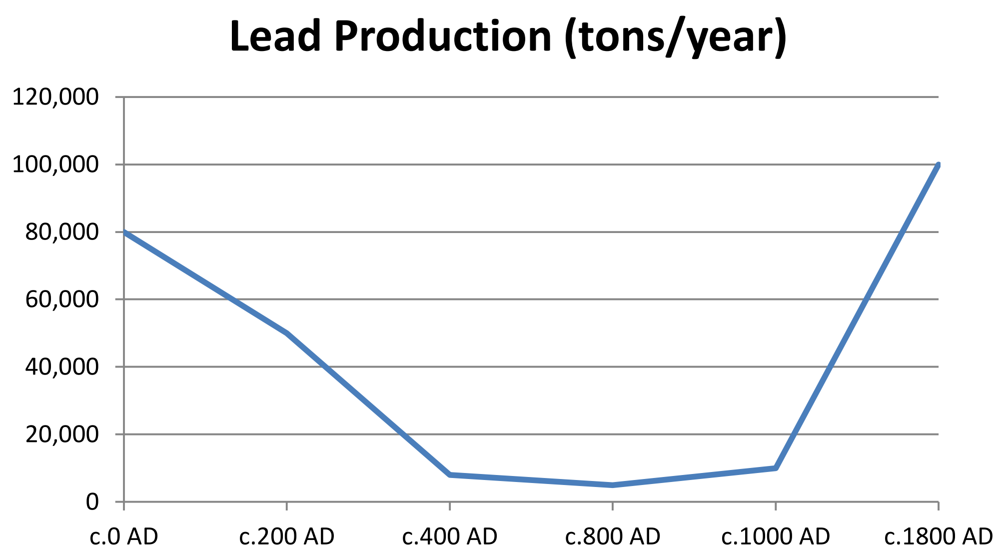
500s	Inner Egypt
600s	Red Sea Coast
400-600	Cilicia
600s	Cappadocia
530	Armenia

(**Table 4.7** From Jones, Domergue, Mangin, Cauuet, Edmondson)

It is unlikely these large mines were replaced by 'small-scale' sites producing at the same level – or anywhere near it. Evidence for this has come from an unusual quarter. Atmospheric pollution from mining descended on Greenland and became packed down under layers of snow and ice, with the spring thaw dividing one year from the next, with a similar effect as rings in a tree trunk. Ice 'cores' taken from Greenland allow us to devise a timeline for hemispheric pollution from lead production. They show that lead was being produced at around 80,000 tons per year at the height of Roman power. Production peaked around the time of the Principate's expansion phase, when it attained a level not reached again until 1800. The 300-350 recovery did not reach peak Antonine levels, and after the West's collapse production shrunk from 80,000 tons to only a few thousand tons per year.[367] Copper mining and smelting emissions show the same trend. The Roman period marked a sharp rise in copper production to a peak of 15,000 tons per year in the first century AD and fell to 2000 tons in the fifth century before declining further.[368] At any rate, the lead figures are corroborated by another unusual source, a Swiss peat bog, which also serves as an archive of atmospheric metal deposition. The surface layers are isolated from groundwater and surface water and receive inorganic solids from atmospheric deposition. As a result the peat bog is a record of changing lead and scandium levels for the entire Holocene. The peak of Roman mining was in the first century AD. Production remained high until it declined in the third century, with a possible

[367] Sungmin Hong, *et al*. 'Greenland Ice Evidence of Hemispheric Lead Pollution Two Millennia Ago by Greek and Roman Civilisations' *Science*, (1994) 5180: 1841-1843.
[368] Sungmin Hong, *et al*. 'History of Ancient Copper Smelting Pollution During Roman and Medieval Times Recorded in Greenland Ice,' *Science*, (1996) 5259:246-249.

recovery thereafter, but production slowly dwindled in the fourth century to an early medieval nadir.[369]

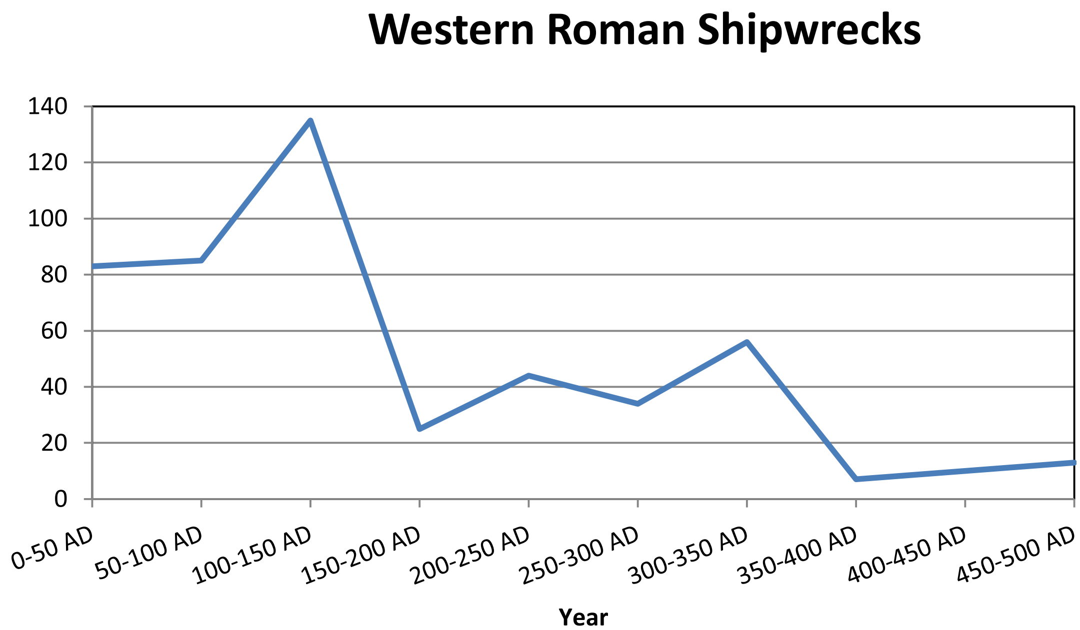


(**Fig. 4.15** Data approx. from Hong 1994: fig1.A.)

The number of shipwrecks discovered in the Western Mediterranean drops significantly for those dated in the late fourth century (Figure 5). What is more, the number of shipwrecks found at the bottom of the sea and dated by archaeologists follows precisely the same pattern as what has been predicted for both the Principate and Dominate secular cycles. The number of shipwrecks found in the entire third century is only 49 percent that of the second century. The period 300–350 indicates a recovery in shipping but 350–399 yields less than 13 percent of the ships that sunk in the preceding fifty years. The entire fifth century yields only 37 percent of the fourth century total, including the decline period.[370] The use of shipwrecks as an indicator of total volume must be done with caution, however, but it

[369] W. Shotyk, *et al*. 'History of Atmospheric Lead Deposition' *Science* (1998) 5383:1635-1640.
[370] A. Parker, *Ancient Shipwrecks of the Mediterranean and the Roman Provinces*, (Oxford: Tempus Reparatum, 1992), 13-15.

demonstrates an interesting parallel to the prevailing trend in other areas.[371] It should be noted all these numbers exclude shipwrecks from the Eastern Empire.



(**Fig. 4.16** Data from Parker 1992:13-15)

Signs of decline in the West manifest themselves in other ways. Settlement archaeology does not need to show the total abandonment of a site to demonstrate decline. While many sites were indeed abandoned completely, many others show a contraction in how they were used. Many Roman villas were modified to fill smaller functions. Slap-dash architecture and make-shift alterations from the fourth and fifth centuries are often seen in once proud villas. Newer structures were usually of wood. Certain parts of sites were abandoned while only sections of them remain occupied. At Horath in the Hunsrück, for instance, the principal building was definitely abandoned with only the annexe buildings being

[371] Andrew Wilson, 'Approaches to Quantifying Roman Trade' in *Quantifying the Roman Economy: Methods and Problems*, eds. Alan Bowman and Andrew Wilson, (Oxford: Oxford University Press, 2009) 219-29 points out that the decline may have more to do with the shift from the use of amphorae to barrels for containing wine. Wilson also treats the second century peak as a statistical anomaly and distributes them among other periods, by using a range of probability for a wreck sinking in a particularly year rather than using Parker's midpoint. This shifts the peak to the first century CE. In the same book, see William Harris, 'A Comment on Andrew Wilson: "Approaches to Quantifying Roman Trade"' 259-260, who points out that neither textual nor material evidence on land leads us to suspect a decline of trade after 100 AD and that the barrel hypothesis seems inadequate, since it is likely many regions of the Roman Empire were suffering deforestation at that time. Harris also points out that metal ingots in shipwrecks follow a contradictory trend from the amphorae first century peak.

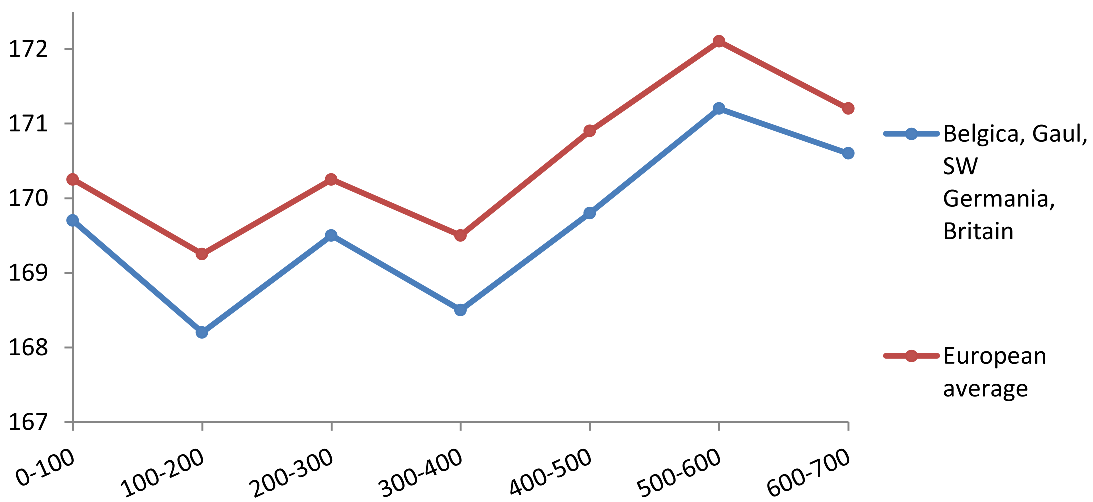
used. The same was the case at Famechon in Picardy. Even more, at Emptinne-Champion in Belgium, only part of the central building was occupied while the rest of the villa and the baths were deserted or even demolished.[372] The degeneration of Roman villas is also demonstrated by certain coarse modifications: cellars were reused as bakeries or filled up with debris, a kitchen was used as a boiler room, Roman living rooms were partly buried or transformed into fire-pits, an ornate gallery full of mosaics was used as a tool workshop, and a high quality building was transformed into a cowshed. Such changes were almost always accompanied by the abandonment of central heating as well as baths, like at Mehring, Newel, Morken, and Emptinne-Champion. Very few sites were created out of nothing, but had been occupied in previous centuries.[373] The utilitarian use of villas may well indicate a form of living that is closer to a subsistence level and it almost certainly indicates a drop in the number of inhabitants at the site. This information shows that even on sites that were not completely abandoned (in contrast to those rural settlements profiled above that were) a drop in population is indicated.

Palaeopathology, or the medical examination of ancient corpses, shows the deterioration of Western villas was matched by the deterioration of people's health. Exhumations from a site at Saint-Martin-de-Fontenay, modern Calvados, in west Gaul show that in the fourth century AD the life expectancy was 31.5 years. This was paralleled by a site at Frénouville, which in the fourth century had a life expectancy of 32. By the sixth century the life expectancy had plummeted to 21.5 years. The sixth century sample shows many cases

[372] P. van Ossel and P. Ouzoulias, 'Rural Settlement Economy in Northern Gaul in the Late Empire: An Overview,' *Journal of Roman Archaeology*, (2000) 13:144-147.
[373] Ossel, 147-148 and Edith Wightman, *Gallia Belgica*, (Berkeley: University of California Press, 1985), 257.

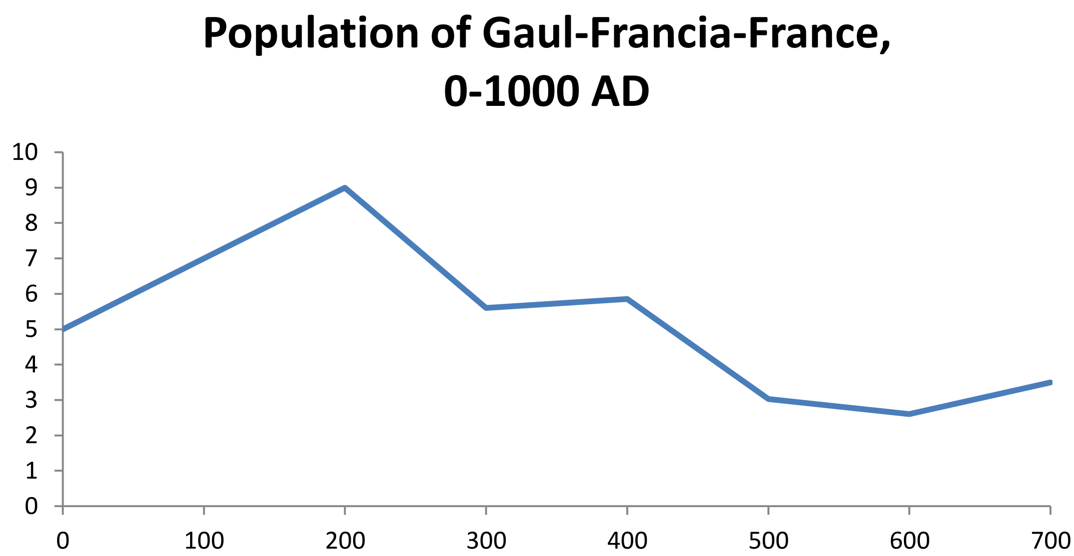
of *cribra orbitalia*, a sign of deficiency in iron, and also *spina bifida* in infants due to the poor diet of pregnant mothers, and a range of other health problems.[374]

A reduced stature might be attributed to poor nutrition caused by population pressure. Contrast this to Gallic populations in the same period (see fig. 4.16). Average heights fall as the population rises in the first and second centuries, fall as the population drops in the third century and stagnates in the fourth, then rise dramatically as depopulation reaches all new population lows.



(**Fig. 4.17** Data from Koepke and Baten 2005, average heights (cm) of men and women from a sample of 9477 heights)

[374] C. Pilet, *et al. La Nécropole de Saint-Martin-de-Fontenay (Calvados): Recherches sur le peuplement de la plaine de Caen du Ve s. avant J.C. au VIIe s. après J.C.*, (Paris: CNRS Editions, 1994), 80-81, 93-96, 123-125, 145.



(**Fig 4.18** Estimates based on Dupaquier 1988, Braudel 1990, Reinhard 1968, and Lewit 1991)

There is also evidence that from 300-700 the overall carrying capacity of agricultural land in the Roman Empire fell significantly. From the third century onward the climate deteriorated until the eighth century. The lowest point was probably in the sixth century, with an average temperature drop of 1.5 degrees Celsius from what was experienced previously.[375] Also in Gaul, one of the regions which experienced the greatest depopulation, it appears there was a shift to spelt as the crop of choice. Spelt does not yield as much as the soft wheat of the early Roman era, but it does possess a great deal of endurance during harsh weather and lasts longer in storage. It is a useful crop in an agricultural system that experiences recurrent famines, where margins for error are slim. In simpler terms, spelt was less likely to fail as a crop, could be stockpiled in case of emergency, and its smaller yields were acceptable for a dwindling population.[376] Additionally, zoologists have estimated the changing size of livestock from excavated remains. Periodisation shows that the average size of cattle after the year 400 fell dramatically from the size reached on Roman farms in previous centuries. To

[375] Jean Pierre Devroey, 'The Economy' in *The Early Middle Ages: Europe 400-1000*, ed. Rosamond Mckitterick, (Oxford: Oxford University Press, 2001), 100.
[376] Jean Pierre Devroey, 'La céréaliculture dans le monde franc' in *L'ambiente vegetale nell' alto medioevo*, (1990) 37:230-240.

sustain a large size of cattle one requires intensive feeding on high quality pasture and plenty of winter fodder.[377] This, it seems, Late Antique farms simply did not possess. Even if one persists in the optimistic argument that the population was not in fact dwindling, the lowered carrying capacity certainly would have brought an end to Western population growth much sooner than the timing of the Principate cycle, conceivably well within the period 350-400. A drop in the carrying capacity would have created a shorter expansion period and a lower population peak before crisis was reached in the Dominate.

c) Western Roman Elite Dynamics

There is indeed little doubt, in face of the evidence, that the Western Roman Empire was entering a 'disintegrative phase' according to Turchin's criteria in the mid-fourth century. This was much earlier than would be expected for a typical cycle like in the East. It is the dynamics of the elite population that help explain why. The key factor in the West's decline may have been elite overproduction. Turchin's demographic structural theory purports that a disproportionate amount of surviving elites next to a reduced common population can complicate an attempt at population recovery. The historical record shows that while the East in the fourth and fifth centuries had low inequality, low elite numbers, and mostly provincial elites, each with a modest amount of wealth, the Western Empire remained throughout the fourth century glutted with vast masses of elites and the hyper-rich. This disparity may well have played a role in the decline of the West as well as the survival of the East. At any rate, it is too glaring a difference to be ignored.

Firstly, we do know that the early fourth century saw an impressive boom in large villa estates in Western Europe, which might indicate the concentration of land into the hands of the

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[377] G. Kron, 'Archaeozoological Evidence for the Productivity of Roman Livestock Farming' *Münstersche Beträge zur antiken Handelsgeschichte* (2002) 21.2: 53-73.

few. The standard explanation, the retreat of the aristocracy to the countryside, is unlikely.[378] We also know something about the immense inequality gap between elite and commoner at this time. The Late Antique historian, Olympiodorus (c.380–? AD), tells us that the richest senators of the West had yearly incomes of four thousand pounds of gold a year, while mid-level senators had around one thousand pounds a year. A commoner, by comparison, could scratch together perhaps five *solidi* in a year's toil, or less than one-fourteenth of a pound of gold.[379] It is interesting to note this disparity of wealth outstrips inequality ratios for the stagflation period of the Principate and also the most extravagant periods of later French or English history.

St. Melania the Younger (c.383–439) came from a foremost senatorial family. She married her cousin, Pinian, around 399. After a miscarriage of two children they found religion, took vows of celibacy, and gave up their worldly possessions. Pinian is said to have held an annual income of 120,000 'pieces' of gold, on top of his wife's income of about the same amount.[380] 'Pieces of gold' has in the past been interpreted as either pounds or *solidi*. If more realistically interpreted as *solidi*, that amounts to 1666 pounds annually, and that roughly equates with what Olympiodorus tells us about the average senatorial income. If multiplied by two, for it appears Melania held a comparable income separate of Pinian, the total income comes to around 3332 pounds of gold annually. This point has been debated among historians. Whether or not Melania and Pinian held a mid-level or a combined upper level senatorial income, it nevertheless appears that when they sold their lands, the sale temporarily caused panic and a

[378] Chavarría and Lewit, 26-29.

[379] For senatorial incomes see Olympiodorus, in Photius, *Bibliotheca*, (New York: Macmillan, 1920), frag. 44. For the estimate for a peasant's income see Allen Ward, Fritz Heichelheim, and Cedric Yeo, *A History of the Roman People*, third edition, (New Jersey, Prentice-Hall, 1999), 446. This astounding inequality ratio and disparity of wealth is also dealt with in Peter Turchin, *War and Peace and War: The Life Cycles of Imperial Nations*, (New York: Pi Press, 2006), 160-161.

[380] Gerontius, *Life of Melania the Younger*, trans. Elizabeth Clark, (Toronto: Edwin Mellen Press, 1984), 15.

fiscal crisis in the property market.[381] Apparently one of the estates sold by Melania in North Africa was larger than the nearest town, Thagaste, birthplace of St. Augustine.[382]

Ammianus Marcellinus (c.325–390), a prominent imperial official and the principal historian of the period, came to Rome from Antioch and was disgusted with the decadence he saw. He writes of a certain number of idle and frivolous senators, who gorged themselves with food at luxurious banquets. They spent large sums of money on exotic dancers and prostitutes. During a food shortage in Rome, all foreigners were expelled from the city, while the senators lobbied for three thousand dancers and ladies of negotiable virtue to remain. The Roman elite gave hugely expensive shows featuring dramatic actors. The elite were given to the habit of conspicuous consumption, and clothed themselves in effete, elaborately designed silk and dyed robes. They lined the streets with gold plated statues of themselves and their ancestors. At the baths, they were attended by as many as fifty servants. Now, it could be that Ammianus was just 'rephrasing late antique commonplaces' but that is precisely the point. They were commonplaces for a reason. Ammianus would hardly need to set up a stock figure to decry elite consumption unless there was something to decry. Furthermore, it is worthwhile to remember that where secular cycles are concerned, it is not so much the specifics of elite behaviour that are important, or the amount of elite wealth in an absolute sense, but the gap between the rich and the poor. And that gap appears to have been very large indeed.

Elites like the extremely influential Petronius Probus, found political power absolutely vital to protect himself and his clan in their many quarrels with hostile families and rival factions. Ammianus describes Probus as a man known for his family, influence and great wealth throughout the world and his possession of multiple estates, some of which he appropriated "unjustly." It was obviously an atmosphere not only of decadence but of intense competition

[381] Wickham, 29.
[382] Gerontius, 21.

amongst the elite population. This is confirmed by the many court intrigues, plots, and violent coups that characterise the entire era. Furthermore, positions like the quaestorship or praetorship, once prestigious and influential offices along the *cursus honorum* had by the fourth century become largely meaningless titles, ceremonially bestowed on the sons of rich men when they came of age. The only real responsibility of the office was to throw a public celebration on its assumption. This confronts one with the notion that the senatorial class was filled with the idle rich, and only a fraction of them stood a chance of gaining any real power.[383] As it happened, the richest Western families, the Anicii, the Caeonii, the Petronii, the Symmachi, and a handful of others, owned the vast bulk of estates throughout the regions of the Western Empire, and played a very dangerous game of faction, which often came at the expense of the state.

It is possible that Western elite competition did not end with the accession of Diocletian. He obtained the imperial purple by overthrowing Carinus in a violent contest. There is no evidence to suggest that a decisive amount of elites perished in the Battle of the Margus (285) which decided the issue. It is true Diocletian reigned through a largely peaceful period. But on closer examination, we see that he ruled for only one year alone, and then forged the Tetrarchy. On the one hand, this may be seen as a more efficient way of administering a sprawling empire, but on the other hand it may be seen as a power-sharing deal among the elites. As it was, the peace brought about by the Tetrarchy did not long outlast the retirement of its founder. Furthermore, Diocletian is known for making the bureaucracy larger and taxing higher than ever before. According to the criteria set forth by Turchin, these are the traits of a stagflation phase, not the dawning of a new expansion.[384] If the period 285–305 was one of

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[383] Ammianus Marcellinus, *Res Gestae Libri*, ed. Antonio Selem, (Torino: UTET, 1973), 14.6.7-19 27.11.1-3, and 28.4.8-18. For an excellent analysis of this source, see John Matthews, *Western Aristocracies and Imperial Court: AD 364-425*, (Oxford: Clarendon Press, 1975), esp. 1-20.

[384] Turchin and Nefedov, *Secular Cycles*, 34.

dubious expansion and tenuous stability in the West, the period 305–325 was characterised by open elite competition and a number of violent clashes. It is noteworthy that the vast majority of such fighting took place in the Western provinces, while the East remained relatively tame. In fact, as table 4.7 shows, this chaotic procession of violent elite competition in the West apparently did not cease until the overthrow of Romulus Augustulus and the 'official' end of the Western Roman Empire in 476.

Sociopolitical Instability in Western Roman Empire, 285-476 AD

Year	*Event*
285	Diocletian beats Carinus in battle, wrests power from him
303-311	Largest and bloodiest persecutions of Christians
305	Diocletian retires, Maximian forced to retire
306	Maxentius'rebellion, Severus is betrayed by his army
309	Maximian fails to overthrow Maxentius and flees to Constantine's court
310	Maximian betrays Constantine, later kills himself; riots in Rome
312	Constantine invades Italy
313	Licinius gains control of East
316-317	Constantine fights Licinius, a truce is declared
320	Licinius persecutes Christians
324	Civil war, battles of Adrianople, Hellespont, Chrysopolis
324-325	Licinius sent to live as private citizen but soon hung
326	Constantine executes his son and wife
340	Constantine II wars with Constans for control of the West and is killed
350	Western ruler Constans is assassinated and usurped 350 by Magnentius
351	Constantius wars with Magnentius, Battle of Mursa Major in Pannonia
353	Battle of Mons Seleucus in South Gaul, Magnentius kills himself
355	Attempted usurpation in Gaul (Claudius Silvanus)
360-361	Julian proclaimed ruler of the West, Constantius dies on the way to fight
361-363	Julian drastically reduces bureaucracy, executes many elites
364	Jovian dies, unclear by murder or natural causes
372	Valentinian I, emperor of West, suppresses usurpation attempt
375	Valentinian II and Gratian have joint rule
383	Gratian assassinated by usurper Magnus Maximus
383-388	Civil war. Theodosius I emperor of the East fights Maximus and restores Valentinian II to the throne
392	Valentinian II is found hanged in his room, Arbogast selects Eugenius as emperor of the West
393-394	Theodosius I elevates his son Honorius as Western emperor instead; war
395-423	Honorius rules West as a puppet of his generals, principally Stilicho till he was ousted in 408; Honorius fights several attempts at usurpation
405-410	Sack of Rome, loss of much of the West
423-425	Joannes usurps Western throne, civil war with the infant Valentinian III
425-433	Valentinian is ruled by the faction of his mother, supplanted by the faction

	of Flavius Aetius.
439	Loss of North Africa
454	Valentinian III treacherously murders Aetius
455	Valentinian III is murdered by Aetius' former faction, Petronius Maximus buys the loyalty of the army and becomes emperor, then is swiftly murdered, a few days later the Vandals take Rome by sea and subject it to a severe four days looting and pillage, much worse than 410, Avitus becomes emperor, Visigoths invade Spain
c.457	Avitus overthrown by a coup of his generals, Majorian becomes emperor
461	Majorian tries to institute reforms that threaten wealth of the nobility, he is killed and his fellow general Ricimer sizes power with senator Libius Severus as his puppet.
465-467	Severus dies, Ricimer rules West without an emperor, then elevates Anthemius as his puppet
472	Anthemius, having defied Ricimer and fought a war against him, is killed, Ricimer elevates another puppet, Olybrius, both men die of apparently natural causes in 472
473	Gundobad, a nephew of Ricimer, elevates Glycenius, an unknown
474	Julius Nepos, Eastern emperor Leo I's choice, deposes Glycenius
475	Nepos overthrown by general Orestes, who appoints the ill-fated Romulus Augustulus
476	Romulus Augustulus is deposed by Odovacer

(**Table 4.8** from Wood 1994)

By contrast to the West, the East had very few hyper-rich in this period and saw a relatively stable chain of succession, after it was divided between Valentinian I and Valens in 364. When Valens was killed at Adrianople in 378 he was replaced by Theodosius I, an immensely powerful emperor, who ruled the East for nearly two decades and even expanded his influence into the West. The reign of Arcadius lasted another decade, 395-408 and the reign of Theodosius II lasted an impressive forty-two years until 450. No successful and permanent coup was staged against an Eastern Emperor until the year 602. That the West should have the monopoly on super-rich elites, and that the East should be extremely prosperous and stable throughout the fourth century and beyond, while the West crumbled and collapsed, is hardly a coincidence.

Sociopolitical Instability (or Lackthereof) in Eastern Roman Empire, 364-476 AD

Year	*Event*
364	Valentinian I and Valens divide Empire for last time, Valens rules the East
365-66	Revolt of Procopius

378	Valens killed at Adrianople
378-395	Theodosius I emperor, intervenes in usurpations in West
395-408	Arcadius emperor, enjoys fairly stable reign
408-450	Theodosius II also enjoys a stable reign, dies in a riding accident
450-457	Marcian, reign is marked by notable prosperity, dies of natural causes
457-474	Leo I, enjoys a fairly stable reign, dies of natural causes
474-6	Instability begins under Zeno

(**Table 4.9** from Wood 1994)

Elite infighting ceased only momentarily after the accession of Diocletian, and throughout the fourth century it grew steadily worse. In times of such socio-political instability, according to Turchin's model, one witnesses not only the usurpations and rebellions that echo down the ages, but also crime and banditry resulting from a weakened central authority. Similarly external invasion becomes more likely and deadly in phases of weakened central authority. Sociopolitical instability also creates war-torn areas where agriculture productivity is destroyed. People flee in the face of armies, some of them dying, others becoming vagrants with a reduced birth rate, others becoming vehicles for transporting diseases from place to place. If instability recurs decade after decade without much relief, commoners deplete their surpluses and even lose the ability to store surpluses for crises that seem likely to happen in the future.

This speaks nothing of the direct losses caused by elite infighting. It is safe to say that the constant stream of usurpations and civil wars that tore through the fourth century West certainly would have taken a toll on the population. Also the tremendous tax burden on the peasantry and the concentration of landholdings in the hands of the privileged few would have exacerbated this problem. In fact, the fourth century West witnessed a scale of inequality that was quite large. This gross imbalance would have been highly detrimental to social cohesion, to speak nothing of the direct casualties of elite violence. Combined with a lowered carrying capacity it could quite conceivably have led to decline and eventually disaster. In sum, the traits of the fourth century seem to resemble more the symptoms of a crisis or depression phase rather than one of expansion. By mid-century, these symptoms had taken the promising demographic recovery of the early fourth century and throttled the life out of it. As we know from chapter three, the fifth century brought invasion, the sixth century plague, and the culmination of all these disasters was a Tasmanian Effect that reduced the collective Western knowledge of Europe and either eliminated or simplified technology. It remained for succeeding centuries to make up the difference.

d) Reflection

As hypothesised in chapter 3, this particular cycle may have been so severe that not only potential innovators declined, but so did collective learning. This may have been a result of the numerous waves of population decline that struck Western Europe: from continued elite infighting, to the Germanic invasions, to the Justinianic Plague. It may also have something to do with the sparse nature of the Roman West in comparison to the East. In this period, Western Europe was a backwater. It was only in the High Middle Ages that the gravity of population and economics slowly began to shift from the Mediterranean to the Atlantic seaboard. This was due to improvements in agriculture and land clearance that we shall survey in the next section. One other attribute of this cycle is that it significantly increased the lead of populous and relatively technologically advanced civilisations in the Middle East and East Asia. This gap was only to widen in Song dynasty China, as we shall see in chapter 5, and was not to be closed until the Industrial Revolution.

After this cycle, collective learning had to begin some of its work all over again, with potential innovators either generating new innovations or trying to recover some of the knowledge of the past. Like a mass extinction event, slowly the cultural niches needed to be filled with new successful variations. The Dominate cycle is an example of how the population crisis and sociopolitical instability, when severe, can actually reduce collective learning and set back the rise of complexity that gradually seems to result from cultural evolution and the Darwinian algorithm. The generation of cultural variations depends upon the numbers of potential innovators to produce them, and also the ability of a species to accumulate more knowledge with each passing generation than is lost by the next. In periods of extreme crisis, this ability can be compromised. We then observe a catastrophe that is no less devastating to cultural evolution than the Permian or Cretaceous extinctions were to biotic life, as surveyed in chapter 3.

Our final case study in the next chapter takes a closer look at France, the first region of the world to be subjected to analysis within *annaliste* demographic-based theories. By and large, the connection between population dynamics and the rise and fall of sociopolitical instability prevailed in France in the medieval and early modern periods. There were a few subtle variations, however, particularly in what I term the 'Malthusian ricochet' of the sixteenth and seventeenth centuries. As such, France is deserving of in-depth analysis to further refine the theory.

Chapter Five: Ladurie Revisited

Our next case study revisits Le Roy Ladurie's old stomping ground of France in the conventional *longue durée* of the high medieval and early modern period. It begins c.1000 and explores the dramatic growth of the French population and decent living conditions until 1300. After that a demographic crisis set in, reducing the population even before the onset of the Black Death. We see the same phenomenon in England. The famines of 1315 and afterward mark a downturn of the cycle that the Black Death later exacerbated. The population was then held low during a period of sociopolitical instability, which occurred in two waves between 1320-1360 and 1380-1450. After both civil infighting and the external war with the English were removed in the mid-fifteenth century, the population began to rebound. The French enjoyed a standard of living unsurpassed in French history until the industrial revolution. Population growth increased to the high watermark of 1300 again by 1550, after which France experienced another population collapse followed by three waves of sociopolitical instability and violence. Notable is that each time the population decreased, then recovered to the carrying capacity, and then declined again provoking another round of elite infighting. It is possible this sort of ripple effect, rather than a more dramatic fluctuation may be typical of cases where neither an external invasion nor devastating pandemic intervenes. Instead the French population lingered at the carrying capacity, suffering smaller waves of ecological and manmade crisis until the French carrying capacity was raised by the agricultural innovations of the eighteenth century.

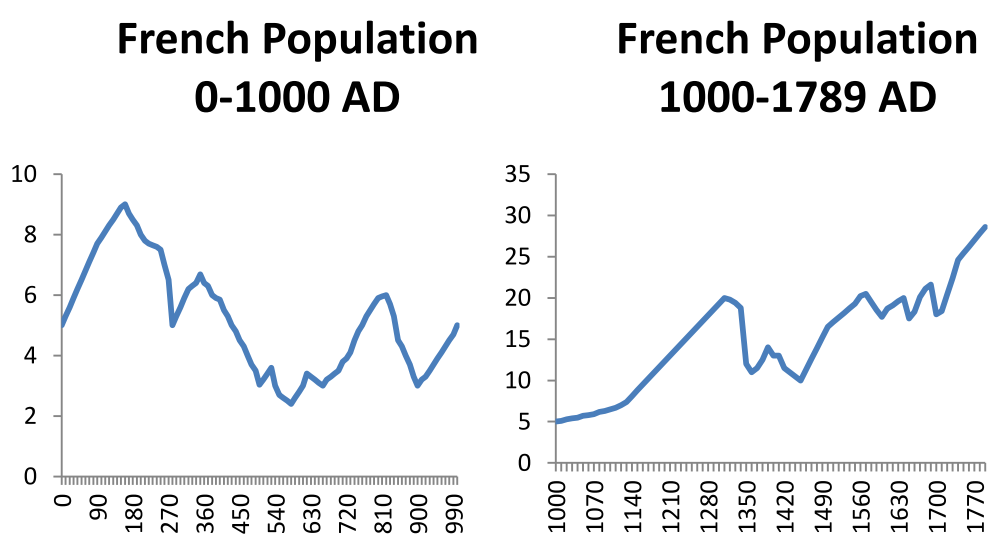
I. Summary of Case Study & Divergences from Turchin

Peter Turchin has also surveyed the same period although his account is less complete in stats and details, and lacks an examination of demographic growth prior to 1150, which he erroneously believes is the start of the new cycle. Like with the English Anarchy, he confuses external warfare and rival dynastic ambitions between the Norman, Angevin, and Capetian states as internal. He also does not adequately account for the Hundred Years War as an external war over perennial dynastic quarrels and therefore an exogenous variable that could have occurred at any point in the population cycle. Instead he classifies the Hundred Years War as an entirely internal conflict because the monarchs of France and England (two very distinct states by this time) both had claims to the throne of France. Yet evidence of internal infighting can be given for France without shoe-horning in the entire Hundred Years War. Finally, Turchin stops short of the reign of Louis XIV and the demographic and sociopolitical implications of that part of the cycle simply because he has subscribed to the belief that Louis XIV's reign was prosperous and glittering even after the massive downturns and shocks of the 1690s and 1700s. But evidence goes to show this was not exactly the case. All these points will be explored in their proper place. The conclusion of this section is that medieval and early modern France endured two major s-curves in which population decline was followed by increased elite competition and a manmade crisis that either reduced elite numbers to a low level, or only slightly alleviated the situation before another spell of population decline and instability intervened. By taking into account the importance of increasing elite competition this section hopes to add to and enrich the accounts of demographic cycles developed by historians of the Annales school.

II. Medieval France

a) Carolingian-Capetian Transition

This section will survey the improvement of agricultural techniques and the clearance of land in France that raised the carrying capacity from about 7 or 8 million in the Carolingian period to 20 million by 1300 AD. First, we will examine a bit of background in the period following the Tasmanian Effect in Gaul. In the aftermath of the Justinianic Plague, one would have expected that the population would rebound. It did not. The post-plague population of Gaul increased slightly but two spats of elite infighting in 500s and then 600s held sustained population recovery down. Then at the end of the 600s the population shot up rapidly, and by the time of Charles Martel and the Battle of Poitiers, the Frankish kingdom had entered a period of growing prosperity that is reflected in the most recent and thorough of economic studies.[385] It lasted throughout the reign of Charlemagne. What fragments of documentation there are from the mid-800s, like the polyptyques (estate inventories of people and property), show us that there appears to have been a population depression and low birth rate in the ninth and tenth centuries, which is not surprising given the sustained period of elite infighting and state collapse following the death of Louis the Pious in 840.[386] This speaks nothing of the possible impact of external predations of the Vikings. It would seem the magnificent reign of Charlemagne, so full of prosperity, came at the end of an expansion cycle. Afterward, for approximately 150 years, his empire was fragmented into small elite holdings.



(**Fig. 5.1** Using data from Dupaquier 1988, Braudel 1990, Reinhard 1968, Lewit 1991, et al.)

[385] The work of Michael McCormick has banished the old thesis that the Carolingian period was one of backwardness and subsistence, *Origins of the European Economy: Communications and Commerce*, (Cambridge: Cambridge University Press, 2001).

[386] Marcel Reinhard, André Armengaud, and Jacques Dupâquier, *Histoire générale de la population mondaile*. (Paris: Éditions Montchrestien, 1968), 65.

The High Medieval cycle began with a period of uninhibited growth c.900-1000, due to unprecedented land clearance and the rise of the carrying capacity. Whereas in Carolingian times poor quality tools did not make it profitable for the average peasant to venture beyond open easily-worked soils, we do know from the 900s onward there was an expansion into territories hitherto unused. In the documents from the tenth century onward we see a multiplication of terms like 'assarts' and 'open country', and a growing number of references to newly conquered land.[387] This may have had something to do with the wider proliferation of the heavy plough, the sickle, the threshing flail, horseshoes and better harnesses for horses and oxen, between 900 and 1100.[388] A process of land clearance was underway at the expense of forests, marshes, and even the sea. Land clearance dramatically raised the carrying capacity, which enabled an increase in the population. It is estimated that out of 26 million ha of forest-cover in France c.1000, one half was destroyed by 1300, 150,000 ha along the Atlantic coastline alone.[389] Most of this work was done between 1100 and 1250 when land clearances really began to pick up pace. Charters of settlement were drafted to attract settlers, lords made public vows to open up new lands, these lands were sometimes given as gifts to settlers (*hôtes*), contracts were drawn up for crop-sharing payments (*champarts*), and new dues and tithes were applied to newly cleared parts of estates.[390] Of this newly cleared land, it is estimated that between 40-100% was brought into production.[391] Also the average yield of each crop increased. Carolingian grain yields had been 1.5-2.5:1 for every seed sown. It appears the average yield increased in northern France from 3-4:1 before the twelfth century

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[387] Georges Duby, *Rural Economy and Country Life in the Medieval West*, trans. Cynthia Postan. (London: Edward Arnold, 1968), 67.
[388] Wilhelm Abel, *Agricultural Fluctuations in Europe: From the Thirteenth to the Twentieth Centuries*, 3rd Edition, trans. Olive Ordish, (New York: St. Martin's Press, 1978), 24.
[389] Fernand Braudel, *The Identity of France: People and Production*, trans. Sian Reynolds, (Glasgow: Collins, 1990), 140. Elisabeth Carpentier and Michel Le Mené, *La France du XIe au XVe siècle: population, société, économie,* (Paris: Presses Universitaires de France, 1996), 158.
[390] Duby, 68-69.
[391] Carpentier and Le Mené, 158.

and 4-5:1 toward 1180, with yields around Picardy approaching 6-8:1.[392] This, of course, is much less than modern yields of 200 or 300:1, or ancient yields of 20:1 or even 70:1 for barley in alluvial agriculture of the Nile or Mesopotamia, but it afforded France a carrying capacity higher than in Roman times: from a ceiling of 9 million to one of 20 million. In most of Languedoïl, the populous region of northern France that lies roughly between the Channel and the Loire, the yields of the twelfth to fourteenth century could be as high as 10:1, but an average of 3-4 or even 5:1 was much more common.[393]

Only in Flanders did they learn to grow legumes in a manner more closely resembling those methods of the Agrarian Revolution, allowing cattle to graze and fertilise fields and avoid leaving the fields fallow.[394] This point will become significant later on for its massive effect in raising the French carrying capacity from 20 million to 30 million in the eighteenth century. But in northern France in the medieval and much of the Early Modern periods, the three-crop rotation system was the norm: one of wheat, one of oats and barley, one fallow. In the south, which generally had less fertile soils, the two-crop alternation was between wheat and fallow, which was even less efficient. Nevertheless, in general the improvement of high medieval farming translates into a 40% increase in the net yield from the Carolingian period to the Capetian.[395]

b) Population Growth in Capetian France (c.1000-1315 AD)

The paucity of sources prior to 1100 makes it impossible to figure out precisely when land clearance began in France. Settlement remained haphazard and discontinuous during the tenth and eleventh centuries. We do know that in southern Burgundy there are indications of

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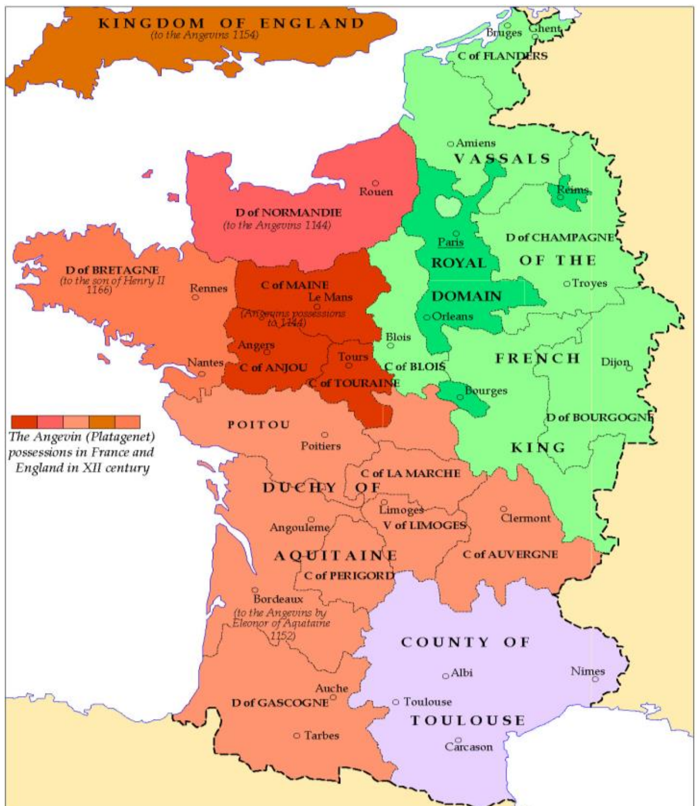
[392] Carpentier and Le Mené, 160-161.
[393] William Jordan, *The Great Famine: Northern Europe in the Early Fourteenth Century*, (Princeton: Princeton University Press, 1996), 25.
[394] Pierre Charbonnier, 'Economy and Society of France in the Later Middle Ages: On the Eve of Crisis' in *France in the Later Middle Ages: 1200-1500*, ed. David Potter, (Oxford: Oxford University Press, 2002), 51.
[395] Carpentier and Le Mené, 161.

forest clearing around 950, that new villages were appearing in the Mâconnais by the mid-eleventh century, and that forty-three new villages appear in Normandy in the eleventh century alone.[396] For the first time, around the year 1000, cities appeared in Western Europe with populations larger than 20,000 people.[397] The number of châteaux in Narbonne province between 950 and 1000 increased from 17 to 44, and the eleventh century châteaux building in Charente increased by a factor of ten.[398] Charente was also the site of a number of important land clearances 1050-1100.[399] In 1065, in the Ile-de-France, the abbey of St. Denis was desperate for labourers to help with land clearances, even if they were escaped criminals or serfs.[400] The number of villages in the Moselle region increased by 150 in the tenth century, 100 in the eleventh, 240 in the twelfth, and 360 during the peak period of growth in the thirteenth.[401] It is distinctly possible that between 1050 and 1100 alone the population of France, whose borders are discussed below, increased by one million people.[402] So although prior to 1100 the clearance of land was still haphazard it is clear that, in the tenth and eleventh centuries, population growth was underway. The reason why we have such a long expansion phase, that is, c.1000-1300, is that a long slow swelling of the population was occurring where technology and vast land clearances were raising the carrying capacity. This compares to the recovery of 1450-1560, where land was repopulated rather than having its age-old forests gradually and diligently cleared, as we shall see later.

‘France’ at the beginning of the expansion cycle was a geographical term only. It was no more a nation than the equator. It was not one state, but a splintered collection of many

[396] Duby, 69 & 80.
[397] J.C. Russell, ‘Population in Europe 500-1500’ in *The Fontana Economic History of Europe*, ed. Carlo Cipolla, (London: Collins, 1969), 23.
[398] Carpentier and Le Mené, 34-35.
[399] Jacques Dupâquier et al. *Histoire de la Population Française*, 4 vols, (Paris: Presses Universitaires de France, 1988), 1:223.
[400] Braudel, 139.
[401] Marcel Reinhard, André Armengaud, and Jacques Dupâquier, *Histoire générale de la population mondaile*, (Paris: Éditions Montchrestien, 1968), 64.
[402] Reinhard et al, 69.

competing ones: the duchies of Normandy, Brittany, Aquitaine, Gascony, Burgundy, and the counties of Flanders, Anjou, Blois, Nevers, Troyes, Gatinais, Picardy, Vermandois, Beauvais, Maine, Touraine, Poitou, Angoulême, Toulouse, Languedoc, the viscounty of Bourges, the kingdom of Navarre, the ecclesiastical lands of Laon, Langres, Reims, Châlons, among many others, not to mention the small sliver of land around Paris controlled by the Capetians themselves.



(**Fig 5.2** Map of 12th century French states. WikiCommons. Retrieved Jan 5 2013: http://commons.wikimedia.org/wiki/File:France_1154_Eng.jpg)

Within those polities, the spread of feudalism and elite overproduction had produced a constant state of infighting throughout the period of 850-1000 AD. Eventually the duke of Normandy and later the French king, among others, were able to gain control over the petty lords within their own realms, but until this process was complete, it was impossible for any one of the magnates of France to consolidate power over the others. Even then, in order to expand, each polity had to reckon with the others through the fortunes of external war. Thus although the year 1000 inaugurates a period of growth in the population, we are not looking at an expansion period for France as a whole, but an expansion period for a number of independent fiefdoms within France.

They butted up against each other, competed for dominance, and only paid lip-service to the sovereignty of the French king. Each constituted their own state. We must not in hindsight, as Turchin's treatment does, knowing of the final victory of the magnate who happened to possess the title of French king, assign a lesser status to the other noble overlords who held a very good chance of achieving hegemony in this period. France could have easily fallen under a Norman dominated polity, or one centred on the county of Anjou.[403] Arguably, these two other states were more powerful than the Capetians around Paris. In the period after 1000, it would appear that Normandy was blessed by extremely vigorous growth, rising to 307,689 hearths, making the Norman duchy form a huge chunk of the total French population, on the order of about a third of the whole.[404] There the 'integrative trend' of population growth seems to have begun early.

By 1100, the draining of marshes in Flanders was underway, 46 new villages sprang up in Normandy in the 1100s and 47 more in the 1200s, the forests of Briard were cleared for a new string of villages 1150-1225, in 1180 the count of Anjou was creating embankments on the Loire to protect newly settled villages from flooding, and settlement was also extremely aggressive in the Paris basin where cereal pollen and vegetable residues increase rapidly after in the twelfth century.[405] Picardy between 1180 and 1250 redeemed territory amounting to 1500-1900 square kilometres, or 15-19% of the total area of the countryside, and the same thing happened in Chartres from 1100-1262, with small localised clearing persisting until 1300. In Poitou and elsewhere in western France, it would appear that clearance reached fever

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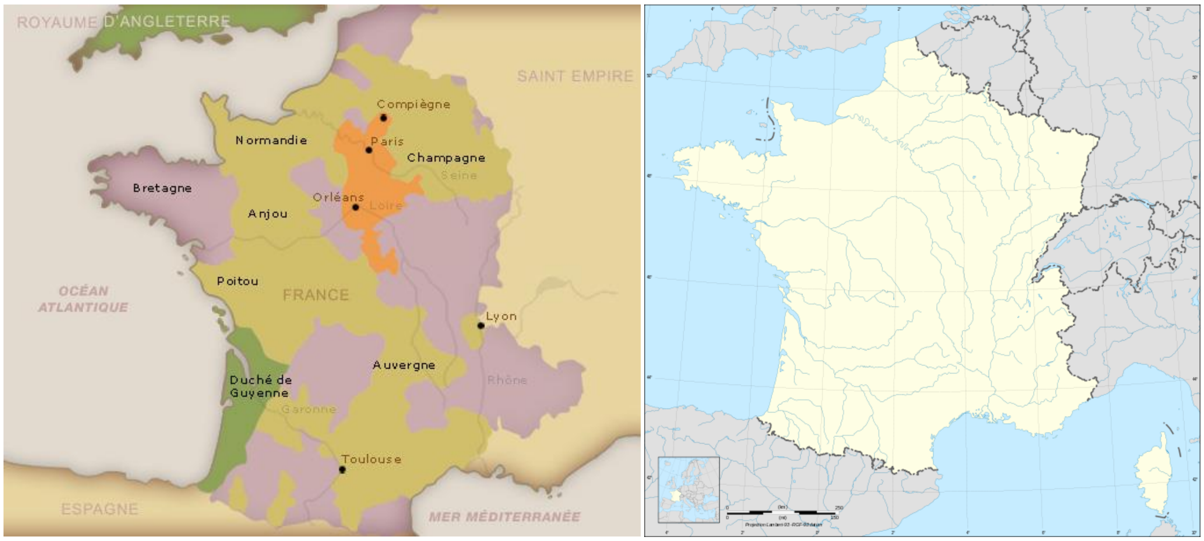
[403] Unfortunately Peter Turchin's treatment falls into this trap. Turchin and Nefedov, 111.
[404] Dupâquier et al., 1:242.
[405] Duby, 69-70 & 80-81.

pitch around 1150 and ended by 1300. In Bas-Languedoc we see population growth 1070-1170, with some important clearances and the draining of marshes there.[406] While the growth in France during this time was general, in Normandy, in Anjou, and in the holdings of the French king, this was the same period where the Capetian house began to gain real ground against its enemies via the fortunes of external war. Philip II 'Auguste' (r.1180-1223) expanded his territory remarkably and absorbed the mighty duchy of Normandy. At this point the Capetians were the strongest force in France.

By 1100, the population of France was 6 million. This had grown to around 20 million in 1328.[407] This latter figure is fairly well supported. It comes from a general survey of the population in 1328 called the *État de Paroisses et des Feux*. It includes the number of parishes and number of hearths per *bailliage*. The densest region in 1328 was the Ile-de-France, with 14-22 households per square kilometre followed by Normandy and Picardy falling in the 12-14 range. Champagne and Burgundy had 8-10, Orléans, Berry, and Nevers, 7-10, the mouth of the Gironde had a cluster of 10 households per square kilometre, while most of the south was very sparsely settled at 5-7.[408] The area of the survey covers about 16 million people within the borders directly administered by the crown. The estimate of Ferdinand Lot for France within its present borders rests at approximately 20 million and perhaps as much as 21.5 million; Paris in the *État* gives 61,000 hearths or around 200,000 inhabitants, making it the largest city in Europe in the fourteenth century.[409] By way of comparison, the population of France before the Black Death was roughly the same magnitude as it was in the seventeenth century, and it was not really surpassed until the Enlightenment and Industrial Revolution.[410] I

[406] Dupâquier et al., 1:222-225.
[407] Braudel, 137.
[408] Dupâquier et al., 1:262.
[409] Charbonnier, 'Eve of Crisis', 54-55.
[410] Emmanuel Le Roy Ladurie and Michel Morineau, *Histoire économique et sociale de la France, de 1450 à 1660*, (Paris: Presses Universitaires, 1977), 485.

shall use the figures for the *limites actuelles*, or the modern borders of France. This makes a difference between the 16 million who existed within the 1328 borders and the 20 million who existed within the modern ones. In 1328 the officials of the royal treasury counted nearly 2,470,000 households.[411]



(**Fig 5.3** France in 1328 next to the so-called '*limites actuelles*'. Left, Atlas Historique. Retrieved Jan 5 2013: http://rea.ccdmd.qc.ca/ri/atlas/medias/cartes/France_1180_1328.jpg Right, WikiCommons. Retrieved Jan 5 2013: http://commons.wikimedia.org/wiki/File:France_map_Lambert-93_with_rivers-blank.svg)

The figure of 16 million does not include the lands of territorial princes who owed fealty to the king but nevertheless whom he did not tax directly. Just be aware that the 'France' I refer to is not just the France that happened to be directly ruled by the Parisian king, but the *limites actuelles* with which most French demographic historians work and which contained approximately 20 million people in 1328. Most demographic estimates of historians deal with the latter figure and it is easier to do so, especially since France's frontiers changed so frequently. What is more the Gallic and Carolingian estimates of ancient and early medieval sources are also outfitted for the *limites actuelles* rather than the borders of 1328. It is better just to stick to the figure of 20 million so reports of population growth and decline deal with roughly the same amount of land area. This number also corresponds to the carrying

[411] Jonathan Sumption, *The Hundred Years War: Trial by Battle*, (Philadelphia: University of Pennsylvania Press, 1991), 10.

capacity that seems to have prevailed within the *limites actuelles* of France from 1300 right up to the eighteenth century. It may seem rather counter-intuitive, but the changes are mild enough and the estimates of demographic historians on these borders so ridiculously abundant that the decision to stay with the *limites actuelles* is the right one for clarity here.

Given Charbonnier's estimate of an average 90% of people toiling at agriculture is safe to say that about 5.4 million of 6 million within the *limites actuelles* in 1100 and 18 million of 20 million in 1300 toiled at agriculture.[412] The proportion of 90% more or less stands for the entire period up to the French Revolution, maybe falling to 80% in the eighteenth century. What distinguished the medieval period was that a greater proportion of food was self-produced, very little was produced for the market in comparison to the eighteenth or even sixteenth century. Wine is the exception, where many farmers produced wine and bought their food. There was also a market for expensive items like spices, salt (to preserve meat), and fresh fish. Given the preponderance of bread in the diet, about 1 kg a day being the norm, 80-90% of farmland was ploughed for this purpose. In good soils, crop yields were as good in 1200-1300 as in 1700.

However, the slightest climatic or military disturbance ruined crops and brought starvation. In periods of overpopulation and low wages and high food prices this provoked famine. Butter was used in the upland regions, nut oil in northern France, and olive oil in the south. The middling peasant got wheat or rye or a combo called *méteil*. The more impoverished had to make do with barley and oats. In times of prosperity, like 1100-1250, more people got their hands on wheat. In times of overpopulation, the barley and oats previously deemed only good enough for sheep dogs began to be consumed by increasing numbers of people. Two litres of watery wine per day was staple for most Frenchmen, while

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[412] Charbonnier, 'Eve of Crisis', 51.

meat was also consumed by most commoners 1100-1300. When it came to malnutrition in the High Medieval expansion phase, religion, not scarcity, was to blame. Catholic Christianity banned meat on Friday and Saturday, during Lent, and on the eve of feast days. In all, this amounted to a whopping 150 days a year. One could compensate with fish, but in non-coastal areas this was three times as expensive as pork, beef, mutton, and chicken. For protein one often made do with salted meats or peas.[413]

c) Thirteenth Century Stagnation

We know that wheat prices accentuated the growth and prosperity of the peasantry for the early and mid-1200s. Wheat prices remained low in France for most of the thirteenth century at about 20-27 grams of silver per 100 kg. Then around 1280 they began a steady increase to 40 or even 50 grams of silver, something catastrophic for the peasantry's standard of living by the close of the century.[414] By 1282, a labourer's income in Paris was insufficient to support a family of four.[415] Then prices embarked on the series of catastrophic waves of price hikes that characterise the fourteenth century (see below). Famines, unheard of in the preceding period, return in the 1300s with a vengeance. The reader will note from the graphs below that population decline coincides with a spike in wheat prices, with wages barely keeping pace: c.1320, c.1340, c.1420. A mild population recovery occurs between 1380 and 1400, when a semblance of sociopolitical stability was achieved. Factionalism and elite infighting resumed and was exacerbated by external invasion. It is not until c.1450 that wages remain high and prices remain low facilitating a sustained population growth.

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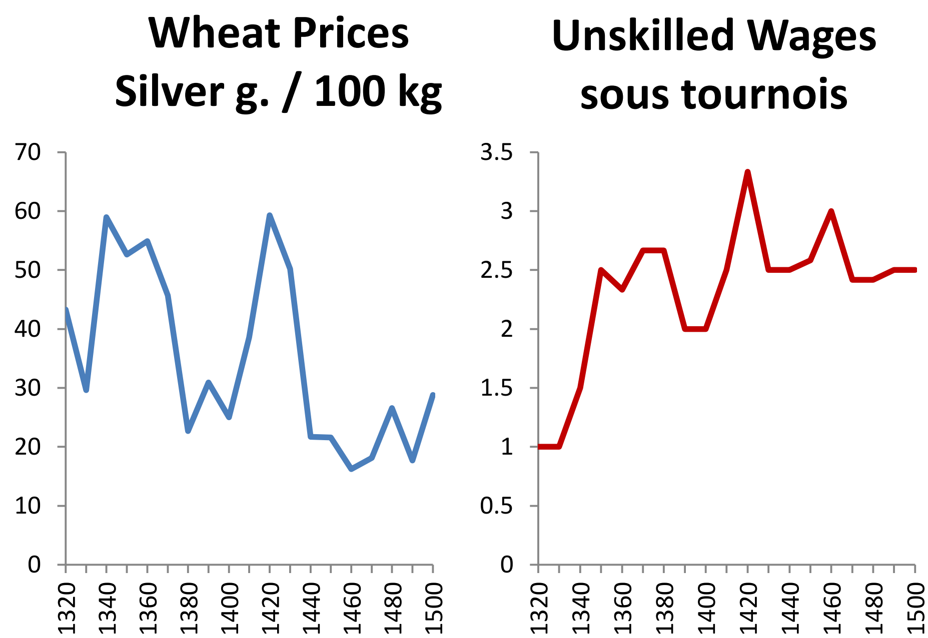
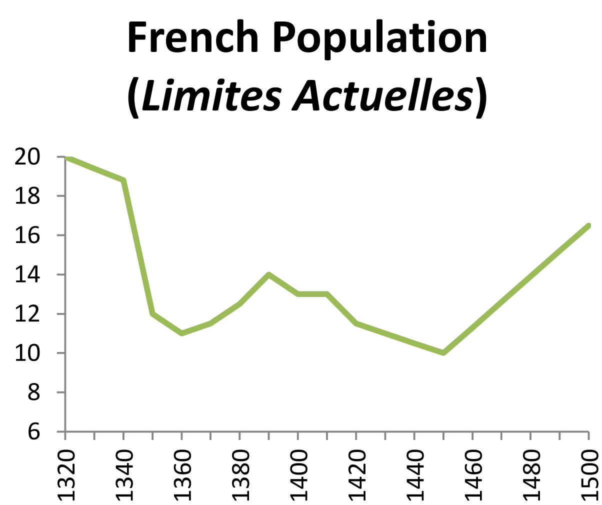
[413] Charbonnier, 'Eve of Crisis', 49-51.
[414] Abel 1978, 304-305.
[415] Farmer, 21.



(**Fig 5.4** Abel 1978, 304-305, average wheat price per decade: g of silver/100kg wheat; Bois 1984, 429-434, wages of building workers in Rouen in *sous tournois*)



(**Fig. 5.5** Turchin 2009, 113, after Dupâquier 1988 & Braudel 1990)

The High Medieval expansion phase is (c.1000-1300) a point where collective learning can contribute to the existing historiography. It has been asserted by some medievalists that the Black Death may have contributed to technological advances in the Renaissance, because depopulation spurred the invention of labour saving technology. But one need only look to the immense labour saving technological advancements that occurred prior to the Black Death in wool and silk manufacture. These occurred in the thirteenth and early fourteenth centuries and really mark the most significant advances in textile manufacture until the Industrial Revolution. The same may be said of the advancements in agriculture in Flanders: legumes, better field systems, the Hainault scythe, which are all pre-Plague. In war, innovations in cannon and gunpowder claim their origins to the thirteenth century.[416] So the idea that only depopulation spurs technological advancement is, in this instance at least, an erroneous one. Where collective learning contributes to the existing historiography is to explain why these advancements occurred in the thirteenth and fourteenth centuries. Everything else being equal (e.g. the efficiency of communications systems and exchange networks) more people means more ideas, more ideas mean more innovations. Collective learning makes population growth rather than population scarcity responsible for technological advancements and here is an example that fits better with the historiography.

The population growth began to slow down in the mid-1200s, which coincides with the time that the land clearances were coming to an end, and there is considerable evidence that the population reached the carrying capacity by the fourteenth century *prior to the Black Death*. For instance, the village of Maillane in Provence had 100 hearths in 1250, but only 80 in 1319 after the Great Famine.[417] The return of overpopulation in the fourteenth century resulted in severe famines, absent in the Great Leap Forward, and reached fever pitch with the famines of 1315-1317. After about 1230, it would appear the vast bulk of land clearing had come to an end. Clearances persisted in places where the population was sparse, but in these cases it was more often the single agriculturalist who was trying his luck on the frontier, not a mass migration of settlers.[418] Land clearances stopped around Paris and Chartres in 1230, in Picardy 1240, in Haute-Provence, Chartrain, Poitou in 1250, Normandy 1260, Artois and the

[416] Both sides of the issue are admirably summarised by Samuel Cohn Jr., ‘Introduction’ in David Herlihy, *The Black Death and the Transformation of the West*, (Cambridge: Harvard University Press, 1997), 10-12.
[417] Duby, 300.
[418] Duby, 81.

Sologne in 1270, in Limousin, Bordelais, and the Pyrenees in 1290, in Dauphiné and Brie 1300, and in the Forez, Brittany, and Anjou in 1320. Only in the southwest did clearances continue until 1340.[419] Between 1250 and 1300 the number of households in Provence doubled. In the nine villages in the viguerie of Nice, there were 440 households in 1263 and 722 in 1315.[420] From 1240-1328, Paris grew from an estimated 160,000 to 210,000 people.[421] In most regions, like Picardy, population growth slowed. In eastern Normandy growth had already begun to stagnate, increasing by only 10% 1240-1314.[422] The seeds of decline were sown in the moment of France's prosperity. The land clearances had suddenly and remarkably expanded the French population twofold from its high Roman peak and fourfold from its average size. Then the clearances suddenly stopped. What had made the French expansion of the population possible was no more. The rug had been pulled from under their feet. There was no more land, only more adults having children, more families multiplying in number, more communities becoming more ponderous and overstretched. A large, unwieldy, and rapidly expanding population was speeding toward a Malthusian wall. And soon it would crash.

It is distinctly possible that the French population was already declining in some areas. In the Marne and Vière regions of Champagne around 1275, numbers appear to be shrinking.[423] Catastrophic shortages returned after 1250 coinciding with the end of reclamation, and the population began to suffer starvation more cruel than anything since Carolingian times. There was repeated division of holdings among heirs resulting in farms that could not support a family of peasants. The peasant population of France in 1300 appears in some districts to exceed that of the eighteenth century with a very high density indeed: like in

[419] Duby, 86-87 and Carpentier and Le Mené, 330-331 and Braudel, 155.
[420] Duby, 119.
[421] Sharon Farmer, *Surviving Poverty in Medieval Paris*, (Ithaca: Cornell University Press, 2002), 17.
[422] Carpentier and Le Mené, 314.
[423] Carpentier and Le Mené, 313.

the Ile-de-France, Senlis, and Valois. Less populated areas were Limousin, Bourges, and the Auvergne mountains.[424] The centre and south of France appears to have enjoyed a slightly extended period of growth. Provence and Dauphiné saw modest growth 1265-1340, the Midi underwent even more dramatic growth up to 1340, Carcassonne enjoyed annual growth rates of 0.6-0.7%, and Bas-Languedoc 0.8%. Most remarkably Béziers flourished with an annual growth rate exceeding 1.4%.[425]

Due to overpopulation, poverty was on the rise in both rural and urban areas. In the tax assessment of 1292, less than 25% of the households of Paris were liable for taxation. While some of the remaining numbers were nobles, clerics, and students, most of the remaining 75% were sturdy wage-earners, devoid of property, who did not even possess the modest amount of 12 *deniers* to qualify for the tax.[426] Fragmentation of rural holdings also occurred as is predicted by the theory of secular cycles. 75% of peasants in Dauphiné had less than two hectares of land and 60% in the vicinity of Hainault had less than one hectare.[427] A vast mass of peasants found themselves well below the subsistence level and counterbalanced the disparity with wage labour. Naturally, the influx of labourers in to the rural and urban markets drove wages down as prices continued to skyrocket – particularly in times of crop failure. Human overpopulation does not, in itself, provoke agricultural shortages. Poor harvests occur in agrarian civilisations no matter what the state of the population is; shortages are dependent on a myriad of other factors: climate, supply methods, infrastructure, and distribution. Overpopulation does, however, make such shortages unmanageable when they do occur. In such times, there are vast numbers of people already living at the margins. It is the factor that turns the periodic crop failure into a widespread famine. Overpopulation also encourages

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[424] Duby, 123-125.
[425] Carpentier and Le Mené, 314-315.
[426] Farmer, 32.
[427] Carpentier and Le Mené, 328.

harmful agricultural practices such as over-farming of the land, which makes poor harvests more likely; and semi-starvation increases the numbers who may succumb to otherwise survivable diseases. In periods where rapid population growth remains below the carrying capacity, famine is not a problem. That is why in the thirteenth century famines had all but disappeared. They returned with a vengeance in the fourteenth. The result was that massive waves of death swept across France even before the arrival of the Black Death. There is no question that even before the advent of this exogenous variable, France had already reached its peak carrying capacity and entered into a crisis phase of starvation and population decline.[428]

d) Population Decline before the Black Death

At the time, there was no substitute for wheat and barley, like buckwheat or potatoes, whereas in the eighteenth century these had become a safety net for the French population, effectively raising the carrying capacity.[429] The first deadly famine struck in 1302, in 1305 there was a food shortage in Paris, in 1309 there was a general shortage throughout France. A few years prior in 1306 the rise in prices caused Philip the Fair to debase the coinage so that propertied Parisians were suddenly paying rents in the new currency at triple the rate.[430] There was a riot in Paris in 1307 as a result. In 1314 there was a bad harvest, in 1315 bad weather and yet another bad harvest. The output of the priory of Saint-Arnoul north of Paris suggests a decline of output of about 50% the average yield 1315-17. The bad weather also destroyed most wine crops too, and it was also a heavy year for livestock diseases, and cattle literally died in droves.[431] The result of multiple crop failures was famine, which ensued and lasted until 1317. The Great Famine surpassed all years of dearth since the ninth century, afflicting

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[428] The Black Death is both by Turchin and myself treated as exogenous because the pathogen can strike at overpopulated and underpopulated regions alike. There is nothing in the population cycle that made the Black death a certainty, though certainly such a disease can be extremely devastating once it enters a region that is overpopulated and already suffering malnutrition.

[429] Pierre Charbonnier, 'Society and the Economy: The Crisis and its Aftermath' in *France in the Later Middle Ages: 1200-1500*, ed. David Potter, (Oxford: Oxford University Press, 2002), 117.

[430] Farmer, 35.

[431] Jordan, 33-35.

England, France, Scandinavia, Holland, the Rhineland, Westphalia, beyond Germany to as far as Poland and part of Russia.[432] All this gave rise to disease, crime, and even cannibalism.[433] In 1315, countless people lay dead in the streets of Paris.[434] Between May and August 1316, 10% of the population of Ypres died of starvation.[435] There was also a noticeable rise in socio-political instability. In 1320, a band of *pastoureaux* raided the countryside, releasing prisoners and killing Jews. In 1321, there was a massacre of lepers whom the superstitious believed to be responsible for the deplorable conditions of the times.[436] The Great Famine struck worst at those regions that had stopped clearances at the earliest date. Various famines erupted in regions of France throughout the 1320s. It is no surprise that those regions that had stopped clearances between 1230 and 1270 should feel the harshest pinch, since problems of starvation and supply are worst in provinces that are the most overpopulated. From 1335, general conditions of dearth spread south and by 1348 all France was engulfed in one form of shortage or another.[437] Severe localised famines struck the south, like the one in 1340 in Provence, or the one in 1348 in the Lyonnais.[438] In Languedoc, between 1302 and 1348, there were 20 years of food scarcity against 27 where supply was enough.[439] The archives of Toulouse count seven catastrophic famines 1334-1450.[440]

The result of population growth is often a growth in the incomes of landowners. Not only do increased numbers mean more households paying rent, it also means that in places where contracts were not entrenched, landowners can take advantage of the shortage of rents and charge more. Overpopulation also means that supply is high and demand is low for labour,

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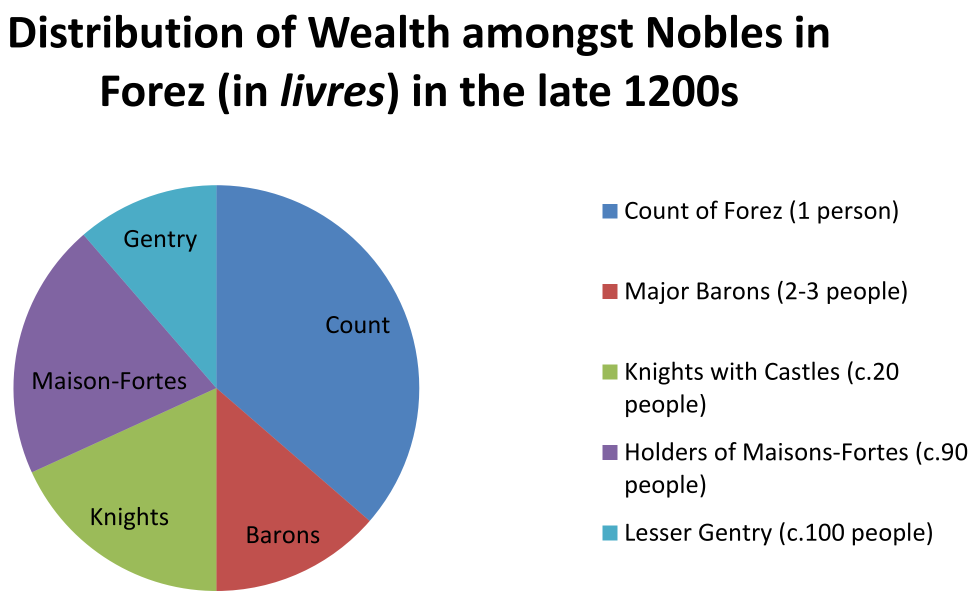
[432] Abel, *Agricultural*, 38.
[433] Hallam, 286.
[434] Farmer, 36.
[435] Duby, 295.
[436] Hallam, 286.
[437] Carpentier and Le Mené, 353.
[438] Braudel, 155.
[439] Herlihy, 32.
[440] Duby, 295.

which translates into lower wages for agricultural wage labourers. Some elites can take advantage of this climate and become immensely rich. Unfortunately the prosperity of the elite frequently means they proliferate. Government weakness expanded the nobility still further. Philip IV (r.1285-1314) gave out a dozen grants of nobility to his officers in his long 29 year reign. Louis X (r.1314-16) gave out six in a much shorter period of time. Finally after the crisis phase had definitely set in after the Great Famine, Philip V gave out 45 titles of nobility in his short reign of six years from 1316-1322.[441] Elite numbers apparently increased in proportion to the total population. Working from Philippe Contamine's figures, Peter Turchin concludes that around 1300, the elites constituted 1-4% of the population depending on the region. He cites Contamine's 'cautious' average of 1.8% for all France, with a possible higher estimate of 2.4%. Both lie in stark contrast to Contamine's subsequent estimate of nobles forming 1.5% of the population of 10 million in 1450. If taken at an average of five family members, it makes the difference of 70,000 noble families in a France of 20 million in 1300 and 30,000 families in 1450. The reduction of total elite numbers in proportion to the population would certainly accord with Turchin's theory. After the crisis phase reduced the population in the fourteenth century, the social pyramid would have been immensely top-heavy until elite numbers themselves were reduced in the subsequent infighting. The higher average of 2.4% would yield an even larger number of 96,000 elite families in 1300.[442] But the point really has less to do with total numbers of elites as it does stratification and shrinking incomes, as I discuss below. Naturally increased numbers of competitors do not help matters, but it is the incentive for elites to become disaffected and rebel that is the major issue.[443]

[441] Hallam, 291.
[442] See discussion Turchin and Nefedov, 114 and also Philippe Contamine, *La noblesse au royaume de France de Philippe le Bel à Louis XII*, (Paris: Presses Universitaires, 1997), 50-53 & 56.
[443] Naturally, because we are talking about human beings here, the incentive for elite rebellion can be mitigated by other factors, which, as we shall see occurred at certain points in both the medieval and early modern cycles.



(**Fig. 5.6** Perroy 1962, 27-28. Stratification of wealth in late thirteenth century Forez)

In a culture of rising prices and rents, the lesser nobility, growing more and more numerous, find it difficult to make ends meet. The result is stratification. Above is a chart for the share of wealth approximately 215 noble households held in the county of Forez. With the information provided by Perroy's study of the area, I was able to calculate roughly how much wealth was at play in terms of annual income, roughly 33,000 *livres* using the average income for each social group.[444] The lion's share of the total, nearly 50%, went to 1.86% of the nobility there. The remainder of the noble wealth of the county was doled out among the vast bulk of the nobility, who obtained an income of between 25-500 *livres* per year. The lowest rung of this bracket was barely enough to support a household of two or three children and the highest rung paled in comparison to the 12,000 per year income of the count of Forez. Elite overpopulation and stratification in itself is not necessarily an unmanageable problem provided the wealthiest and most powerful nobles in the state remain loyal to the government. When, however, the population actually begins to shrink due to famine, plague, or war, elite

[444] Eduoard Perroy, 'Social Mobility among the French Noblesse in the Later Middle Ages' in *Past and Present* (1962) 21: 27-28.

incomes across the board decline. Those nobles at the highest levels of society have a strong incentive to compete for the resources of the state and turn to faction and those nobles already living at the margins become desperate and easily recruited by either side.

e) The Black Death Exacerbates a Downward Spiral

As if the strain of the Hundred Years War and a disintegrative cycle were not enough for the French state, there then came the onslaught of the Black Death. The first wave of the Black Death in France was preceded by yet another famine in 1346.[445] In all, as the first wave of bubonic plague swept across France in 1347-49, between a quarter and a half, in some cases 80-90 percent, of the population perished, depending on the region.[446] Only regions like Béarn escaped the Black Death due to their isolation. From 1375-1440 there was widespread starvation, even though the weather was not too bad and the population no longer strained at the carrying capacity. But other factors intervened: sociopolitical instability and external warfare, things that kept France in a secular depression until the mid-fifteenth century.[447] The plague arrived in Marseilles in November 1347 and was exacerbated by a similar outbreak in Genoa, the twin forces of plague spreading across the southeast. At Marseilles, then a city with 15,000 inhabitants, we do not know the precise casualty figures, but it is known that only one of 150 monks there survived.[448] Standard estimates of casualty rates range between 25-50% for the entire city, implying 3750-7500 deaths. As the Black Death spread out into Provence, it reduced the surrounding population by 52%. The estimate is based on the number of households in 17 towns and rural villages of various sizes, where 7655 existed prior to the Black Death and afterward only 3664 remained. There is every indication that this is representative of the patterns seen in the total of 45,000 households in Provence, if one takes

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[445] Herlihy, 32.
[446] Braudel 157 also Herlihy 17.
[447] Charbonnier, 'The Crisis and its Aftermath', 117.
[448] Samuel Cohn Jr., *The Black Death Transformed: Disease and Culture in Early Renaissance Europe*, (London: Arnold, 2003), 108.

the standard average of roughly 4-4.5 people per household in rural villages and 3.5-4 people in towns.[449] By December the Black Death had reached Aix-en-Provence and by January it had hit Avignon and Arles. At the same time the plague ran along the south, from Montpellier, Béziers, to Carcassonne on the Spanish border between January and March.[450] Papal records reveal the following about the rate of casualties among the monks in the south: 358 Dominican monks are said to have died in Provence between March and April. At Montpellier, 133 out of 140 friars died. At Magdeleine, 153 out of 160 died. At Avignon, 66 Carmelites and all of the Augustinian monks died.[451]

The plague hit Bordeaux, we do not know precisely when, but sometime in the summer and quite possibly by sea trade as early as March. By April the plague had spread along the trade routes of the Rhône valley to Lyon. In that town, during 1346 or 1347, registers from the church of Saint Nizier indicate that the annual death rate was 80-85 adults. When the Black Death struck Lyon in 1348, the death rate leaped to 600-650 adults along with 300-350 children constituting an estimated 25-30% of the pre-plague population. [452] At Albi in Languedoc, it is estimated that out of a population of 10,000 over 5000 were killed in the first wave.[453] Of the 305 electors at Ganges, at town in the Cévennes of Languedoc, only 132 survived the first wave, and by the population low-point the mid-fifteenth century, only 89 remained.[454] Overall it is estimated that Languedoc lost around one third to one half of its population.[455] Nearby at Millau in Rouergue, just north of Languedoc, saw a drop in the

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[449] Ole Benedictow, *The Black Death, 1346-1353: The Complete History*, (Woodbridge: Boydell Press, 2004), 310-312.
[450] Benedictow, 96 &101.
[451] Cohn, *Black Death Transformed*, 108.
[452] Dupâquier et al., 1:319.
[453] Emmanuel Le Roy Ladurie, *Peasants of Languedoc*, trans. John Day, (Urbana: University of Illinois Press, 1976), 13.
[454] Ladurie, *Languedoc*, 14.
[455] Emmanuel Le Roy Ladurie, *The French Peasantry: 1450-1660*, trans. Alan Sheridan, (Aldershot: Scolar Press, 1987), 25-26.

number of households from 1541 to 918, 1346-1353, a decline of 40.5%.[456] Meanwhile to the east, Dauphiné was hit in May and Savoy was devastated not long after. Montmelian in Savoy saw a decline of 53% of its households in the first wave.[457] The epidemic reached Forez by July/August 1348, the minimum estimate is that 25% of the population died during the first wave of the Black Death. This is a bare minimum and is probably as high as 30 or 40%. [458] We know that 296 wills were registered 1348-49, compared to 151 in the outbreak of 1360, though the fatalities of 1398-1400 appear to have outstripped even the first wave in Forez, with 368 registered wills.[459]

Overseas trade brought the Black Death to Rouen in April 1348; it seems to have moved faster by sea than by land. Normandy as a whole lost approximately 30% of its population in the first wave of the Black Death, an additional 20% from 1360-1380, and then dropped to about 75% of its pre-plague size due to the Hundred Years War and elite infighting of the fifteenth century.[460] Combined with the impact of the Hundred Years War, the amount of cultivated land fell to just 33% of its pre-plague level in Normandy.[461] Paris and the Ile-de France were hit in August.[462] Deaths in Paris are alleged in one chronicle to be 50,000 and another 80,000 from 1348 to 1349. Given a total population of 200,000 and the trends we have seen elsewhere, a death rate of 25-40% is not unreasonable.[463] The source that provides the former number of 50,000 dead goes on to say that an average of 800 people died daily in Paris

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[456] Benedictow, 331-332.
[457] Dupâquier et al., 1:322.
[458] Dupâquier et al., 1:319.
[459] Cohn, *Black Death Transformed*, 198.
[460] Guy Bois, *The Crisis of Feudalism: Economy and Society in Eastern Normandy, c.1300-1550*, (Cambridge: Cambridge University Press, 1984) 57-58.
[461] Emmanuel Le Roy Ladurie and Joseph Goy, *Tithe and Agrarian History from the Fourteenth to the Nineteenth Centuries: An Essay in Comparative History*, trans. Susan Burke, (Cambridge: Cambridge University Press, 1982), 78.
[462] Benedictow, 102.
[463] Dupâquier et al., 1:320.

amounting to the total figure between 1348 and 1349.[464] The Ile-de-France, as a whole lost 25% of its population in the first wave and would lose an additional 40% of its pre-Black Death population by the end of the High Medieval cycle.[465] The Black Death struck out of Rouen from another direction, arriving in Caen September or October and arriving in Anjou in late November 1348.[466] Just to the south Périgueux in Aquitaine saw a drop from 1224 households (pre-plague) to 903, a drop of 26%.[467]

Besançon was infected in June and we know that 311 will and testaments were registered for the dead the following year, in contrast to 195 in the second outbreak of 1360, 92 in a minor outbreak of 1361, 97 in the wave of 1400, 62 in 1418, and 75 in 1439.[468] The rest of Burgundy was overtaken by the end of July. The number of deaths from August to October at the town of Givry was 580. The average death rate from 1334-1347 for the same period of three months would have been 6-9.[469] The Black Death arrived at Reims, in Champagne, by a pincer movement coming out of Paris and Burgundy at once. The outbreak was underway by September 1348 and claimed perhaps 2500 of the 10,000 people living in this city as a minimum estimate.[470] In the direction of the northeast out of Burgundy, the Black Death slowed down, and meandered slowly from Montbéliard, to Mulhouse, to Colmar, and ending up in Strasbourg by July 1349, a distance of 220 km in 240 days, or about 0.9 km a day.

Sociopolitical instability reared its ugly head in the south and east among the commoners in this period, fuelling popular religious hatreds against the Jews. In a conspiracy theory that was not endorsed by the king or any major elite magnate, popular rumours alleged

[464] *Les Grandes Chroniques de France*, ed. Jules Viard, vol IX, (Paris: Société de l'histoire de France, 1937), 315.
[465] Ladurie, *French Peasantry*, 25 & 29.
[466] Benedictow, 108.
[467] Dupâquier et al., 1:322.
[468] Cohn, *Black Death Transformed*, 189 &197.
[469] Dupâquier et al., 1:319.
[470] Dupâquier et al, 1:321.

that the Jews were responsible for the plague. In September 1348 at Chinon in central France and Chambéry in the French Alps, the Jews were accused of poisoning wells. At Strasbourg on Valentine's Day 1349, an angry mob burned 900 Jews to death in a cemetery.[471]

Meanwhile in the north, Calais was infected in the late fall of 1348 and Amiens in January the following year. When the plague finally reached Artois in 1349, the region was reduced from 2121 households in a sample of 32 villages to 1222, or a decrease of 42%.[472] The plague had begun to slow down at this point and Lille was hit as late as August 1349. In central France, the wave of epidemic reached the Auvergne by 1349, which saw its population reduced by a minimum of 25% in the villages of the countryside and up to 75% in some localities. The sparsely populated hills of the Auvergne were relatively 'spared' – losing an average of about 18% of the population.[473] Saint-Flour in the Auvergne had 1540 households in 1345, and after the first wave of the Black Death it had 805, a 48% decline in the number of households and a mortality rate of the inhabitants of them as high as 57%.[474]

These figures represent the losses of what was just the first wave. The plague was to strike again in various regions of France in 1360-61, 1366-7, 1373-74, 1381, 1390, 1400, 1405, 1411, 1418, 1433, 1435, and 1437-39.[475] Overall, the French population declined by about one-half, from approximately 20 million in 1300 to 10 million people in 1450. [476] For about a century population numbers fluctuated at a low level, attempting to recover 1380-1400 but struck down again by elite infighting and the Hundred Years War, and starting to increase only after about 1420 in the south and after 1450 in the north. Within that period of population decline and secular depression, a bare minimum of three to four million hectares of land was

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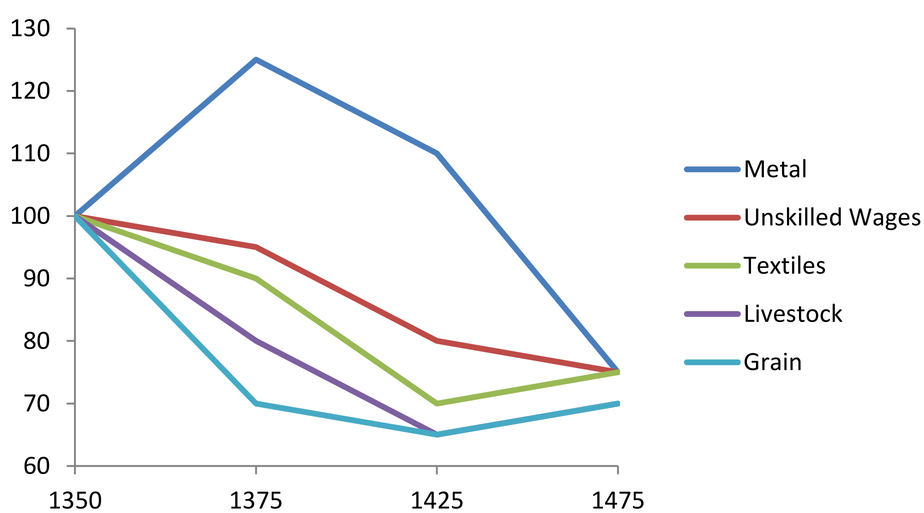
[471] Helihy, 65-66.
[472] Ladurie, *French Peasantry*, 30.
[473] Dupâquier et al., 1:321.
[474] Benedictow, 337.
[475] Cohn, *Black Death Transformed*, 32.
[476] Dupâquier et al, 1:149.

abandoned, representing approximately one-sixth of the land that had been so painstakingly cleared since 950 and raised the carrying capacity from 9 to 20 million.[477] Thanks to the Black Death and external and internal warfare, the population fell again to 10 million, which was above the Carolingian carrying capacity but well below the levels that could be sustained by the Capetian one. Nevertheless, the amount of land under cultivation remained relatively high compared to the start of the cycle, and the land that was abandoned was not lost for long. The forests that had lain on those lands at the beginning of the High Medieval cycle would not return by 1450, when expansion renewed. Instead clearing of abandoned fields would require less industry and less time to repopulate the lands of the dead. In the meantime, however, the Black Death had been responsible for a tremendous loss of life unsurpassed in French history *in proportion to the total population*. Not even the First and Second World Wars can claim a greater toll.

f) A Higher Peasant Standard of Living & A Rise in Elite Instability



(**Fig 5.7** From Abel 1978, 52. Change in prices and wages in France with an index of 100 at 1350)

Despite the biological destruction wreaked upon the population, the standard of living for the surviving peasant population suddenly improved. By and large, wages stayed far ahead

[477] Ladurie, *French Peasantry*, 42.

of a drop in prices. This meant a return to the trend of c.1000-1280. The same relief the Black Death brought the peasantry in relation to population pressure also brought about a decline of noble incomes. Fewer tenants paying rent on their land meant less revenue. A labour shortage meant they had to pay higher wages and charge lower rents. Rising prices meant the profits a landowner did make were not as valuable as in earlier years. At the time of the Black Death approximately 50% of the French nobility were making an annual income of 40 *livres* or less.[478] Thereafter, from 1350-1450, the French elite lost 50-75% of their revenues.[479] This significant decline in noble incomes was roughly proportionate to the loss of the total population during the Black Death. What is more, during the Black Death the elites did not die at the same rate. At Albi during the first wave, the number of those owning less than 50 *livres* in property fell by 14% while at the same time the rich who owned between 50 and 200 *livres* increased by 7.5% in proportion to the total population, and the numbers of the super-rich owning more than 200 *livres* literally doubled in size compared to the rest.[480] The tremendous loss of elite revenue and the creation of a top-heavy social pyramid provoked the rise of elite competition between themselves and with the government for power and resources to address the imbalance and to cope with the declining standards of the times.

Sociopolitical Instability 1270-1358 AD

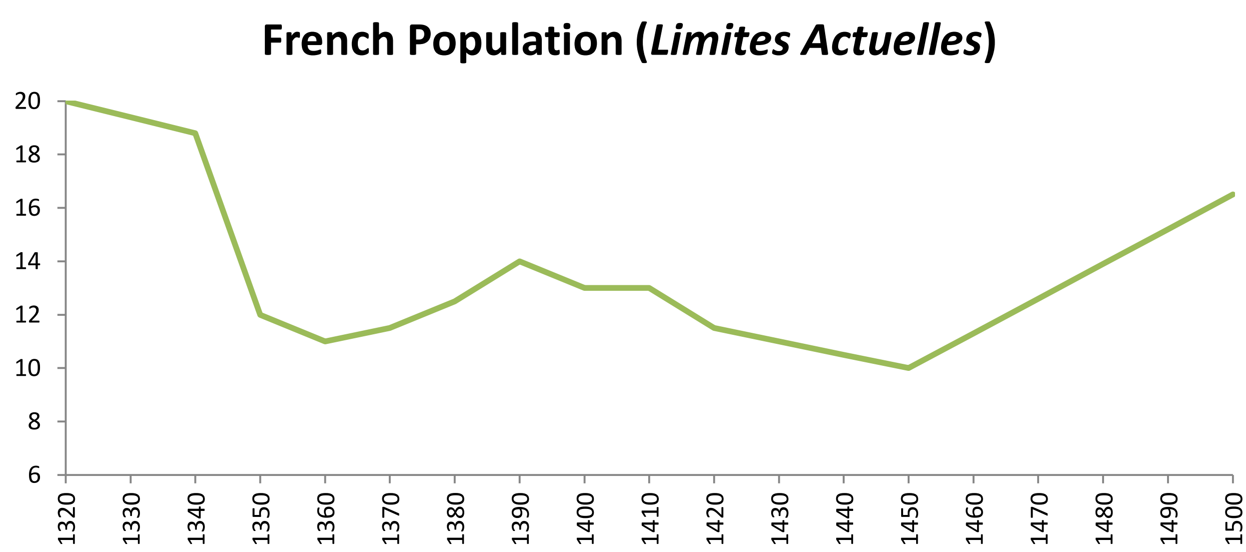
Year	*Event*
1270-1278	Faction between Pierre de la Broce, the king's chamberlain, and Queen Mary of Brabant
1294-1302	War with English and in Flanders leads to hikes in taxation: the 'nationalised' in-lieu-of-service fine (1294), extends fine to all men of the kingdom with a certain amount of land or goods in property, i.e. income tax on the rich (1302), and regular hikes in taxes
1302-1321	Leagues formed against taxation, armed resistance continues despite mediation of Louis X (1314-16), and elite groups not pacified until 1321
1323-1328	Peasant revolts, to elite tax revolts, then full scale rebellion in Flanders

478 Carpentier and Le Mené, 464.
479 Guy Bois, *La grande depression médiévale, XIVe-XVe siècles: le precedent d'une crise systémique,* (Paris: Presses Universitaires de France, 2000), 115.
480 Dupâquier et al, 1:323.

1328-1334	Factionalism surrounding the succession of Count Robert III to Artois, ending in his eventual exile to England and encouragement of Edward III to claim the French throne
1341	Disputed succession between houses of Blois and Montfort to the duchy of Brittany
1341-1345	Revolts against John II in Normandy
1355	In exchange for one year's levy to carry on the war with England, John II is forced in an edict to cede powers of consent to taxation, control over forced loans and the currency, the right to convene the Estates which would then meet annually, and the right to make a call-to-arms without the consent of the Estates. The levy, however, was not paid by the elite tax base.
1356-1357	After John II's capture at Maupertuis, an emergency session of the Estates led by Etienne Marcel and Robert le Coq (1356 & 1357) attempted once more to wrest executive power from the Charles, the dauphin. When negotiations broke down, Marcel approached the dauphin's rival for the throne, Charles of Navarre, and raises an army of 3000 men.
1358	The Jacquerie erupts, a rebellion of the peasants led and supported by elites like Etienne Marcel and Robert le Coq, later brutally suppressed by nobility. North of France particularly devastated by fighting. 20-30,000 nobles and commoners are killed.

(**Table 5.1** from Strayer and Taylor, Mignon, de Laurière, Secousse, Henneman, and Cohn)

The period prior to the famines of the early fourteenth century was characterised by a bit of petty factionalism while the central state nevertheless remained strong. The period from 1300-1321 was characterised by population decline, the decline of noble incomes, and the creation of many armed leagues against taxation (French nobles had not yet gained the exemptions from taxation that would characterise the late fourteenth century to the end of the *ancien régime*). Things deteriorated even further in the 1320s and 1330s, particularly in Flanders. During this time the French population had declined by approximately 1-2 million (see fig. 4.18). The real upheaval, however, began when the Black Death caused the French population to plummet by almost half of its medieval peak. In the following ten years, one sees a rash of sociopolitical instability in which there was a state breakdown. Even while the war raged with the English, the Estates, particularly the wealthy bourgeois of the Third Estate, but with support from the nobility, tried to wrest an unprecedented amount of executive power from the king and later from the dauphin. Their attempts only failed because of the tax revolts of other elites further down the social hierarchy, refusing to pay, and completely destroying the bargaining power of the Estates.[481] Then the Jacquerie, a revolt composed of peasants and led by the professional and merchant classes against the nobles, complicated by a noble pretender to the throne, caused a great deal of upheaval and the worst slaughters in northern France – all while the war raged. It is notable that it was only in the period after this cataclysm from c.1360-1390, when the majority of sociopolitical instability stopped that we see a slight population recovery. In a strictly Malthusian realm, one would expect the French population to immediately rebound after the Black Death, as the Marxist critics of the *annalistes* pointed out. Instead, sociopolitical instability kept the population low. It is only in the period following the ravages of the Jacquerie, when infighting stopped, that the French population recovered to approximately 14 million – even though external war raged for 20 of those 30 years from 1369-1389.



(**Fig. 5.8** Turchin 2009, 113, after Dupâquier 1988 & Braudel 1990)

[481] *Ordonnances des roys de France de la troisième race, recueillés par ordre chronologique*, ed. Secousse, (Paris: L'Imprimerie Royale, 1723), III, 15-16, 29, 36-37, 53-5, John Henneman, *Royal Taxation in Fourteenth Century France: The Development of War Financing 1322-1356*, (Princeton: Princeton University Press, 1971), 295-296, and *Royal Taxation in Fourteenth-Century France: The Captivity and Ransom of John II, 1356-1370*, (Philadelphia: The American Philosophical Society, 1976), 18, Samuel Cohn, *Popular Protest in Late Medieval Europe*, (Manchester: Manchester University Press, 2004), 143-150.

Heavy factionalism and elite infighting resumed after c.1388, as did population decline, even though external war did not return until 1415. When Charles V lay on his deathbed in 1380, he abolished the *fouage*, a widespread tax that spared neither urban nor rural areas, neither commoner nor nobility. It had been levied in 1363 and had largely permitted the French to ride out twenty years of war with England and recover much of its territory, despite there being no major victory in a pitched battle on either side.[482]

A strong government is able to impose taxes, and in a period of continued elite infighting, manmade crisis, and a depressed population, a government became less capable of 'competing' with the elite for income. In many ways the 'class struggle' is not just between commoner and noble, but between commoner, noble, and government. The juvenile Charles VI, under the regent Philip the Bold and his brothers, was forced to reaffirm the cancellation of the *fouage* and abolish the *aides* and indeed all extraordinary taxes levied since the reign of Philip IV.[483] Charles was again forced to reaffirm this in 1381.[484] This makes clear that faction and elite-government competition was still going strong. The costs of warfare did not allow the drastic reduction of tax income in 1380 to last for very long. By 1382 the regency government had reinstituted the *gabelle* and the *aides*, though not the *fouage*.[485] Yet the *gabelle* and *aides* were not in themselves sufficient. A broad-based tax was needed to fully tap the numbers and wealth of France. Accordingly, it is in 1384 that we see the advent of the *taille*. In a letter of May 3 1384, the royal government introduced a '*nouvelle imposition*' as a surtax on the *aides*.[486] Factionalism, however, would not allow these taxes to be levied on the

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[482] Secousse, III, 646, Turchin gets this wrong and claims that it was introduced in 1360. No mention is made of 1363. & VII, 710-711.
[483] Secousse, VI, 527-528.
[484] Secousse, VI, 552-554. Secousse states the date of the ordinance January 1380. It was not. This is obvious since Charles V had not yet died or abolished the *taille*. He died in September.
[485] Secousse, VII, 746-751.
[486] Secousse, VII, 759.

elite for very long. The regent, Philip the Bold, in 1388 was trying to hold onto power. He won elite support for the *taille* by granting the nobility, certain bourgeois and certain cities an exemption, despite the vast amount of wealth they possessed. This largely left the burden of the *taille* on the rural peasantry – the group least equipped to pay.[487]

In the same year, Charles VI came to his majority and hurled Philip the Bold and his faction, the Burgundians, from power, and opted for the opposing faction, the *Marmousets*. Then in 1392, the *Marmousets* turned against Charles VI and his own government, and so Charles VI, after an assassination attempt, much fighting, and a campaign against *Marmousets* in Brittany, had to turn back to Philip the Bold. This immediately created a reaction to Philip the Bold and a faction was created under Louis duc de Orléans. Once again in order to win elite support for his rule, Philip issued a similar tax exemption to the nobility for the *aides* in 1393, a few months after the king went mad.[488] This is the point where the infamous noble tax exemptions were fully constructed.[489]

Similarly, from its inception in 1384 until 1412, the *taille* was levied extremely sparingly due to elite resistance. External war was the only emergency which allowed the weak government to levy the tax on those middling elites who did not receive an exemption in 1388. Five of the six *tailles* levied within that time dealt directly with funding the French war machine. Only one levy dealt with something else: in 1396 the royal government raised a dowry of 800,000 *livres* for the marriage of Richard II to Isabel of France. This was a feudal custom. All the other *tailles* were levied for the 'evident necessity' of war. In May 1402, a *taille* was raised to man fortresses on the Gascon frontier and for a crusade against the Turks, which never came to be. The edict requested 1,200,000 to 1,300,000 *livres.* Due to protest of

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[487] Secousse, VII, 186-189.
[488] Secousse, VII, 524-527.
[489] The role of exemptions in limiting tax revenue in later centuries is best discussed in Richard Bonney, *The King's Debts: Finance and Politics in France 1589-1661*, (Oxford: Clarendon Press, 1981).

local elites only a fraction of this was actually collected – around 200,000. In January 1404, 800,000 *livres* were granted for an invasion of England, though a conference in June estimated its cost at 1.2 million. A reduced yield was a common occurrence. The remaining three levies were also for war. In 1406, there was a *taille* of 400,000 *livres*; 1411, 300,000; 1412, an amount of 900,000 *livres*. All of the above were for war with England.[490]

In the earliest years of the *taille*, perpetual resistance to taxation in a population depression rife with socio-political instability restricted the occasions on which it could be levied. It also inevitably reduced the amount the king requested. Meanwhile factionalism and intra-elite violence was rising again in fifteenth century France. At the time of Charles VII's birth in 1403, he stood third in line to the throne. Louis, duke of Guyenne, and John, duke of Touraine, preceded him. After 1392, his father, Charles VI, was struck by mental illness interspersed with periods of lucidity. He became the puppet of whichever faction had the possession of his person. The division lay between the Burgundians and the 'Armagnacs'. With the death of Prince Louis in 1415 and Prince John in 1417, the young Prince Charles suddenly became heir to the throne of France. This sickly youth was thrown into the midst of a fierce rivalry between the factions. The sympathies of the prince lay with the former.

Henry V of England invaded France and the French eagerly confronted him and were defeated at Agincourt in 1415. From 1417 onwards, with the English inundated with victory and glutted with success, Henry V of England decided upon systematic conquest of territory.[491] The enemy of France was something of a Caesar. All of Gaul lay before him ready for the taking, and Henry V was perfectly willing and capable of taking it. During the invasion crisis, the French government was zealous in levying the *aides* (sales taxes). Between 1416 and 1418, four *aides* were levied on the kingdom. This was necessary, because the Dauphin's

[490] Maurice Rey, *Le domaine du roi et les finances extraordinaires sous Charles VI: 1388-1413*, (Paris: Sevpen, 1965), 326-330.
[491] Curry, 98-101.

financial situation was teetering on the brink. He was forced to sell jewels and contract massive loans. On January 30 1418, things went from bad to worse. John the Fearless, duke of Burgundy, abolished his *aides* in his own territory and Charles found that he was not in a position to resist the tide of elite opinion and had to follow suit. The *aides* were an excellent source of funding but they were now lost to Charles for several years.[492]

John the Fearless seized control of the government in Paris in May 1418 and the Dauphin Charles fled southwards. He then attempted and failed to appease the English holding the north. On July 30 1419, Henry V stormed Pontoise. From here he threatened Paris. The image was no longer of a line bent or temporarily broken, but of a besieged fortress. In his darkest hour, the Dauphin Charles resolved upon a desperate ploy. On September 10 1419, John the Fearless was murdered on the bridge at Montereau, by the Dauphin's men, forty-five miles south of Paris. The result was electric. The new Duke of Burgundy, Philip, sought an immediate rapprochement with the English, which resulted in the Treaty of Troyes which, after a series of parleys and negotiations, was ratified on May 20 1420. On the death of Charles VI in 1422, Henry V became king of France as well as England. Charles VII meanwhile set about shoring up his control south of the Loire and east of Guyenne.[493] Coincidentally, this territory almost exactly resembles that held by the French government at Vichy after the German occupation of 1940. It was during this period that the population in the north of France, particularly the Ile-de-France and Normandy, declined to 25-30 percent of its 1300 peak.[494]

[492] A letter of Charles to a captain in Languedoc cancelling the *aides* printed in Claude de Vic and Jean Vaissette, *Histoire Générale du Languedoc avec notes et les pièces justificatives*, (Toulouse: Édouard Privat, 1885), vol. 10, 1984-1985. See also Rey, 370.
[493] Curry, 98-101.
[494] Turchin and Nefedov, 129-130.

g) The Slow Reversal of the Elite Instability Trend

This was the low point of the French depression phase. Elite infighting and external war had caused a state collapse. The English held some of the most populous and powerful regions of the north. However, Charles VII was lucky. Already in the south, whose losses had been less severe during the external war, the population had begun to recover. This process began c.1410-1420, with no English troops or widespread elite violence to continue the work that the Black Death had already begun. Famines still occurred in the south due to climatic events and war related shortages, but on the whole the population began to recover. Increased population numbers meant a relative, if slight, increase in the payment of rents and elite share of crop yields. This translated in to a greater willingness among the elite of the south to pay taxes to carry on the war. Suddenly Charles VII found himself the recipient of numerous tax grants of the various Estates of the south. Whereas in the reign of Charles VI, the lucrative *taille* had been levied without ratification of the Estates-General or provincial assemblies, the *taille* in the 1420s under Charles VII was levied almost exclusively by consent of a central representative body.[495] After two severe periods of elite infighting, exacerbated by pestilence, famine and war, the High Medieval cycle was coming to an end. The number of noble families was reduced from 70,000-96,000 in 1300 to only 30,000 in 1450.[496] Burgundy defected to the French side in 1435 and the French reconquered Paris in 1436. The Estates were still willing to grant the king what he asked for: the prosecution of the war. In the same period Charles VII

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[495] For the various grants by Estates- General during this time: Clermont (1421) from printed extracts from the archives de Tours: C. de Grandmaison, 'Nouveaux documents sur les Etats Généraux du XVe siècle' *Bulletin de la société archéologique de Touraine*, 4 (1887-89), 139-151; For an overview of all the grants see the old but unsurpassed work of Antoine Thomas, *Les Etats Généraux sous Charles VII: Etude chronologique d'aprés des documents inédits*, (Paris: L'École des Chartes, 1878), 11-29: in this work he corrected and reconciled the erroneous figures of two previous attempts by Picot and Vallet de Viriville; For Languedoc see: Henri Gilles, *Les Etats de Languedoc au XVe siècle*, (Toulouse: Édouard Privat, 1965), 40-47; also Ferdinand Lot and Robert Fawtier, *Histoire des institutions françaises au moyen âge*, (Paris: Presses Universitaires de France, 1958), 271-2; and also Antoine Thomas, 'Le Midi et les Etats Généraux sous Charles VII' *Annales du Midi* 4 (1889) 290-312 and 4 (1892) 1-15.

[496] Contamine, *Noblesse*, 53 &56.

managed to entrench both the *aides* (1436) and the *taille* (1439) to be levied without consent.[497] The English had been beaten back and had to be expelled from France altogether. All that remained was the long push to the sea. *Écorcheurs*, veteran soldiers turned plunderers of the French countryside, also caused a great deal of concern.[498] The cooperative spirit of the Estates remained. The period of state-elite competition had ended and the population had begun to recover because the elite numbers in the south had been finally reduced sufficiently that there was less intra-elite competition for resources to bolster their incomes. The earlier recovery of the population in the south also helped boost elite incomes.

England underwent a similar trend, with demographic growth until 1300, when shortages and famines returned, a population collapse with the Black Death, and elite infighting in two waves – one in the fourteenth century and one with the War of the Roses in the fifteenth. Such are the conclusions of the work of Peter Turchin.[499] The German states recovered sooner from the demographic ravages of the Black Death to hit another period of sociopolitical instability in the early fifteenth century, while in both the case of France and England that phase did not begin until after 1550. On the other side of the continent, Sergei Nefedov has established fourteenth century population growth in Russia, which was less effected by the Black Death, ecological strain and decline c.1400, and sociopolitical instability lasting until the end of internecine war in 1453 and keeping the Russian population low – just as in France.[500] Across all Europe in the fifteenth century sociopolitical instability had exhausted itself. Then regions once again enjoyed periods of stability and population recovery as the cycle reset itself anew.

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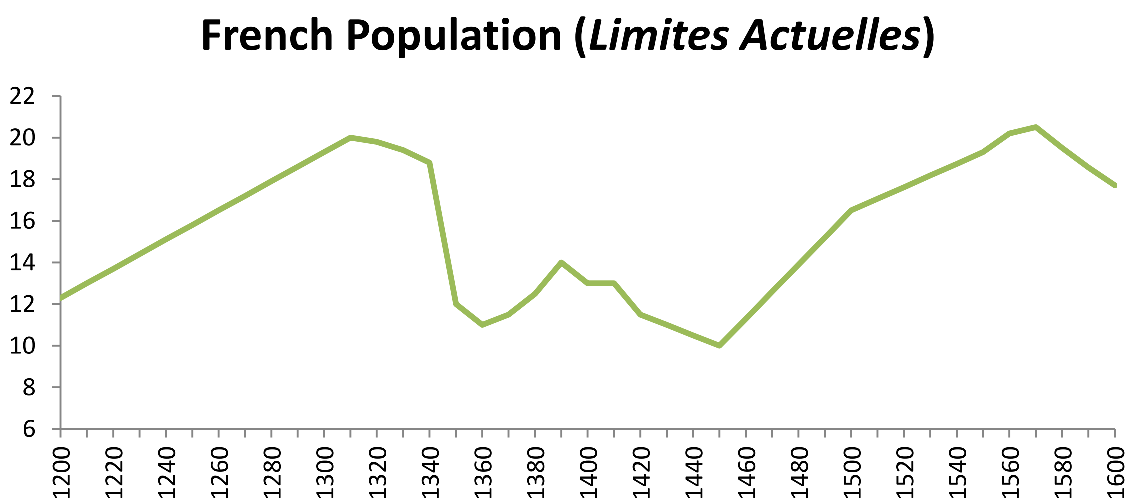
[497] *Aides*: Secousse, XIII, 211-215; François-André Isambert, *Recueil général des anciennes lois françaises: depuis l'an 420 jusqu'à la révolution de 1789*, vol. 8 (Paris: Imprimerie et Fonderie de Fain, 1833), 834-842, *Taille*: Isambert, IX, 57-71; Secousse, XIII, 306-13.
[498] Martin Wolfe, *The Fiscal System of Renaissance France,* (New Haven: Yale University Press, 1972), 30.
[499] Turchin and Nefedov, 35-80.
[500] Turchin and Nefedov, 240-242.

The Black Death and the ravages of France by the English army in the Hundred Years War somewhat mask whether the cycle in France was precipitated by these two massive exogenous forces. The trends of the cycle were certainly exaggerated and perhaps prolonged by them. Fortunately, the succeeding cycle had neither a plague nor a major war on French soil. It depicts the same trends, though they occur with a much lower ratio of loss and recovery. In fact, while the precise numbers of population loss and the duration of elite infighting slightly alter the duration and shape of the cycles, the process of expansion, stagflation, crisis, and manmade depression remains the same. Growth spanned 1450-1520, stagflation 1520-1550, and the first wave of demographic crisis and infighting becomes apparent thereafter.



(**Fig. 5.9** Turchin 2009, 113, after Dupâquier 1988 & Braudel 1990)

III. Early Modern France

a) Renaissance Shifts in Population & the Standard of Living

The new cycle began in earnest during the second half of the fifteenth century. The standard of living for the average French subject was extremely good. There was enough land, enough food, and the number of those who lived quite well increased while those who lived nearer to the margins declined. The population flourished accordingly. The period 1450-1560 was an endogenous revival of fortunes that mostly had to do with the rise of French populations back to their fourteenth century peak.[501] The population did not increase much beyond pre-1315 levels, however. The carrying capacity for France within the *limites actuelles* remained at a maximum of 20 million people, and every time it was approached in the sixteenth and seventeenth centuries, starvation was the result. Due to the depopulation of the previous cycle, the period from 1450 to 1500 was characterised by a labour shortage, high wages, and low prices. Because the devastation of the Black Death and Hundred Years War was so pronounced, the recovery was equally so, with commoners enjoying high wages and low prices to an extent unsurpassed until the Industrial Revolution. Only then would the cheap mass-production of goods allow wages to keep a substantial gap between the price of daily amenities. Here was the unusual effect of the exogenous forces of plague and external war on the French cycle.

After 1450, the French population enjoyed a period of slow uninterrupted growth from approximately 10 million people to 15 million people by 1500, and onward to 20 million by 1560.[502] By the mid-fifteenth century trees and scrub had invaded farmland and entire villages had disappeared, particularly in areas of the north, which had been subject to the most severe fighting of the final phase of the Hundred Years War.[503] In 1460, for example, the population of Normandy was half of what it was in 1413 and one quarter of what it was before the Black Death.[504] There was a decline in sociopolitical instability within France after 1450. The widespread looting of *écorcheurs* that had prevented agricultural growth came to an end.[505] The vast amount of depopulation suddenly shifted from bane to boon for the commoners. The

[501] Braudel, 170.
[502] Emmanuel Le Roy Ladurie, *The French Peasantry, 1450-1660*, trans. Alan Sheridan (Aldershot: Scolar Press, 1987), 9.
[503] Braudel, 171.
[504] Jonathan Dewald, ‘Social Groups and Cultural Practices’ in *Renaissance and Reformation France: 1500-1648*, ed. Mack Holt, (Oxford: Oxford University Press, 2002), 30.
[505] Knecht, 3.

lands of the dead now lay open to be re-cultivated by an increasingly prosperous class of peasant farmers. Agricultural production increased by leaps and bounds in the latter half of the fifteenth century, by a massive 45% in some areas of the north, as a result of re-farming abandoned lands rather than the introduction of many new techniques.[506] Urban centres swelled too. At the beginning of the cycle c.1450, urbanisation had been relatively slow. 10% of the population lived in urban areas and only a fraction of those were living in cities with over 10,000 people.[507] Then over the course of the integrative phase, a new string of large towns popped up. The populations of already large places like Lyon, Rouen, Marseille, and Bordeaux between 1450 and 1560 grew by 200-250%, with Bordeaux surpassing its pre-plague level.[508] By 1500, approximately 20 towns in France had a population over 10,000. The population of Paris in 1500 was 200,000. There were four towns with a population over 40,000. Around 40 towns had over 5,000 people in 1500. In addition to this there were around 30,000 villages in France.[509] After 1500, however, agricultural growth moved more slowly, lagging behind population growth, to the point that by the 1520s, 90-95% of the land that was abandoned after the Black Death was back under cultivation, and by 1540, the price of wheat increased dramatically.[510] It is unfortunate that the increase in agricultural productivity between 1450 and 1540 was accomplished not by innovation in farming techniques but by reclamation of land.[511] As a result, France simply sprang back to limit that she had reached as far back as 1315.

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[506] Emmanuel Le Roy Ladurie and Joseph Goy, *Tithe and Agrarian History from the Fourteenth to the Nineteenth Centuries*, trans. Susan Burk, (Cambridge: Cambridge University Press, 1982), 75.
[507] Dewald, ‘Social Groups’, 32.
[508] David Potter, *A History of France, 1460-1560: Emergence of a Nation State*, (London: Macmillan, 1995), 10.
[509] Knecht, 4.
[510] Ladurie and Goy, 78 & 104.
[511] Knecht, 3.

(**Fig 5.10** France by region. Medieval-spell. Retrieved Jan 5 2013: http://www.medieval-spell.com/Images/Travel-France/Travel-France-Map.jpg)

In terms of regional population trends, the south, which experienced earlier growth, also generally peaked earlier. In Provence, the number of houses tripled between 1480 and 1540, with the main growth after 1500.[512] Languedoc doubled its number of taxpayers between 1500 and 1540, though grain production certainly did not double. In Languedoc around 1450, the land was so empty that bears, dear, and wolves descended from the mountains and roamed the forests and abandoned fields. This allowed plenty of game for the peasantry between 1450 and 1500.[513] Some regions in the centre that had recovered earlier,

[512] E. Baratier, *La démographie provençale du XIVe au XVIe siècle*, (Paris: Ecole Practique des Hautes-Études, 1961), 75-81 and Robert-Henri Bautier, 'Feux, population et structure sociale au milieu du XVe siècle: L'example de Carpentras' *Annales* (1959) 14:255-268.
[513] Braudel, 171.

like the Auvergne around 1418, also grew up till the population peaked c.1540. [514] In many southern regions by 1540, the strain was beginning to show, famines were frequent and devastating, and in many regions decline was already underway.[515] French agricultural yields could be 50% of the average in a bad year and perhaps 150% in a good one.[516] This was a significant difference that could be absorbed in periods where the population was low, but when it strained the carrying capacity it was enough to push the population over the edge and into a state of famine. There is some correlation between these regions and the state of violence in the early modern disintegrative phase. As a general trend, the southern population peaked first, experienced strain first, faced the most conversion, and thereby bore the brunt of the Wars of Religion.

The northern populations peaked later, continuing to grow through the 1540s and 1550s and peaking c.1560. In Picardy, the population more than tripled after 1470, and pre-plague levels of overpopulation (c.1328) were reached by 1560. The same may be said of the population of Cambrésis, where population growth was rapid after 1470, stagnated in the sixteenth century, and peaked around 1560 as well. Brittany saw steady growth, somewhere in the range of 30-50% between 1490 and 1560, thereafter going into decline. In Bar-sur-Seine, there were 5-6 people per square kilometre c.1480. Population density was at the highest of pre-industrial levels. By 1550, there were 50-60 people per square kilometre. Some places in the Paris basin had a higher population density than in the eighteenth century, totalling 1.5 million for Paris and its surrounding environs. In the Ile-de-France as a whole, growth resumed after 1470. The number of villages there increased by 200% to even 600% in some

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[514] Pierre Charbonnier, *Une autre France: La seigneurie rurale en Basse Auvergne du XIVe au XVIe siècle*, (Clermont-Ferrand: Institut d'Études du Massif Central, 1980), 843-855.

[515] Ladurie, *Peasants of Languedoc*, 54-56 & 73-76.

[516] Robin Briggs, *Early Modern France: 1560-1715*, (Oxford: Oxford UniversityPress, 1977), 36.

areas until 1560.[517] Thereafter, across the north we see a decline in tandem with the south, and while rural conversions were fewer, religious riot and Catholic persecution of minority Protestants became prevalent due to a collapse of social cohesion, particularly in the 1570s.

The population of France was distributed mostly in the north as in the previous period. North of the Loire and east of the Cherbourg peninsula, the territory was flat and open, allowing for wheat production and numerous other products such as wine. The north in the sixteenth and seventeenth centuries contained roughly 35% of the French population. The regions of western Normandy, Brittany, Anjou and Maine contained a further 25% of the French population, combining into 60% of the French people living north of the Loire. These provinces were not as flat and had less rich soil, thus were not suited to intensive grain production and had a lower population density. The south had an ideal climate for production of wine, olives, fruits, and eventually silk. Wheat yields were limited by a two-crop rotation as opposed to the three-crop rotation in the north. Nevertheless the nature of the climate and easily tilled soil mean that ploughing was cheaper and the crops produced were worth more per unit. Thus a smallholder could still eke out a decent living. This allowed for high population density in many areas of the south, particularly along the Mediterranean coast and the Bay of Biscay. Accordingly the south contained roughly 25% of the population, with approximately 15% dispersed in the regions of the Pyrenees, Alps, and central France.[518]

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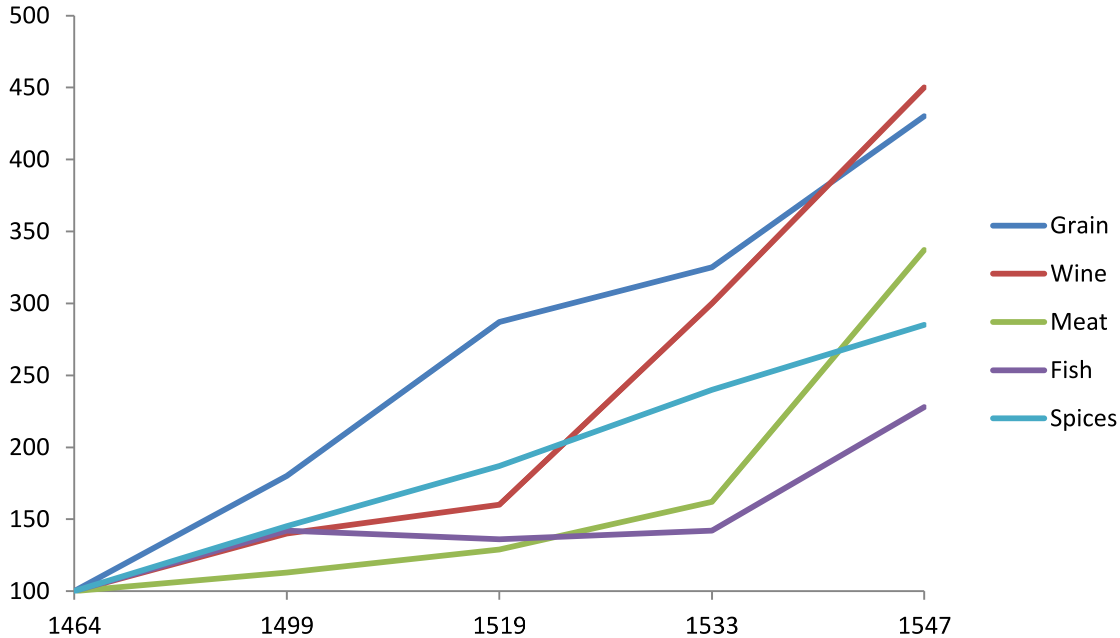
[517] David Potter, *War and Government in the French Provinces: Picardy 1470-1560*, (Cambridge: Cambridge University Press, 1993), 22-24, H. Neveux, *Vie et déclin d'une structure économique: les grains du Cambrésis, fin du XIVe – début du XVIIe* siècle, (Paris: École des hautes-études en sciences sociales, 1980), 167-78 &186-93, A. Croix, *Nantes et le pays nantais au XVIe siècle: Étude demographique*, (Paris: SEVPEN, 1974), 161-170 & 221-224, M. Belotte, *La region de Bar-sur-Seine à la fin du Moyen Age: du début du XIIIe siècle au milieu du XVIe siècle, etude economique et sociale,* (Lille: Université de Lille, 1973), 146, Guy Fourquin, *Les campagnes de la region parisienne, à la fin du Moyen Age,* (Paris: Presses Universitaires de France, 1964), 443, J. Jacquart, *La crise rurale en Ile-de-France: 1550-1670*, (Paris: Armand Colin, 1974), 44 and *Paris et l'Ile-de-France au temps des paysans, XVIe-XVIIe siècles, recueil d'articles*, (Paris: Publications de la Sorbonne, 1990), 227-230.

[518] Jonathan Dewald and Liana Vardi, 'The Peasantries of France, 1400-1789' in *The Peasantries of Europe from the Fourteenth to the Eighteenth Centuries*, ed. Tom Scott, (London: Longman, 1998), 22-23.

The standard of living in the Early Modern expansion phase fell into line with the trends our models might predict. The golden age for the average standard of living was c.1480, when prices were low and wages were high, for both urban and rural labourers, whether they received actual money or payment in kind via grain, wine, olive, oil, and salt.[519] The working classes enjoyed an income about twice what they were in the best years of the seventeenth century. It is no surprise, therefore, that there was no major famine in France between 1440 and 1520.[520] The daily intake of your average labourer could buy 16 kg of grain in the prosperous phase of 1450-1500, compared to 7-8 kg a day 1550-1580, and less than 4 kg in the deepest moment of the first crisis phase, the 1590s, which were rife with casualties caused by famine and elite infighting. We now know that approximately the monetary equivalent of 15kg of bread is enough to comfortably feed, clothe, and house a family for a day. The breaking point is the equivalent of 9kg of bread.[521] This means that the lowliest wage-earner in the latter half of the fifteenth century could live quite well and have all the needs of his family met. After 1550, this ceased to be the case. The result is that when famine strikes, the hike in prices that could easily be absorbed by a labouring family with a bit of disposable income, was catastrophic for a family already close to the margins in the best of times. The result is starvation, malnutrition, and proneness to disease, unrest, and revolt.

[519] Ladurie, *Peasants of Languedoc,* 40-41.
[520] Knecht, 3.
[521] Mark Konnert, *Early Modern Europe: Age of Religious War, 1559-1715,* (Toronto: University of Toronto Press, 2007), 60.



(**Fig 5.11** Data from Bois 1984, cost of living quadruples in Rouen, index 1464=100)

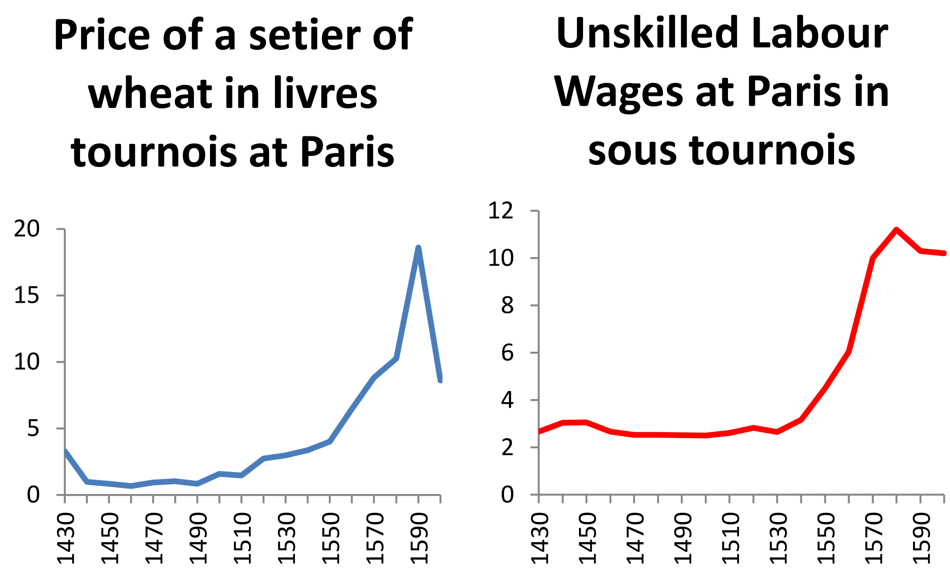
Now we move to the question of incomes. While rural wages are harder to track than urban ones, the fluctuations of urban wages are fairly representative of the standard of living for labour in general because wages in income roughly equivocate with wages received 'in kind' of agricultural goods. In terms of payment in kind, rural wage workers got 10% of the harvest in 1480, 9% in 1525, and 5.5% after 1560, a level of depreciation that accords with what we know of urban wages.[522] The question of whether the real wage is representative of the standard of living of commoners has been thrown into doubt in recent years. The question is complicated by the fact that the poor often used other expedients like woman and child labour and non-market income to supplement the wage of the head of household. This has led scholars like Jan de Vries to claim the seventeenth century was an 'industrious revolution' where people explored all avenues of finding income. However, as Jan van Zanden has pointed out, the wage rate was a substantial part of household income and influential on the strategy of that household. Additionally, a decline in real wages will result in a fall in living

[522] Ladurie, *Peasants of Languedoc*, 98.

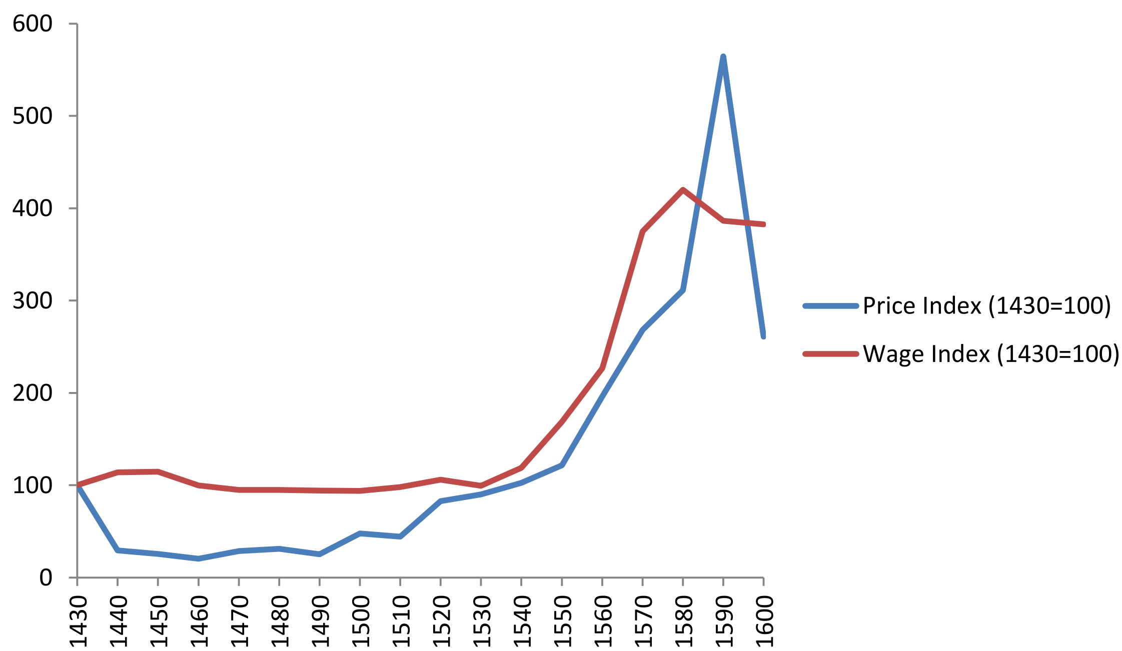
standards because more labour has to be exerted to make up the shortfall. Non-wage activities will also pay less as prices rise and there is more competition between people looking to supplement their incomes. A household may counteract a fall in the real wage by working harder, as De Vries asserts, but this comes at the cost of diminished leisure, overworking, and so forth. The wage level remains probably the best way to analyse the standard of living of working class families in the long run.[523]

Below I take the information provided by prices and wages in Paris and its impact on the standard of living for an unskilled construction labourer. The documentation for Paris was readily available and more reliable than information for rural wages, which are often distorted by the fact that money does not always change hands and payments are often made in kind with agricultural produce. This is especially true of the lowest earners, who are of the greatest interest to us here. While one may argue that urban labourers may have experienced different wage dynamics than workers in the countryside, that does not appear to be the case: the real wage of vineyard workers declined by 60-75% between 1500 and 1560.[524] Therefore it would appear the information of Paris seems roughly indicative of the general rule. I have taken the price of grain per *setier* in livres tournois and calculated the average price per decade to form the graphs below:

[523] Jan Van Zanden, 'Wages and the Standard of Living in Europe, 1500-1800' *European Review of Economic History* (1999) 2:178-179.
[524] Ladurie, *French Peasantry*, 185-186.



(**Fig 5.12** Data from Baulant 1968, 520-540, Baulant 1971, 463-483 and Durand 1966, 468-480)



(**Fig 5.13** Extrapolated from Baulant 1968, 520-540, Baulant 1971, 463-483 and Durand 1966, 468-480)

At first glance it appears wages and prices follow a roughly equivalent rate of inflation. This is not the case. The examination of the fluctuations in prices and wages together permits us to see where there were gaps wages and prices and when they overlapped. The gaps represent a period where the wage rose much faster than prices, indicating an extremely high real wage and prosperous standard of living. The largest such gap existed between 1440 and

1520. This small, seemingly insignificant gap indicates a standard of living for the common people that went unsurpassed until the advent of industry. Food was plentiful, disposable income high, and it enabled a period of unfettered population growth and high sociopolitical stability. After this, one sees a period of rapid inflation during which wages struggled to keep pace with rising food prices. The amount of disposable income of common households shrank considerably. This is the period 1520-1560, which was the stagflation phase of the early modern cycle. As we shall see this period was characterised by increasing food shortages, famines, and rising sociopolitical instability. Finally, the graph illustrates the onset of the first crisis phase of 1570-1600, where wages and prices fall into complete disjuncture, coinciding with a period of state breakdown, massive famine, and depopulation on the order of one-tenth of France.[525]

b) Renaissance Kings & Low Sociopolitical Instability

The lack of sociopolitical instability in the reign of Louis XI (r.1461-1483), 'the Spider King', allowed an unusual degree of power in royal hands. During his twenty-two year reign the tax burden increased from 1.8 million in 1461 to 4.7 million in 1483, with considerable bribes passed out to local elites and towns to ease the collection process.[526] This amount was three times as heavy as any burden on the peasantry levied by Charles VII. And, naturally, the elites were still exempt. Something like this would have been unheard of in the fourteenth or early fifteenth centuries, with their shrinking real wage and widespread impoverishment. Louis XI was not only able to extract an unsurpassed amount of revenue from his subjects but he was also able to renege on his many promises for tax relief. For example, at his coronation

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[525] Micheline Baulant, 'Le prix des grains à Paris de 1431 à 1788' *Annales, Histoire, Sciences Sociales* (1968) 3:520-540 and 'Le salaire des ouvriers du bâtiment à Paris de 1400 à 1726' *Annales, Histoire, Sciences Sociales* (1971) 26:463-483 and Yves Durand 'Recherches sur les salaries des maçons à Paris au XVIIIe siècle' *Revue d'Histoire Économique et Sociale* (1966) 44:468-480.

[526] Martin Wolfe, *The Fiscal System of Renaissance France*, (New Haven: New Haven: Yale University Press, 1972), 54.

in 1461 he pledged to relieve the inhabitants of Reims of its entire tax burden. However, after several months nothing was forthcoming. Louis broke his promise. In reaction, the common people of Reims led a revolt a few months later and drove out the local tax officials.[527] They never received the tax relief promised to them and a lack of elite support made it impossible for the rioters to gain any serious ground.

The reign of Louis XI is characterised by a significant increase in centralised power. It finalised the process by which the semi-independent feudal polities that had competed for supremacy at the turn of the millennium were forged into the greater state of France. Royal power was briefly resisted in the War of the Public Weal in 1465. After some initial fighting, Louis XI quickly sued for peace in October 1465 and concluded the treaties of Conflans and St. Maur. Louis was compelled to agree to the most pathetic and humiliating terms that befitted the elite. His brother Charles got Normandy, along with suzerainty over Eu and Alençon. The duke of Burgundy got Boulogne, Guines, Péronne, and the towns of the Somme. The duke of Brittany got Étampes. Louis XI was also forced to surrender enormous 'pensions' for the dukes of Lorraine and Bourbon and the counts of Armagnac and Dunois. The great magnates of the Second Estate had risen against Louis XI, formed an alliance with his external enemies like the duke of Burgundy, and attempted to revive the feudal autonomy of the past. For a time it looked as though they had succeeded.[528]

Nevertheless, we must not mistake this for state breakdown because soon after the two treaties of October 1465, Louis XI reneged on the terms mentioned above. To reinforce the legitimacy of his actions, he convoked the only Estates-General of his reign in 1468. The deputies of the First and Third Estates were content with their holdings and the state of their incomes and opposed to the revival of large noble landholdings and even urged the king in

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[527] Isambert, X, 422; Victor Duruy, *A History of France*, vol. 1, (Charleston: Bibliobazaar, 2008), 252.
[528] Duruy, 254-260.

case of another noble rebellion to levy taxes and mobilise troops 'without waiting to convoke the Estates' since it was not easy to bring them together.[529] Here in a moment of unity against the Second Estate, the Estates-General, led by the Third Estate, somewhat perversely repudiated one of the primary reasons of their own existence: consent to taxation. Though the *aides* and *gabelle* remained at the same rates, their share in the total revenue of the crown shrank because Louis continued to increase the *taille* to take on a steadily larger portion of the whole. The lack of sociopolitical instability in France during the reign of Louis XI prevented large factions stretching across the elite from forming against him. There was no period of sustained violence or state breakdown as seen in the high medieval crisis phase.

The War of the Public Weal amounts to what Turchin calls a revolt in an expansion phase that was easily put down due to high social cohesion and sociopolitical stability. The whole crisis lasted about a year. Then it slowly fizzled out. Even the external involvement in the revolt was short-lived. In 1477, when the Duke Charles died without a male heir, Louis annexed Burgundy, Nevers, and parts of Flanders and Picardy and increased his wealth even further.[530] Although there was always a great deal of dissent and bitterness in the country about the excruciating levels of taxation, no *parlement*, *pays d'état*, or 'corporate group' of elites were able to force Louis XI to lower his taxes. Even though it would likely have been the will of his subjects, in light of the threefold increase of taxation and the clamour for reduction after his death, Louis had control. The others did not. There is no plainer example of the will of a king trumping the wishes of his country, with the renewed prosperity of an expansion phase playing a central role. With France in the middle of a vigorous growth phase, with the standard of living of the commoners being higher than it had been in centuries, or

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[529] Georges Picot, *Histoire des États Généraux*, (Paris: Hachette, 1888), I, 342.
[530] Knecht, 28.

indeed higher than it would be until the nineteenth century, there was not much stomach for rebellion, not least because so many stomachs were full.

On the other hand, when Louis XI died in 1483, Charles VIII (r.1483-98) was a minor. His regent was his sister, Anne of Beaujeu. Like all regencies – especially female regencies – there was a significant challenge to her power. It took a weak regency for all the frustrations and outrage at Louis XI's tax policy, which had been latent for twenty-two years, to boil over. An Estates-General was called in 1484 to deal with dissent, address grievances, and win support for the regency. The foremost of their demands was to abolish the arbitrary *taille*. The regency government agreed to cut taxes, reduce the size of the army, reduce pensions to favourites, and to remove several officials, all of which is somewhat reminiscent of the demands imposed by the Estates-General of 1355 and 1357. The Estates also demanded back the right of consent to taxation. After fierce negotiations, the *taille* was not abolished, but reduced only. The amount shrank from 4.5 million to 1.5 million *livres*. The Estates did not gain the right to consent to this levy.[531]

On the surface this appears to be a victory for the Estates. In fact, it was a colossal and unmitigated failure. The amount of taxation may have been reduced, but as has been stated a number of times before, the issue is not so much the amount the people are taxed but *how* they are taxed. Consent to the *taille* was not re-established. As such the Estates did not gain a tool by which they could have demanded regular meetings. As such, the regency felt no compulsion to call another Estates-General in 1486, as the assembly had demanded and the regency had agreed in 1484. The government had the money, and therefore did not need to address the grievances of a representative assembly. The Estates-General was not called again until 1560 – three quarters of a century later, when the population had hit a Malthusian wall,

[531]Knecht, 23-25.

when elite incomes began to shrink, when sociopolitical instability was on the rise, and a disintegrative phase began anew.

The Mad War, 1487-1488, was a largely externally driven conflict directed at the Beaujeus, with Brittany (then independent) being a safe haven for elite rivals to the crown. However, the crown really had no trouble putting it down, with the colluding French elites being swiftly crushed. Wars with Brittany, which fall under the category of external warfare, continued until 1491, when Charles VIII married Anne of Brittany and began the long process of annexation through marriage that was finalised under Francis I (r.1515-1547). Other external wars included the Italian wars, begun in 1494 that would persist on and off until Cateau-Cambrésis in 1559. Additionally, Provence was formally annexed in 1486, after being inherited in 1481.[532] Occasional revolts 1450-1500 were not symptomatic of a crisis phase, which sees revolts intensify and the government's revenues being increasingly unable to cope with the pressure. Overall, the kingdom was immensely prosperous and incomes were growing across the board. Nowhere is this more firmly demonstrated than by the reign of Louis XII (r.1498-1515), who oversaw a period of low taxes and general prosperity. Combined with an expansion phase, Louis XII also reduced the *taille* and kept it low by avoiding excessive expenditure at court and reducing gifts and pensions to his elite subjects. Combined with the fruits of an expansion phase, it is no wonder that Louis XII became one of the most popular and well regarded monarchs in French history.

Francis I (r.1515-1547) experienced a relatively stable reign as well, despite his heavy-handed approach to leadership and the increase of taxation under Francis to fight his many wars. Ruling during the twilight of the expansion phase, he faced increasing discontent among the common population from the 1520s onward, but no great threat from factionalism during

[532] Knecht, 25-30.

his reign. The biggest elite rebellions against his power were easily crushed. The most powerful subject in France after the king was the duke of Bourbon. He controlled three duchies, seven counties, two viscounties, and seven seigneuries in central France. In 1522 and 1523, Bourbon collaborated with foreign powers, England and Habsburgs, seeking to invade France. His plot failed and the invasions sputtered out, Bourbon was forced to fleet and the king officially annexed all of Bourbon's lands in 1527.[533] The second major challenge to royal power was the *parlement* of Paris refusing to ratify the Concordat of Bologna, which effectively abolished the Pragmatic Sanction of Bourges and was a slap in the face for Gallicanism and the independence of the French church from Rome. The *parlement* of Paris gave Louise, the regent after Francis I was captured at Pavia, a very hard time and flouted her directives, but swiftly after the king's return, Francis humiliated the *parlement* and forced the ratification of the Concordat via a *lit de justice*, a ceremony where the king can coerce the passage of a law. At no point did these two incidents threaten widespread violence or state breakdown. Francis I's reign fell in a stagflation phase, and elite unrest was even milder than it had been under Louis XI or Charles VIII. In fact, the entire period is one of the most stable the French monarchy ever experienced and no upheaval in these years was comparable to the cataract of disaster awaiting the French after 1560. The quarrels of the reigns of Louis XI, Charles VIII, Louis XII, and Francis I pale in comparison to that period of upheaval, faction, civil war, and regicide,

The removal of Burgundy as a serious threat to the French crown along with the pacification of Brittany and the tranquillity and wealth of the expansion phase, allowed France to engage in a campaign of expansion. Italy was the goal. From 1494 to 1504, Charles VIII and his successor Louis XII made some very successful attempts to dominate the entire Italian

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[533] Knecht, 94 & 115.

peninsula in a very short space of time, but unfortunately met with serious reverses that hurled the French out of Italy again. The biggest problem was that France was not the only country enjoying an expansion phase that facilitated territorial ambition. The greatest opponent of France was Spain, which was on the rise and soon to become, for a time, the most powerful force in early modern Europe. The interests of two vastly powerful entities slammed up against each other in Italy, with states like Venice and the Papacy switching sides once they became alarmed at Spain or France becoming too powerful. The conflict spilled over again in 1508, with England, the Holy Roman Empire, Venice, and the Swiss, conducting a game of alliance between France and Spain. Francis I at the beginning of his reign delivered a great victory at Marignano in 1515, bringing Italy under French and Venetian control.

In the following decade, these fortunes were reversed yet again. The combination of Spain and the Holy Roman Empire in the person of Charles V of Habsburg challenged French influence. Two successive wars saw the massive defeat at Pavia, the capture of Francis I, the French unceremoniously thrown out of Italy, and the peninsula falling under Habsburg domination by the end of the 1520s. No fewer than three more decades saw the French and Habsburgs fight an increasingly exhausting battle over Italy, carrying past the death of Francis I and the accession of Henry II (r.1547-1559), and ending almost exactly with the beginning of the early modern crisis phase in 1560. In that sense there is a form of symmetry in the Peace of Cateau-Cambrésis, for it signalled not only the end of war with Spain, but the end of French attempts to aggrandise themselves abroad and the beginning of their collapse into domestic anarchy. Additionally, the cessation of all population growth and France’s entry into the crisis phase of the early modern cycle can both be dated roughly around 1560. It is a grim form of symmetry.

c) The Peak of the Early Modern Cycle

We must turn our attentions to the decline of France's fortunes in the stagflation phase of the Early Modern cycle. The south peaked earlier than the north, the food crises of 1526-1535 marking a turning point. From 1450-1500, the peasantry had gotten used to eating meat on a regular basis. Then with overpopulation, particularly after 1520, farmers focused on grain yields and neglected livestock, meaning that the peasantry by and large stopped eating meat again. Increasing malnutrition was the result.[534] Vagrancy grew by leaps and bounds, and Protestant propaganda found greater sympathy with a starving peasantry against an allegedly wealthy and gluttonous clergy. In Provence, Languedoc, and the Auvergne, and other regions of the south the population growth ended around 1540.[535]

The north was not immune either, with food shortages hitting places like Brie and the Ile-de-France as early as the 1520-1525.[536] There was a terrible famine in Normandy between 1545 and 1546.[537] Bad harvests in the Ile-de-France occurred between 1551 and 1552 and 1555-1556, with plague intervening in 1553.[538] Across the north, from Brittany, to the Ile-de-France, to the eastern border, population growth had ceased by 1560.[539] Due to overpopulation, after 1520 about 80% of the French peasantry owned less than 5 ha of farmland. Anything less than 5 ha meant they could not eke out a subsistence living on their own land and had to sell their lands or supplement their harvest with wage labour. Middling landholdings disappeared rapidly by 1560, with an increase in vagrancy and begging, and a

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534 Ladurie, *Peasants of Languedoc*, 137-141.
535 Baratier, 75-81, Bautier, :255-268. Charbonnier, 843-855, Ladurie, *Peasants of Languedoc*, 54-56 & 73-76.
536 Knecht, 136.
537 Bois, *Crisis of Feudalism*, 11.
538 Barbara Diefendorf, *Beneath the Cross: Catholics and Huguenots in Sixteenth Century Paris*, (Oxford: Oxford University Press, 1991), 21.
539 Potter, 22-24, Neveux, 167-78 &186-93, Croix, 161-170 & 221-224, Belotte, 146, Fourquin, 443.

decline in the availability of employment and by extension the likelihood of an increase in wages.[540]

Where middling landowners in the fifteenth century had owned 10 ha, the average peasant in the Paris region owned no more than 1.3 ha by 1560, a pathetic amount that could not sustain a family.[541] Increasing poverty is reflected in the inauguration of the *bureau des pauvres* in 1544 to distribute poor relief and medical treatment and the conscription of sturdy beggars to work on public infrastructure. By 1551, in Paris the numbers receiving assistance from the *bureau des pauvres* tripled since its inauguration.[542]

The standard of living of the commoners dropped during the stagflation period and revolts commenced after the 1520s, with the popular revolts in 1522 in the Ile-de-France, the grain revolt at Agen in 1528, the brutally suppressed *Grande Rebeyne* of 1529 in Lyon, that was directly motivated by wages falling behind prices, or the violent strikes at Lyon a decade later in 1539. By the 1540s, public discontent reached epidemic proportions. In 1542, a grain ship docking at Rouen was attacked and plundered by the townspeople – they were not all paupers and there was not a famine that year – but the raid was prompted by high prices and a declining real wage. There was another riot at Rouen when the public charities ran out of funds there. The salt tax revolt of 1542 spread over much of the west of France and riots followed again in 1548 at Angoumois and Saintonge, where the rebellion numbered as much as 20,000 people with crown officers being brutally murdered and covered with salt as a sign of contempt. The strain people were feeling was not aided by the grain famine of 1545.[543]

[540] Briggs, 7.
[541] Ladurie, *French Peasantry*, 162.
[542] Diefendorf, 20.
[543] Knecht, 135-136, 179-180, 209-210, & 260-263.

The first major outbreaks of religious violence began in 1557, notably coinciding with the downturn in the secular cycle.[544] Protestantism had been spreading across France as early as 1519, but as conditions deteriorated, suddenly religious dissent or the reinforcement of Catholic orthodoxy became outlets for increased intra-elite violence. During the summer of 1562 there had been another subsistence crisis due to poor weather that was exacerbated by another outbreak of the plague, leading to a death toll estimated in the thousands. Another bad year occurred in 1564, with rain rotting crops in the summer and the winter being so cold that wine froze in the cellars (and alcohol has a lower freezing point than water) and peasants died of exposure in the fields. France was hit hard again in 1565, with a poor harvest and high prices high. In 1566, rain destroyed the harvest yet again. Prices rose even higher, grain riots occurred with barns and homes ransacked with the mob looking for private stores and merchants and bakers being threatened.[545] During the period from c.1540-1570, the population reached its high-water mark of 20 million, or roughly the level of the population prior to the Black Death.[546] The perceived strain on the carrying capacity by 1560 indicates there were no significant productivity-raising innovations since the medieval period. There was a return to the conditions of the late 1200s and early 1300s. Wages stagnated, prices rose, the demand for labour shrank, and peasants found it increasingly difficult to eke out a subsistence living off their increasingly fragmenting land. The difference was that this time there would be no Black Death. Everything else remained much the same. Cereal production had not advanced much since the fourteenth century, increasing by perhaps a mere fraction in terms of total output, and wine had not yet made the dramatic leap into large-scale commercial production.[547]

[544] Diefendorf, 7.
[545] Diefendorf, 74.
[546] Braudel, 172.
[547] Ladurie, *French Peasantry*, 185.

d) Elite Dynamics

On the other hand, the years between 1500 and 1550 were quite prosperous for large numbers of the French elite. An oversupply of labour meant they did not have to pay as much for wages and fragmentation of land meant they could purchase more from struggling peasants. The house of La Trémoille expanded its revenues by 220% from the fifteenth century. The annual income of Montmorency increased tenfold between the years 1524 and 1564. By 1550, the Cardinal of Lorraine and the dukes of Guise and Nevers were all extraordinarily rich. These beneficiaries of the stagflation phase would become the leaders of the factions of the period of elite infighting.[548] Wealth stratification also happened at lower levels of the elite. Certain *fermiers* whose rents were fixed by custom, like in Languedoc, paid low wages and rents, but gained a lot of profit due to the rise in food prices. This hurled record numbers into the elite. Landowners higher up the hierarchy also did well between 1520 and 1550, in places where rents were not fixed, particularly in Poitou and Ile-de-France. In fact, in 1550 rents reached a level higher than anything reached in the seventeenth century.[549] Finally, landowners and urban bourgeoisie were able to buy up a great deal of land after 1530, when subdivision among the peasantry meant they could not sustain themselves on plots 5 ha or less. This meant that after 1530, land and wealth once again became increasingly concentrated within the hands of the few and the inequality gap widened.[550] In short, the rich got richer and the poor got poorer.

Increasing wealth stratification combined with the breeding of wealthy families made elite numbers grow. In 1500, the nobility numbered 120,000-200,000 individuals of varying states of wealth and the clergy totalled 100,000, with 100 bishops and 30,000 parish priests,

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[548] Potter, *A History of France*, 179-181, Carpentier and Le Mené, 468, and also Figure 29.
[549]
[550] Knecht, 261-262.

along with a surprising number of clergy without a benefice.[551] Nobles hogged the vast majority of appointments to benefices. From 1516-1789, there were 1289 appointments, of which 95% were given to members of the nobility.[552] In terms of background, the First and Second Estate were as overlapped. According to the figures, the total number of the first and second estates amounted to 1.3-1.8% of the French population in 1500, or the reasonably stable levels that had existed since about 1450. The highest estimate of 1.8% begins to approach levels of elite overpopulation that would characterise a stagflation period, so it is possible that level was reached sometime after 1500. However, 1.8% remains a high estimate for the period and it is much more likely such a percentage of the population was only reached closer to 1530 rather than 1500. The onset of the stagflation phase saw the size of the French court grow 15% from around 1520 to 1535, and increased competition and conspicuous consumption increased the total wages paid to favourites, officers, staff, and artisans increased by 229%.[553] We also know that the first major sales of government offices purely for profit began under Francis I. During his reign, he sold about 5000 in order to fund the increasingly exhausting series of wars with Spain and the Holy Roman Empire.

With the inclusion of wealthy *fermiers* and urban bourgeois who neither possessed a title nor belonged to the clergy, it is highly likely that by the Wars of Religion, when income from rents began to decline, elite numbers had reached crisis levels. We do know that certain levels of the aristocracy, the middling chevaliers and the highest stratum of duke-peers, increased by 66-100% between 1500 and 1580.[554] Taking the lower rate of growth as representative of the elite class as a whole, an extremely low estimate, this implies elite

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[551] Contamine, *La noblesse au royaume de France de Philippe le Bel à Louis XII: Essai de synthèse,* (Paris: Presses Universitaires, de France, 1997), 57, and Knecht, 10-11.
[552] Gwyne Lewis, *France, 1715-1804: Power and the People,* (London: Pearson Longman, 2005), 18.
[553] Knecht, 154.
[554] Manfred Orlea, *La noblesse aux États Généraux de 1576 et de 1588: Étude politique et sociale*, (Paris: Presses Universitaires de France, 1980), 59 and Jean-Pierre Labatut, *Les duc et pairs de France au XVIIe siècle,* (Paris: Presses Universitaires de France 1972), 61.

numbers had grown to around 2.9% of the population, or levels that would precipitate a crisis should the population decline and the social pyramid become top-heavy again. This would certainly explain the growing rivalry between nobles in the court of Henry II in the 1550s and the bitter fighting between elite factions that outstripped anything seen in the medieval period. Approximately 50% of the elite were Protestant by this time, having arranged themselves into a powerful faction led by the likes of Montmorency, Condé, Coligny, and the house of Bourbon and further backed up by about 10% of the French population, or 2 million people, who had organised themselves into about 1000 churches.[555] They faced down an equally fierce contingent of Catholics led by Lorraine, Guise, and Nevers.

Of the fact that the revenues of some French elites went into decline there is little doubt. The question that has dominated the historiography is exactly how this happened and in what sections of the elite it manifested itself. The old thesis is that land revenues declined in the 1550s and 1560s and many elites could no longer afford the lifestyle that maintained their status, while at the same time the rising bourgeoisie swelled elite numbers and led to competition between the old and new nobility for resources. [556] But of course the idea that old nobility declined *en masse* is wrong. In any form of competition there are winners and there are losers, and these issues are decided on an individual basis, not by social order or class. Some elites, particularly at the higher end of the spectrum, did very well out of the crisis phase, though their incomes did not grow as quickly as they did a few decades earlier.

But as a general rule, when people started dying in large numbers, segments of both the new and old money saw their incomes decline. And to be sure, the conventional historical antithesis to the 'nobility in crisis' and new vs. old dichotomy frames itself along these lines,

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[555] Konnert, 100.

[556] See Lucien Romier, *Le royaume de Catherine de Medicis: La France à la veille des guerres de religion*, (Paris: Perrin, 1922), Gaston Roupnel, *La ville et la campagne au XVII siècle*, (Paris: Club des Libraires de France, 1955), and Davis Bitton, *The French Nobility in Crisis: 1560-1640*, (Stanford: Stanford University Press, 1969).

though without the talk of secular cycles. Historians have pointed out that the decline did not apply to all the nobility but that stratification made some of the old nobility exceedingly rich while others became poor. For instance, at Bayeux it has been proven that many old noble families persisted alongside new ones, and many old noble families made the transition to the *noblesse de robe* alongside those of new money.[557] This does not contradict the thesis of competition or the idea that this competition was responsible for the elite infighting that happened after 1560. The crucial division is not between old and new nobility, but between rich and poor nobility. The core problem was there were too many elites, both noble and non-noble, by 1560, while prices were rising and many incomes were declining. This was a recipe for disaster. Where the theory of population cycles innovates in the historiographical debate is by offering a possible explanation of what happened next and why.

The rivalries that emerged under Henry II came at a time when royal revenues had stagnated, which made it difficult to quell or control the growing sociopolitical instability that was emerging. Tax revenues remained at the same level as they were under Francis I, but price inflation had whittled away their actual value. At the Treaty of Cateau-Cambrésis in 1559, the French royal debt was 43 million livres, approximately three times the yearly income and with an interest rate that was nearly two-thirds of the size of the yearly income.[558] Meanwhile the increased number of elites, the growth of the wealth of the topmost few, made keeping them loyal more expensive. The cost of royal patronage had grown by leaps and bounds. Combined with the elite dynamics of the stagflation phase and the overriding demand to sell more offices to pay for wars meant that the crown was giving out more and more to its acolytes. Constable Montmorency earned an income from his estate and from royal favours

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[557] See J.B. Wood, *The Nobility of the Election of Bayeux: Continuity Through Change*, (Princeton: Princeton University Press, 1980), pg 48.

[558] Mack Holt, ‘The Kingdom of France in the Sixteenth Century’ in *Renaissance and Reformation France: 1500-1648*, ed. Mack Holt, (Oxford: Oxford University Press, 2002), 19.

that amounted to 180,000 livres per year – the largest income in France outside of the royal family. Other elite incomes were equally sizeable, but as Mack Holt has pointed out the incomes at the top like Montmorency's made other elites jealous and intensified competition.[559]

Stratification among the elite became a real problem. The top 300 families of France earned 50,000-200,000 livres annually, or even more in some instances, whereas the lowest rungs of the traditional nobility earned less than 1,000 livres.[560] A growing number of noblemen became *hobereaux*, or impoverished noblemen who, except for their lineage, were virtually indistinguishable from labourers or even vagrants. In Brittany, Normandy, Ile-de-France, the Orléannais, Champagne, and numerous other places in northern France, legal custom dictated equal division of property among all the heirs. This exacerbated the problem that was already under way. In the south, most of the property was given to the eldest son, and this served to make the phenomenon less severe.[561] Nevertheless as decades passed in the sixteenth century, the process of enrichment and impoverishment of noble families caused a decline in many elite standards of living – particularly after 1560. In every class, there were winners and there were losers. And due to the dynamics of the time, most nobles were the latter.

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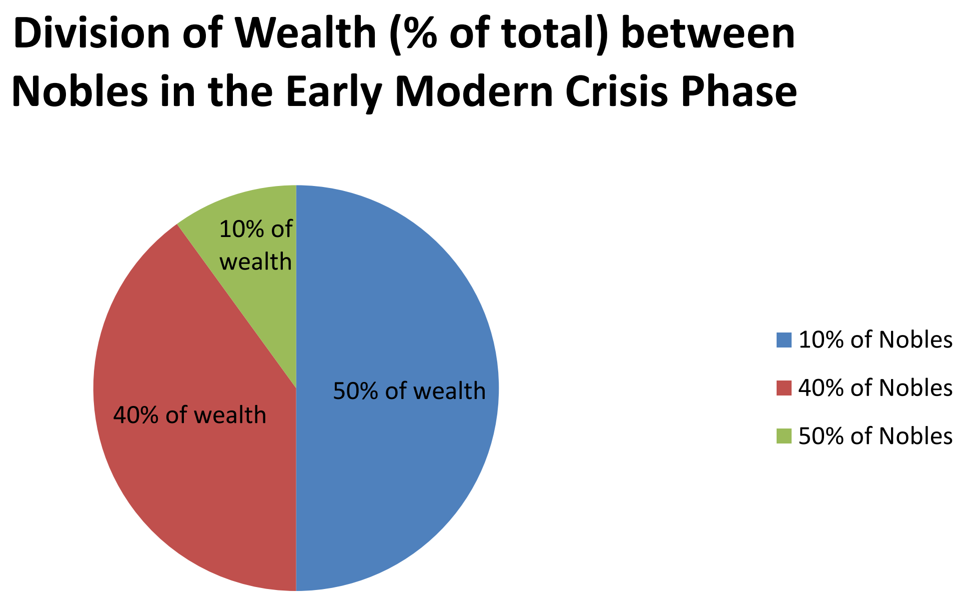
[559] Holt, 20-21.
[560] Lewis, 69.
[561] Holt, 22.



(**Fig 5.14** Data from Wood 1980, share of wealth among nobles at Bayeux)

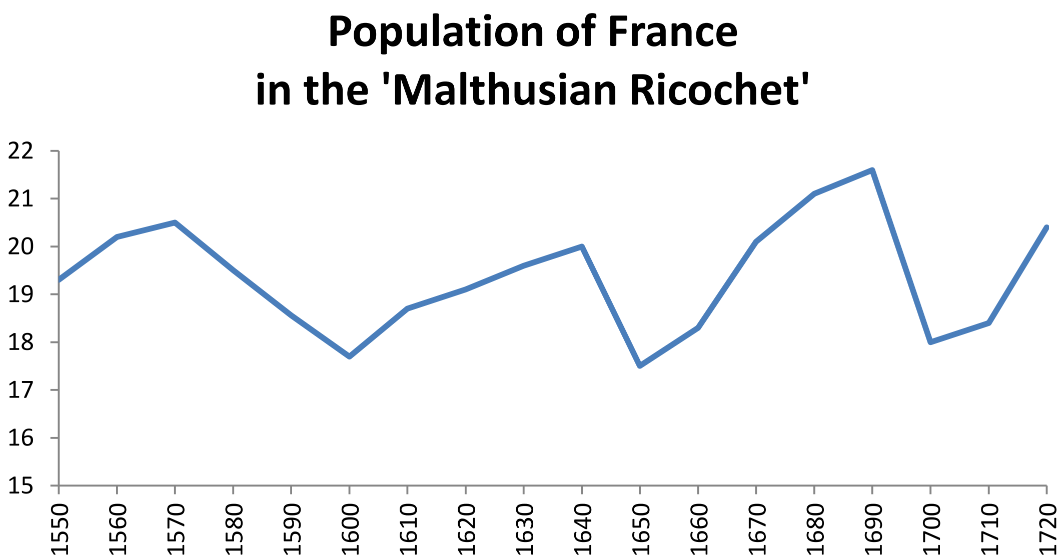
While land fragmented in the hands of the vast majority of nobles, a cadre of others who were well placed were able to take advantage of the situation and expand their holdings. The result was an exorbitant amount of wealth being held by a small fraction of the nobility. Other regions that have been surveyed – Beauce, Auvergne, Toulouse, Dauphiné, Poitou – also demonstrate similar trends.[562] Taken as representative of the whole, including various ranks of clergy and wealthy bourgeois, and adjusting for population growth and the rate of elite inflation, say between 2.25 and 2.9%, then of the total number of elites in France around 1560, there would have been between 45,000 and 58,000 hyper-rich, 180-230,000 of middling wealth, and around 225-290,000 elites that were dirt poor.

[562] Knecht, 271.

e) Sociopolitical Instability

The demographic shift impoverished many elites and they began to compete with each other and the state, which was growing increasingly strained and unable to deal with them. Factionalism erupted in the form of Protestantism and also the radicalisation of Catholics who reacted to it. Some Protestant conversions were sincere, a result of cultural transmission; others were cynical, like lesser nobles converting because their patrons did. Disaffected nobles sometimes converted to legitimise their rebellion. However it is not as simple as poor nobles joining the Protestant movement and rich ones staying loyal, since profit could be found by cooperating on both sides, whether it was the Huguenots or Catholic League. There is more to the selection of beliefs than mere historical materialism. As the foremost of the elite made a play for power, some very prominent Huguenots sprang up among the nobility, dominating the Bourbon family, the closest relatives and rivals of the Valois. The future Henry IV was the product of the marriage of Jeanne, a sincere Protestant and Queen of Navarre and Antoine de Bourbon. Joining him at the head of the Huguenots was Louis, prince of Condé and Gaspard de Coligny, Admiral of France.

While Henry II was alive he ruled alongside both extreme Catholics, personified by the Guise family, and staunch Huguenots like the houses of Bourbon and Montmorency. A jousting accident in 1559, held to celebrate the Peace of Cateau-Cambrésis removed Henry II from the scene, dead at age 40. He had hitherto kept the Protestant and Catholic factions in balance. Francis II (r.1560) did not. This sickly, weak-willed youth, was dominated by the Guise faction, who wasted no time stepping up the persecution of Huguenots. The Montmorencys, the Bourbons, and their acolytes found themselves out of power. In March 1560, they tried to kidnap Francis II to ‘get him away’ from his ‘evil advisors’. The botched attempt became known as the Tumult of Amboise, in which the Guises summarily executed several hundred conspirators. Louis of Condé was sentenced to death, but before his execution, he was saved by the death of Francis II. The accession of Charles IX (r.1560-1574), a boy of ten, and his regent Catherine de Medici, set the stage for the collapse of social cohesion, and the first of a series of waves of sociopolitical instability, famine, civil war, and death.



(**Fig 5.15** The 'Malthusian Ricochet', straddling the carrying capacity, from Dupâquier 1988)

Sociopolitical Instability in France, 1557-1653 AD

Year	*Event*
1557-58	First large scale religious riots following a string of years of famine, with several dozen major events, a large proportion happening around Paris.
1559	Henry II intensifies his persecution of Calvinists, culminating with the arrest of five magistrates
1559-60	Francis II succeeds to the throne, ruled by the Catholic faction, people arrested, put to 'the question', burned, mutilated, and their bodies dragged through the streets, those rumoured to be Protestant were assaulted by disorganised mobs
1561	Huguenots faction begins fighting back, riots now instigated by Protestants
1562	Massacre at Vassy and first war of religion
1563	Assassination of the duke of Guise and second war of religion
1567-70	Period of stalemate and sparse infighting between factions, followed by peace
1572	Truce broken by an assassination attempt on Coligny, gates of Paris shut, and 2000 Protestants massacred with a further 3000 murdered elsewhere in the country
1572-76	Outright warfare, emergence of a third faction under the duke of Alençon

1576-80	A failed peace attempt and more infighting
1584-89	Death of Alençon, fighting between the two major factions, assassination of both the younger duke of Guise and Henry III
1590-98	A period of severe infighting in which the Protestant faction slowly gained the upper hand and crushed the radical Catholic faction; the conversion of the king and the Edict of Nantes inaugurates compromise and peace
1610-14	Henry IV assassinated, a new round of factionalism erupts between the camp of Marie de Medici and Concini and other nobles who threaten an uprising
1620-29	Louis XIII at war with the Huguenots faction
1630-43	Uneasy tension between factions of the *dévots* and the crown
1643-53	Population downturn and the second wave of severe infighting
1649	Revolt of the judges of Paris, joined by revolt of the nobles
1650-53	Period of severe infighting that devastates the population of the north

(**Table 5.2** Diefendorf 1991, Konnert 2007)

By 1561, Huguenots were getting more aggressive. They constituted roughly 2 million people and 50% of the nobility. They were also meeting more openly than before. One such service outside St. Antoine contained 8,000-9,000 people during the fall, provoking massive outrage and a wave of arrests. It is also clear at this point that the Huguenots started fighting back, with numerous clashes in 1561, some of which were quite arguably instigated by Huguenots themselves.[563] The regency sponsored the colloquy of Poissy, a failed attempt to reconcile Catholic and Huguenot. It also issued an Edict of Saint-Germain in January 1562, which allowed the toleration of limited Protestant worship as a sop to the Montmorency-Bourbon faction. The government of Charles IX then set about the arduous task of keeping the increasingly belligerent Catholic and Protestant factions from each other's throats in a period of the secular cycle during which we would predict that social cohesion was rapidly deteriorating. In March 1562, the Guise faction interrupted a Protestant service and killed a number of worshippers. This happened at Vassy and was soon mimicked in other towns, inaugurating the first 'war' of religion. The Huguenots took up arms and the rest of the year was spent in minor skirmishing. In February 1563, the duke of Guise was assassinated, no doubt by someone in the Protestant faction. Rumour implicated Admiral Coligny. Fighting

[563] Diefendorf, 61-62.

continued until the Peace of Amboise (1564). Two subsequent 'wars' of religion followed in 1567 and 1570, interspersed with a brief truce, and with most fighting being sparse and fairly minor in comparison to later periods.

Another peace in 1570 saw more concessions to the Huguenots and a renewed desire of the government for stability. Charles IX and Catherine sought to reconcile the two factions in 1572, with the marriage of princess Marguerite to the Protestant Henry of Navarre (future Henry IV). Four days after the wedding, there was an assassination attempt on the head of the Huguenot movement, Admiral Coligny (Condé was killed in battle in 1569). The Protestants who were in the city became angry, and the duke of Guise capitalised on the fear to convince the king and his mother to wipe them out while they had the chance. Coligny was murdered in his bed and 2000 Huguenots were murdered in Paris; the city gates were shut and the massacre proceeded for a week. Similar massacres were staged elsewhere in France and all told 5000 Huguenots were killed.[564] Here opens a more brutal phase of elite infighting, during which the Huguenots, previously nominally loyal to the king, split openly with him and competed against the government and the Catholic faction combined. War raged between 1572 and 1576, with Charles IX dying in 1574 and being replaced by his brother Henry III (r.1574-1589).

The south and west were under Huguenot control, most notably the massive fortresses of Montpellier and La Rochelle. Both Charles IX and Henry III sold church land in order to make up the shortfall of tax revenues and keep up their end during elite competition for resources. This had the result of driving the clergy further into factionalism and the hands of the Catholic League.[565] A third faction emerged under the heir presumptive, Francis, duke of Alençon and Anjou, and brother of Henry III. They were Catholics who wanted peace and

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[564] Konnert, 106.
[565] Ladurie, *French Peasantry*, 239-240

limited toleration of the Huguenots. This third faction brokered the truce of 1576 and the Estates-General of Blois in the same year. Nevertheless it failed due to an increasingly militant Catholic faction, who dominated the Estates-General and more conflict continued until 1580, when both sides exhausted themselves. Then in 1584, the duke of Alençon and Anjou died, with the Protestant Henry of Navarre becoming heir to Henry III. The Catholic League refused to recognise this and elected their own heir, the Cardinal de Bourbon, and made a treaty with Spain, whereby Philip II began to subsidise the Guise faction.

Henry III meanwhile began to compete with the increasingly popular Catholic faction and turned against them. In 1588, he even went as far as to murder the duke of Guise. This was his undoing. He was denounced by the Catholics and excommunicated by the pope. Henry III had no choice but to ally with the Huguenots, but was assassinated while trying to besiege Paris in 1589. The Protestant Henry IV thereby became king. The Catholic faction could not accept this. War continued with Henry IV gaining decisive victories at Arques in 1589 and Ivry in 1591. But even then Spain intervened to prevent his outright victory for a number of years. The Catholics were split between radicals and moderates. The Cardinal de Bourbon died in 1590 depriving them of an alternative heir. In 1593, the Catholics considered a Spanish princess, but many Catholics were against the idea. And thus at this moment, Henry IV announced he would convert to Catholicism. This killed the major objection to his succession stone dead. There was a catastrophic famine in 1596-1597 that significantly lowered the population by 1 or 1.5 million people. By 1598, the Catholic hardliners were subdued and the Spanish were expelled from France. The combination of war and famine had cost approximately 3 million lives. It would appear that a combination of demographic decline and exhaustion relieved some pressure and a brief recovery ensued.

f) Population Dynamics of the 'Malthusian Ricochet'

The crisis phase of the Early Modern cycle proceeded in three waves as the French population 'ricocheted' off the carrying capacity. The population of France in 1550 was about 19.3 million peaking at perhaps 20.2 million or 20.5 million between 1560 and 1570. By 1600, the population of France had declined to 17.7 million people, amounting to a loss of 2.8 million people as a result of the combination of famine and sociopolitical instability that characterised the Wars of Religion.[566] 1587 and 1596-1597 were particularly bad years for famine that was caused by military movements.[567] During 1596-1603, an outbreak of plague, not as virulent as the Black Death, but nevertheless severe, had killed 500,000 people on the Atlantic coast.[568] With a loss of around 2.8 million, this means the period of population decline and elite infighting reduced the French population by roughly 13.7%. This was just the first wave. The bulk of the share of that decline was absorbed by the south. That region not only endured severe population strain about twenty years earlier than the north, but also housed the most Protestant dominated areas and suffered the worst fighting of the Wars of Religion. This is not a coincidence. The south lost quite a lot of people in the Wars of Religion. The north peaked earlier in the next wave and the north was hit hardest in the Fronde while the south escaped some of the worst fighting. Then the country realigned and the famines of Louis XIV were borne evenly by both north and south France.

It would appear there is a correlation between when a population peaks and the amount of sociopolitical instability and violence that occurs on their soil. Extrapolating from the distribution percentages of Dewald and Vardi, cited earlier in the chapter, we know that with a population of roughly 20 million, the distribution would be as follows: 7 million living west of Cherbourg peninsula and north of the Loire, 5 million living in western Normandy, Anjou,

[566] Dupâquier et al, 2:60.
[567] Dupâquier et al, 2:195.
[568] Konnert, 27.

Maine, and Brittany north of the Loire, leading to a combination of 12 million people in the north of France. The south contained 8 million with 3 living in Pyrenees, Alps, and Centre, and 5 living in south proper (i.e. Languedoc, Provence, etc).[569] Of that at least half of the losses of the Wars of Religion, or 1.4 million people, would have been borne by the south. The ratio is undoubtedly higher, perhaps closer to two-thirds. This translates into a loss of between 17.5 and 22.5% of the population of the south, higher than the national average of 13.7% but lower than the high medieval losses ranging anywhere between 30-50% and even 75% in some areas. The result was that in the second wave of disaster, the Fronde, the south was still enjoying a recovery phase while the north had already peaked. The south escaped relatively unscathed and continued to grow until stagnation set in later in the seventeenth century. Intriguingly, some of the most loyal members of society during the Fronde were the southern Protestants.

After 1560, the population did not decline as radically as in the medieval period, at the absolute most incurring a loss of about 3 million before enjoying a brief recovery.[570] The major difference, of course, was there was neither an epidemic on the scale of the Black Death nor any major external war being fought on French soil. It would appear that minus the influence of exogenous variables, demographic crisis and elite infighting costs a population somewhere between 10 and 15%. This pales in comparison to the loss of a full 50% of the population during 1315-1450. As a result of the smaller loss, the population required less time to recover.

After the High Medieval cycle, the population took approximately 110 years to reach the carrying capacity again – and even that was at a remarkable rate of growth unsurpassed until the Industrial Revolution. Yet the early modern cycle saw oscillations between crisis and

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[569] Dewald and Vardi, 'The Peasantries of France, 1400-1789', 22-23.
[570] Ladurie, *French Peasantry*, 14.

recovery every forty years or so. Instead of the smooth progress from expansion, stagflation, crisis, depression that Peter Turchin placed on a 300 year timeline, the early modern cycle saw the population straddle the carrying capacity and endure wave after wave of crisis and recovery.

The major factor in this chronology was that in the demographic crisis and the elite infighting that followed it there was 'insufficient death' to inaugurate another long-running expansion phase. The disintegrative half of the early modern cycle cannot be neatly divided into two phases. It was a series of three mini-waves consistently hitting the carrying capacity without significantly reducing the population thereafter – a drop of a few million at most. This was made up within a few decades. The three mini-waves of crisis and recovery can be dated 1560-1630, 1630-1675, 1675-1720. Afterward we see the beginning of exponential growth as the carrying capacity was slowly raised, though not always keeping pace with the rise in food prices, state debt, or rise in taxation.

g) War & Peace & War in the Malthusian Ricochet

The period 1598-1610 was a recovery period for the French kingdom, along with a strained and less prosperous period of growth c.1620-1640. During the reign of Henry IV, however, the population recovered as did the royal finances under the guidance of the finance minister, Sully, and the harvests in these years were mercifully stable as well. Henry IV took a special interest in the average standard of living, once famously stating that he wished for every family to have a chicken in its pot on Sunday, earning him the nickname *roi poule-au-pôt*. He also tried to avoid open conflict with France's greatest rival at the time, Habsburg Spain, to keep expenses down and to mollify the pro-Spanish, extreme Catholic party at court, for although conditions were much improved in the recovery period of 1600-1610, with lower prices, decent wages, and an improved standard of living, they were nowhere near the standard of an expansion phase or stagflation phase.

Elite factions remained, and popular discontent was simmering and not extinguished. In 1610, when Henry IV appeared to be making moves toward war with Spain, he was assassinated by a religious zealot and deluded madman, François Ravaillac. By the end of the reign of Henry IV in 1610, the French population, north and south within the *limites actuelles*, had recovered to roughly 18.7 million people in the twelve years of stability following the Edict of Nantes.[571] The population would continue to recover through the next few decades before hitting the carrying capacity and plunging into disaster once again.

Louis XIII (r.1610-1643) had ascended the throne a minor, and a female regency was set up under Marie de Medici, who dismissed Sully but kept all other of her late husband's ministers and reaffirmed the Edict of Nantes. The 1610s were still part of a recovery phase where prices were relatively low and wages remained stable. The years still were not as prosperous as the previous decade, however, and as the decade drew to a close things deteriorated somewhat. Nor was Marie as stable in her rule. She quickly depleted the treasury, assiduously stocked up by Sully, on buying the loyalty of the elites and lavishing favours on her favourites, Concino Concini and his wife. They were foreign and extremely unpopular. In 1614, elite discontent with the regency threatened an uprising when many nobles left Paris for their military commands in the provinces, but Marie issued another round of bribes and called an Estates-General, the last until 1789.

Louis XIII reached his majority in 1615 but for a time remained closely bound to his mother, and elite discontent with government continued. By 1617, the factions at court were divided between the duke of Luynes, who had won the confidence of the young king, and

[571] Dupâquier et al, 2:60.

Concini, and the former murdered the latter in the courtyard of the Louvre, executed his wife, and sent Marie into guarded exile in the city of Blois. Luynes' faction predominated until his death in 1621. Then the period 1621-1624 was characterised by an unstable balance of factions, a swift succession of ministers, and a great deal of infighting. Thereafter Richelieu found his way into power. Nevertheless, despite Richelieu's modern reputation, stability did not return. The next few decades contained many conspiracies between Richelieu's party and the *dévots*, who crowded around the Queen Mother and king's brother and heir presumptive, Gaston, duke of Orléans. Surrounding them were a number of conspiracies until Louis XIII produced an heir in 1638. There was also, of course, the king's quarrel with the Huguenots in the 1620s. The king also took steps against the nobility in general to reduce their threat. In 1626, Louis decreed that all fortified castles in the interior of France were to be demolished.[572] The edict took time to be obeyed, with some noblemen actually facing a besieging army before their castles were destroyed. This reduced the ability of nobles to dig in, but also indicates a continued uneasiness between the nobility and the central government.

As the population reached the carrying capacity once again, power devolved on the infant Louis XIV (r.1643-1715) and the regency of his mother Anne of Austria. She was advised by the Italian cardinal Giulio Mazarini, better known as Jules Mazarin. They inherited a bad situation. In the 1640s, France was strained by external war, internally its commoners suffered high taxes and an appalling standard of living punctuated by famine and outbreaks of plague. The bureaucracy were angry at the increased rate of the *paulette*, and the nobility were angry at the decline of their incomes in the north, the loss of their fortified castles, and the highest offices of power being in the hands of a female regent and a total foreigner, both of

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[572] Konnert, 178.

whom were highly unpopular. Just as the war was winding to a close in spring 1648, the regency demanded that officeholders pay four years salary to continue the *paulette.*

In June, as the series of treaties later known as the Peace of Westphalia were in the middle of being signed (but the war with France and Spain continued) the *parlement* of Paris demanded reform of government practices, to which the government initially agreed. Soon afterward, the government attempted to arrest several judges. Tensions grew and the elite revolt of the judges was fuelled also by popular revolt. The name of the revolt, the Fronde, came from the slingshots that the urchins of Paris used to fling rocks and trash at the carriages of the rich.[573] By January 1649, the regency left Paris and besieged the city. Peace was made in March as the judges submitted. But now the nobility had got hold of the revolt. They came, opportunistically, to the 'aid' of the judges. But they cared nothing for reforms. This tumult of elite infighting proved the most devastating, from 1650-1653. A number of great battles erupted in the north, with elites assisted by Spanish invasion from the Netherlands, and the devastation of Champagne and the Ile-de-France, and also fighting along the Loire. By 1653, fighting was over and the royal government was restored, with Mazarin returning to power.

h) Population Dynamics of the Fronde & its Aftermath

The Fronde reduced the total population of France from approximately 20 million to somewhere around 17.5 million to 18.5 million, with most of the losses occurring in the north.[574] By 1670 the population had recovered to 20.1 million within the *limites actuelles*, and by 1680 this number had reached a slightly higher peak of 21.1 million, with population growth slowing and stagnating thereafter to about 21.6 million in 1690, just prior to the worst famine of the seventeenth century in 1693-1694.[575] In the south, which had been smitten

[573] Konnert, 181.
[574] The median estimates range between 1.4 million and 2.45 million, with extremes at 500,000 and 3.5 million Dupâquier et al, 2:68.
[575] Dupâquier et al, 2:60.

harshly by the Wars of Religion, the Fronde was not as traumatic as it was in the north. The southern population continued to recover till around 1660, whence growth began to slow, and then stagnate after 1680. Aside from slight dips in the seventeenth century and outbreaks of the plague in the 1620s and 1630s, the south followed a different trajectory from the north. In the north, the population recovered c.1600 until 1635/40, and by 1645 the population had gone into sustained decline again, inaugurating yet another period of crisis during the Fronde and its aftermath.[576]

The Fronde was particularly devastating to Champagne, the Ile-de-France, and the Beauvaisis. Up to 33% of people in some villages were killed 1652-1653, with a total of 10% of villages in Champagne abandoned completely.[577] The years 1626-1632, especially the famine of 1631, were years of extreme dearth for France. Another crisis occurred in 1636-1637, though the cause of this crisis was not Malthusian, but was due to disease and the ravages of war. In 1649-1653, a population crisis occurred due to the sociopolitical instability of the Fronde and the famines it provoked. The north lost a total of 15-20% of its population during this time. According to the population distributions of Dewald and Vardi, this amounts to 1.8 to 2.4 million people. Then the last blast of relatively natural population strain and famine occurred 1660-1662, after which the population began to recover for a time.[578]

i) The Third Wave of Louis XIV & Divergences with Turchin

The ascendancy of France and the decline of Spain after 1659 left no rival of appreciable size to stand single-handedly in the way of French dominance of Europe. There were less populous but wealthy nations like England and the Dutch Republic, of course, but for a time France was at the summit of her influence. This period of external dominance coincided with a fall in grain prices while wages remained relatively stable, leading to an

[576] Ladurie, *French Peasantry,* 267.
[577] Ladurie, *French Peasantry,* 277.
[578] Dupâquier et al, 2:195.

increase of the standard of living. By about 1665, all of France had entered into a recovery phase similar to that experienced under Henry IV. The population grew once more. All this added lustre to the early reign of the Sun King. The recovery phase made the real wage reasonably sufficient in the late 1660s in addition to the 1670s and 1680s. The high standard of living appeased many subjects and noble intrigues went into abeyance. The stability permitted a series of reasonably successful wars.

The external wars waged from 1665-1690 posthumously bequeathed Louis XIV with the reputation for a glorious and stable reign. This is, of course, not the entire picture. Two more lengthy and bloody wars were to be fought over the course of the next two and a half decades of his reign, the War of the League of Augsburg (1688-1697), in which he lost almost all the gains of the last twenty years except Strasbourg, and the War of the Spanish Succession (1702-1713), in which the great Marlborough, Winston Churchill's illustrious ancestor, distinguished himself. These wars gained Louis even less in the way of land and coincided with yet another secular downturn, the deterioration of the standard of living, and two of the worst famines of the early modern cycle, 1693-1694 and again 1709-1710.

Far from a glorious reign, the French people emerged from the rule of the Sun King in 1715, war-weary, starved, impoverished, and teeming with discontent. Sustained population expansion did not begin until well after the Sun King's reign had come to an end. The population hit the carrying capacity in the 1690s and there still were famines that were felt severely because of that. There were three mini-waves that hit the population ceiling but were not significantly reduced when they recoiled in the subsequent crises. To be blunt, not enough people died to lower the population significantly below the carrying capacity to allow a longer period of prosperity beyond the years 1660-1690. Louis XIV's assumption of Personal Rule was not the beginning of a 'new expansion phase' as Turchin claims. The move to exclude

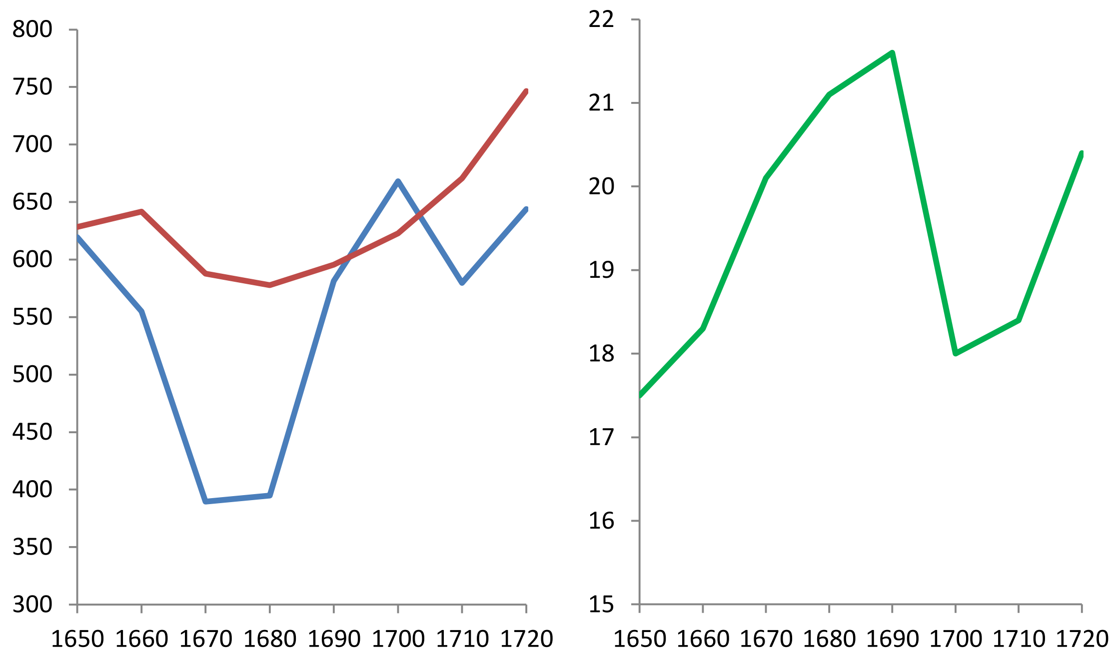
Louis XIV from the ‘crisis phase’ is partly motivated by the desire to have an expansion phase coincide with what is popularly seen as the golden age under the Sun King. The reality of his rule, as any recent history of the era will tell you, is somewhat different, since ‘the glittering court life at Versailles has sometimes led observers to mistake the illusion for the reality and has overshadowed both the realities of political and social life and the miseries that the king’s policies compounded.’[579]

The major post-Fronde uprisings were in the Boulonnais in 1662, Gascony 1664-1665, the Vivarais in 1670, and Bordeaux and Brittany, 1675.[580] All of them involved heightened resistance to taxation against the government, something which, as we have seen from the medieval period, typifies a disintegrative phase. The affair at Boulogne was a tax revolt against a ‘voluntary gift’ that coincided with the last period of dearth in the early 1660s, in which the nobility, bourgeois and the peasantry were all involved. The uprising in Gascony 1664-1665 was against the *gabelle,* endured for many months, and involved upwards to 6,000 men. The revolt in the Vivarais in 1670 was also motivated by taxation. The worst violence occurred in 1675 in Bordeaux and Brittany, and once again it was against taxation, this time on tariffs placed on consumer goods.[581] Intriguingly, these revolts coincide with a year of dearth of about medium severity.

There is nothing here to indicate that Louis XIV’s assumption of personal rule inaugurated a new secular cycle, as Peter Turchin has claimed. There is no question that gradually after the Fronde and the last serious years of dearth in the early 1660s things improved, but the idea that France embarked on a new expansion phase is an exaggeration. Gradually prices fell, while wages remained stagnant, and the standard of living improved for

[579] Konnert, 251.
[580] Leon Bernard, ‘French Society and Popular Uprisings under Louis XIV’ in *State and Society in Seventeenth Century France*, ed. F. Kierstead, (New York: New Viewpoints, 1975), 159.
[581] Bernard, 160-170.

a time, peaking in the 1680s (see fig 4.26). This coincides with the glory days of the Sun King. But it did not endure.



(**Fig 5.16** Prices (blue) wages (red) on the left with index 1430 = 100, and the French population (green) on the right in millions, extrapolated from Dupâquier 1988, Baulant 1968 &1971and also Durand 1966)

As fluctuations in prices and the population show clearly, this was a brief recovery phase of a few decades, as the French population straddled the carry capacity and endured another wave of crisis and decline in the 1690s and early 1700s. The growth in opposition to Louis XIV arose first with Jansenism. The Sun King's prosecution of this revisionist Catholic sect broadened its appeal as an opposition doctrine. Numerous elites in the *parlement*, officer class, and wider nobility were sympathetic to them. There was also an opposition group forming around the dukes of Burgundy and Saint-Simon and the archbishop Fénelon. They represented a traditional elite who felt disenfranchised by Louis XIV and wanted more political power, a smaller bureaucracy, and share in the spoils of high office. Finally, intellectuals like Boisguilbert and Vauban increased the demand for tax reform.

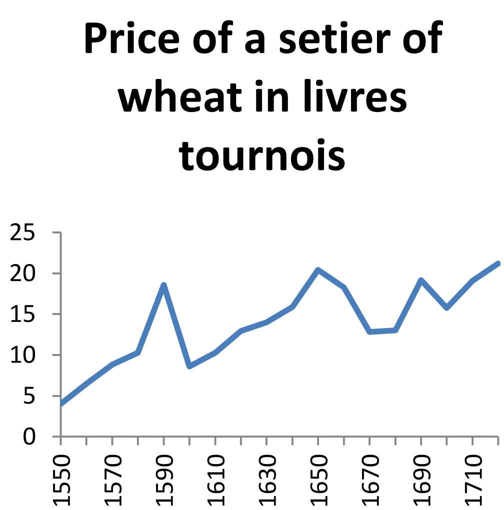
While Louis XIV always retained the mystique of absolute power that he had consecrated in the first half of his reign, it is clear that after the population went into decline in the 1690s and 1700s, the Sun King was delegating more and more of his power to his ministers and advisors.[582] The coincidence of the decline of the population and the rise of dissent is not a coincidence. It is exactly what is predicted by the theory of secular cycles. In the Cévennes, the Camisard rebellion saw the worst fighting 1702-1704 and then scattered fighting till 1710. There were other revolts under Louis XIV against the capitation tax of 1695, forcing the king to abolish it in 1697, later reinstating it in 1701, once it was safe. In 1703, there were riots in Casrais, Albigeois, Toulouse, and Languedoc. 1706 and 1709 there were riots in Cahors. In the immediate aftermath of Louis XIV's death, opposition groups put the regency of the duke of Orléans under great pressure, forcing him to reverse Louis' Jansenist policy, and subjecting the regency to two major conspiracies, one of which involving a failed revolt in Brittany. Things looked likely to deteriorate further when in 1720 the population began to take off under an increased carrying capacity.

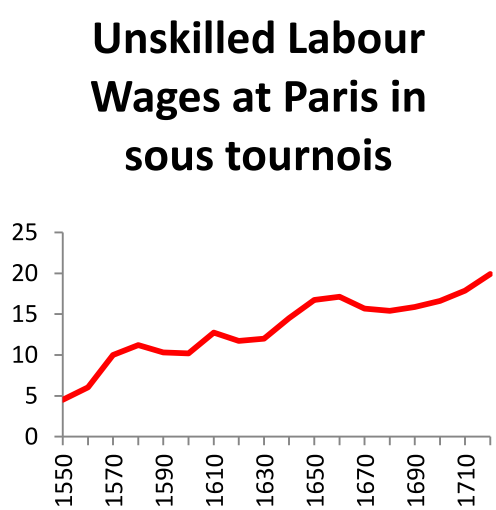
The combined famines of 1693-1694 and 1709-1710 had reduced the French population from an estimated 21.6 million in 1690 to 18.4 million in 1710.[583] This was a loss of 3.2 million people and a loss of 14.8%, roughly equivalent to, and indeed even slightly higher than, the previous two crisis phases of 1560-1600 and 1630-1660. Each decline of each disintegrative phase hovers between the 2.5 and 3.5 million mark. Much of the work was already accomplished in the first famine in which the French population had shrunk to 18-19 million.[584] The famine of 1693-1694 was the most violent of the seventeenth century.[585] There was a brief recovery in the eighteenth century, but then the second famine dropped the population to about 18.4 again.

[582] Briggs, 163.
[583] Dupâquier et al, 2:60.
[584] Dupâquier et al, 2:55.
[585] Dupâquier et al, 2:206.

The worst phases of the years 1705-1712 can be split into three peaks: 1705, 1707, and 1709.[586] 1709-1710 was, of course the worst, but with minor shortages in 1719 and 1724. This amounts to a loss of somewhere between 5-10% of the population, caused by dynamics that are endogenous to the theory. Contrast this to the roughly 30% loss of population from the exogenous Black Death. Obviously, when a cycle is devoid of such exogenous variables, its trajectory will be vastly different. The population reversals of Louis XIV's reign were borne more evenly between the north and the south than either the Wars of Religion or the Fronde, or using Dewald and Vardi's distribution estimates for a guide, a loss of about 2 million people in the north and 1.2 million people in the south.

j) Living Standards & Population in the Malthusian Ricochet



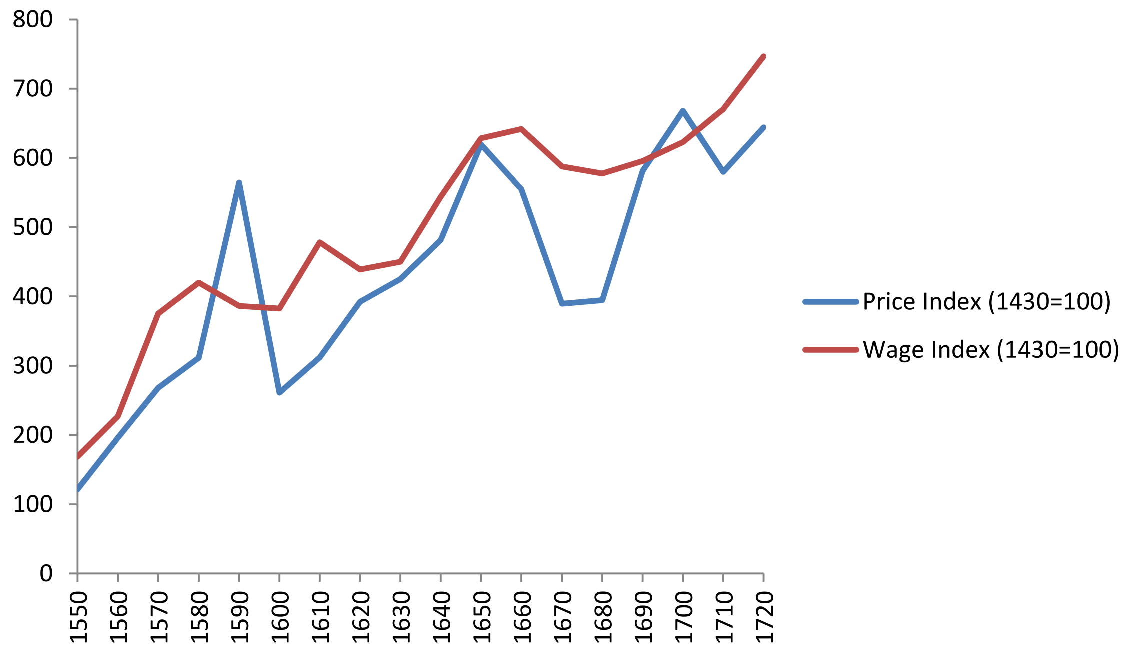


(**Fig 5.17** Data from Baulant 1968, 520-540 Baulant 1971, 463-483 and Durand 1966, 468-480)

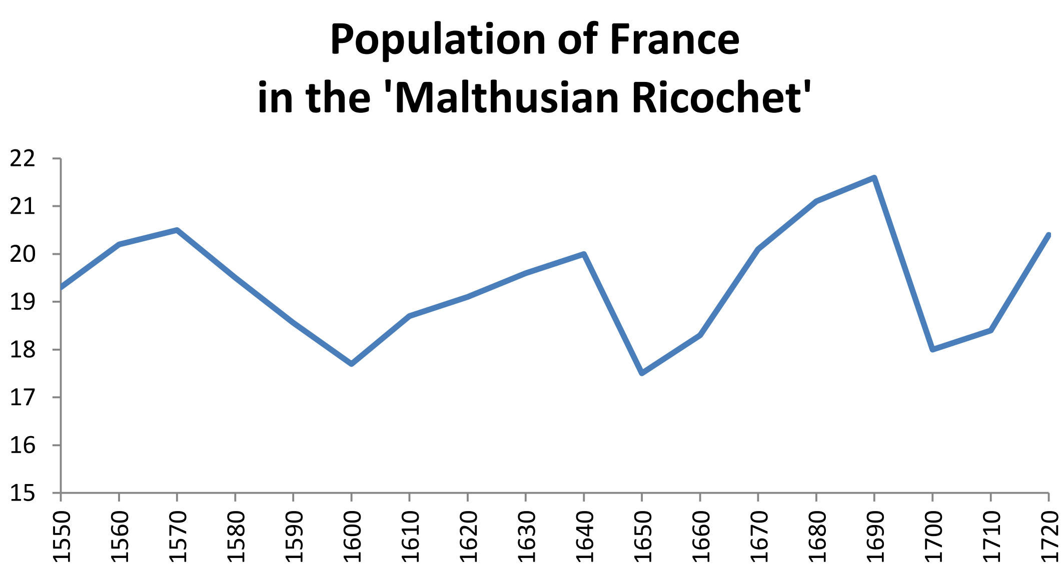
We now move to a summary of population and the standard of living during the three waves of disaster. The first thing to note is that although the wage had a fairly steady rate of inflation over 170 years, the spikes in prices were much more dramatic. That wages stagnated in this period is in little dispute. Note the rise in prices 1540-1560, how things were getting gradually worse due to Malthusian dynamics but then when sociopolitical instability began to kick in it really deteriorated the standard of living and the real wage. After 1580 prices were

[586] Dupâquier, 'Demographic Crises', 191.

spectacularly high. Then during 1600-1610 there was a recovery of sorts. Prices drop while the wage remained steady and even increased. We just saw that this period coincides with one of population recovery. It must be noted however that living conditions during the recovery after the Wars of Religion were nowhere near the levels of the early modern expansion phase 1450-1520.



(**Fig 5.18** Extrapolated from Baulant 1968 &1971and also Durand 1966)



(**Fig 5.19** The ‘Malthusian Ricochet’, straddling the carrying capacity, from Dupâquier 1988)

Population growth continued after 1610, and we witness another steady rise of prices until the Fronde, when we witness yet another steady spike in prices, coinciding with another period of instability and population decline. To go into a little more detail, the 1640s saw an average price of 13.88 livres per setier, 1640-1647. When the Fronde kicked off, the average price shot up to 17 livres. The 1650s were the same, ridiculously high at 29-31 livres while the Fronde raged but a marked drop to 18.88 in 1653 and then 14.94 in 1654. High prices continued during the famine years 25.7, 1661-1664, but coincided with a healthy increase in the labour wage that softened the blow. [587] Nevertheless, the early 1660s were not without strain, and while conditions were not as bad as the Fronde, we do know that smatterings of instability continued even several years after Louis XIV (r.1643-1715) assumed his Personal Rule in 1661.

Combined with the fact that the real wage was not particularly spectacular, that famines still raged, and the population had really not declined to a point that would distinguish it from the conditions of the brief recovery following the Wars of Religion, Turchin's idea that 1661 inaugurated a new cycle seems flawed. The early years of Louis XIV's reign were more reminiscent of the recovery following the Wars of Religion than the beginning of a new cycle. The 1670s and 1680s were decades of extremely low prices, with prices rising in the 1680s but still not bad. Meanwhile wages experienced only a slight depreciation as prices plummeted. The years 1684-1685 saw a price hike, especially during the expulsion of the Huguenots, but the following year the price problem was immediately ameliorated. Famine struck in the 1690s and caused prices to jump. We do know that the population recovery of the 1670s and 1680s had replenished the casualties of the Fronde, strained the carrying capacity, and thrust many people close to the margins into danger when famine struck. This constitutes the third wave of

[587] Micheline Baulant, 'Le prix des grains à Paris de 1431 à 1788' *Annales, Histoire, Sciences Sociales* (1968) 3:520-540.

crisis that occurred under Louis XIV. There was a spike 1693-1694, then a fall 1695-1697, then another spike in prices 1698-1699. There was a second crisis 1709-1710 that kept living conditions in the doldrums, which was not quite as bad as the famine of 1693-1694, but probably worse than any famine of the seventeenth century.

Three times in the early modern period, in a ‘Malthusian ricochet’, the French population bounced off the carrying capacity. The period 1610-1720 saw very little rise at all beyond the 20 million mark. It crashed mid-century. Then it recovered in the first half of the reign of Louis XIV and perhaps strained perhaps just past 21 million around 1690 as the carrying capacity was slightly raised by agricultural improvements at the end of the century (see chapter 5). But this new high was immediately followed by the crash of 1693-1694. The carrying capacity was not raised quickly enough. Nor was there a substantial improvement in the quality of life of the common people comparable to the late fifteenth century. Nor were elites significantly reduced to bring a permanent end to the threat of elite infighting. The whole period is notable for its high prices, low wages, and a series of agricultural crises: 1630-1631, 1648-1652, 1661-1662, 1693-1694, and 1709-1710.[588] The last two famines were extremely bad. All cut deeply into population figures, though not on the level of the Black Death. Nor were periods of plenty even remotely as prosperous as that which followed the Hundred Years War. Sociopolitical instability during the Fronde did not help the agricultural situation. Peasants fled the countryside and pillaging troops, overburdening towns and letting crops rot in the fields. Because of the location of most of the violence in the north, the population was more ravaged than in the south.[589] This contrasts sharply to the fighting and depopulation during the Wars of Religion, which were harsher in the south. In fact, it is highly conceivable that the north-south divide in secular cycles since the fifteenth century proceeded

[588] Braudel, 173.
[589] Braudel, 173-174.

as follows: recovery in the south beginning c.1420-1430 and recovery in the north after 1450; population peaking in the south c.1530 and in the north c.1560; fighting and depopulation kingdom-wide, but worst in the south; southern recovery c.1600-1650 while the north's recovery was short-lived because not enough people had died off compared to the south and endured another peak and depression during the Fronde, c.1650; and finally both cycles coinciding during another population peak and famine in the late seventeenth and early eighteenth centuries.

Indeed there is nothing to indicate Louis XIV's reign inaugurated a new expansion phase. Conditions remained as dismal as they had been since 1560. The majority of the French peasantry c.1650 still had around 5 ha or less, which was not nearly enough to subsist, with one-tenth of all peasants living at the margins in severe poverty, needing only a year or two of bad harvests to push them over the edge. This trend continued to persist.[590] There were serious subsistence crises in France in 1661-1662 and considerable shortages in 1675-1676 and 1679-1680.[591] The demographic crisis of 1690-1710 led to peasant indebtedness, worsened by wartime taxes, and allowed for their lands to be snapped up by the nobility and wealthy bourgeois. Here is a continuation of the same trend that had existed for the last century.[592]

k) Elite Dynamics in the Malthusian Ricochet

In the south, which suffered less during the mid-seventeenth century, land began to be concentrated in the hands of the few again by 1680, resuming a state of elite inflation. This would persist until about 1750, when land was divided up among greater numbers once again.[593] Elite overpopulation was rampant under Louis XIV. Francis I in a stagflation period

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[590] Dewald and Vardi, 28.
[591] Jacques Dupâquier, 'Demographic Crises and Subsistence Crises in France: 1650-1725' in *Famine, Disease, and the Social Order in Early Modern Society*, ed. John Walter and Roger Schofield, (Cambridge: Cambridge University Press, 1989), 191-192.
[592] Konnert, 260.
[593] Ladurie, Peasants of Languedoc, 5.

had 5000 bureaucrats to cover a population of 15 million people, while Louis XIV had 55,000 for a population that had only increased by one-third to 20 million.[594] In 1515, the French king had one official for 4,700 inhabitants. By 1665, there was one for every 380 inhabitants.[595] There were around 1000 nobles at Versailles, and this number included France's wealthiest 300 aristocratic families – the upper echelons of the elite.[596] Some offices immediately bestowed noble status. Other offices conferred it when they had been held in the same family for three generations.[597] The *paulette* allowed officeholders to pass their offices on to their heirs for an annual fee. This meant that whatever income or status one officeholder enjoyed, it would not disappear upon his death. Louis XIV did not end the *paulette* in his reign, nor did the sale of offices end. Production of elites still vastly exacerbated regular expansion of pre-existing families, with new elites constantly bloating the hierarchy. Turchin's treatment of the decline of the nobility after 1660 is contradicted by the fact that Louis started his reign with roughly 65,000 venal bureaucrats, a group that did not contract but continued to expand throughout his reign. Louis relied heavily on his thirty *intendants* but never managed to actually reduce the number of officeholders.[598] Elite numbers remained high in the 1690s at approximately 400,000, or 1.9-2.2% of the total population.[599] This number is comparable to the proportion of elites in the disintegrative phase of the high medieval cycle.

There is nothing here to indicate that elite numbers were sufficiently reduced and that after 1660 a new cycle had begun. The top 300 families of France earned 50,000-200,000 livres annually, or even more in some instances, whereas the lowest rungs of the traditional

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[594] Knecht, 199.
[595] Dewald, 'Social Groups', 45.
[596] Lewis, 17.
[597] Dewald, 'Social Groups', 46.
[598] Konnert, 254-255.
[599] Konnert, 259.

nobility earned less than 1,000 livres.[600] The idea that Louis XIV kept all the aristocracy in the 'gilded cage' at Versailles is also nonsense. The vast majority of the nobility did not live at Versailles. Only about 10,000 of them were attracted there, seeking some form of patronage or prominence in the kingdom. The rest remained on their estates, managing them, living nobly, and dealing with local issues. They remained an immensely powerful and influential group in the kingdom.[601] Another thing that exacerbated elite dynamics and stratification was the tax exemptions of the nobility from the heaviest forms of taxation. The noble exemption from the *taille*, *aides*, and *gabelle*, had existed since the late fourteenth century. This meant that some of the heaviest taxes fell on those groups least equipped to pay. The extra capital the elite enjoyed from these tax exemptions allowed them to buy up even more land from the poor during periods of fragmentation.[602] This exacerbated elite inflation and wealth stratification and played a role in perpetuating the burden of the elite on the early modern cycle well beyond the first wave of crisis. None of this indicates a renewal of a new cycle.

There is quite frankly not a single concrete variable that distinguishes the crisis reached under Louis XIV and that of the Fronde, despite what Turchin hypothesises. In fact it would appear that the crisis of the 1690s was more severe. Turchin is reluctant to admit that because Louis XIV fared well relative to the days of the Wars of Religion or the Fronde. During the entirety of the early modern disintegrative phase c.1560-1720, the shrinking of middling farmers and the stratification of wealth across French society as a whole worsened over time. It would appear there was insufficient death during the Wars of Religion to reverse the trend. The middling farmers who had lost their land after 1550 still, by the reign of Henry IV, had not seen a return of better fortunes. By mid-century, wage-labourers constituted 90%

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[600] Lewis, 69.
[601] Konnert, 258.
[602] Philip Hoffman, 'Rural, Urban, and Global Economics' in *Renaissance and Reformation France: 1500-1648*, ed. Mack Holt, (Oxford: Oxford University Press, 2002), 91.

of the inhabitants of rural villages, many of them owning insufficient amounts of land to eke out a living on their own.[603] Throughout the entire period 1560-1720, there were two recovery periods under Henry IV and Louis XIV that saw the hiatus of this trend, but not the full reversal.

l) Lessons of French Population Dynamics

It would appear that unlike the centuries-long cycles of rise, crisis, and decline that animate the Pueblo, Roman, medieval English, and early modern Russian, Ottoman, Chinese periods, that a population can straddle the carrying capacity and go through smaller periods of rise, crisis, and decline. In the French early modern cycle, there were three waves of demographic crises appearing extremely roughly in thirty-year oscillations: 1570-1600, 1630-1660, and 1690-1720. Each of these sharp shocks of suffering coincided with i) the approach of the population toward the carrying capacity of approximately 20 million, ii) the worst periods for high prices and stagnant wages, iii) a subsequent die-off of the population again, either by Malthusian or manmade causes. These three waves were interspersed with two periods of slight recovery, c.1600-1630 and 1660-1690, both of living conditions (though nowhere near conditions of the late fifteenth century) and of the population to roughly the 20 million mark again.

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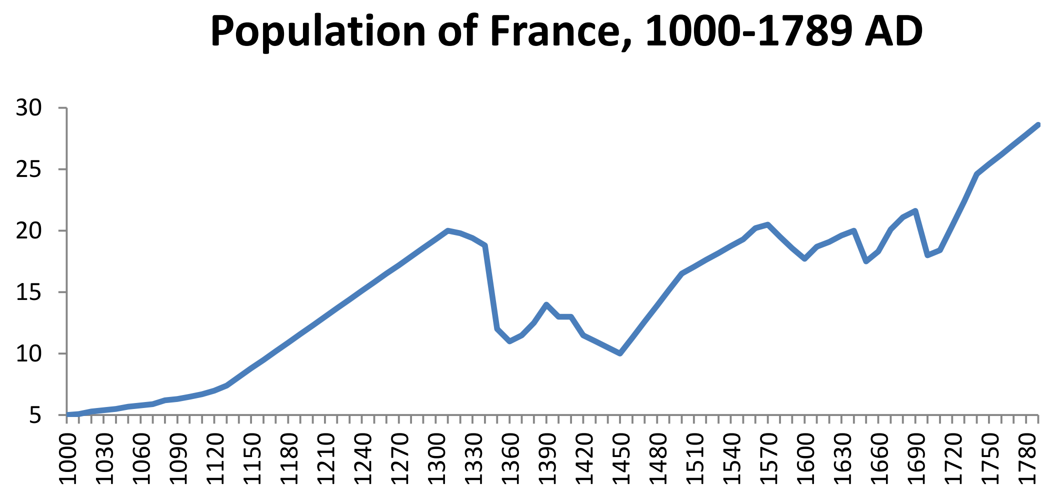
[603] Dewald, 'Social Groups', 34-35.



(**Fig. 5.20** The s-curves and rise of the carrying capacity, using data and estimates from two case studies)

The French medieval cycle is strikingly similar to England, except that the population expanded much more considerably 1000-1300 due to a vast amount of land clearance. The French cycle also mirrors the English cycle in that overpopulation and crisis was reached in the early 1300s well before the Black Death, which exacerbated a downturn that was already underway. The French medieval cycle also illustrates an instance where a brief hiatus in sociopolitical instability such as that in the reign of Charles V (1364-1380) managed to create a brief period of population recovery before manmade crisis sent the population on a downward spiral again from 1380-1415, which was then exacerbated by war with England. In the early modern cycle, the lack of a devastating plague outbreak like the Black Death and the lack of a bitter war fought mainly on French soil seems to have created smaller waves of crisis and decline that claimed only a few million lives, rather than tens of millions.

The agricultural improvements from the Low Countries of legumes and four-crop rotation did not reach France as early as England. It was not until the eighteenth century that the carrying capacity began to rise significantly, and even then population growth was more limited than the growth resulting from the expansion of new agricultural practices in England. We will explore this dynamic further in chapter 6. The delay in France acquiring these new innovations that allowed for better exploitation of the environment and energy flows created population strain once again at the end of the eighteenth century. It was not until the mid-nineteenth century before the lid of the carrying capacity was truly lifted and France began its ascent into modernity and a rapid increase of free energy rate density.

The historical events of the French *longue durée* were governed by a mixture of population dynamics and shifts in sociopolitical instability. These in turn were governed by the carrying capacity and the slow rise of collective learning. Once successful variations were selected that either raised the carrying capacity or increased the connectivity between potential innovators, cultural evolution could continue the work of raising the complexity of human society. We shall examine what some of those variations were in the next chapter. Cultural evolution continues a process of random variation and non-random selection that exists in biological evolution, mineral evolution, stellar evolution, and right back to the 'cosmic natural selection' of Universes. The Darwinian algorithm thus potentially ties together the entire *plus longue durée* and gives the grand narrative a set of similar dynamics and a common theme.

Chapter Six: The Rising Tide of Collective Learning

In the last two chapters, we looked how the slow rise of the carrying capacity relative to population growth influenced the historical evolution of many agrarian states, even at the micro-scale, by causing recurrent periods of population strain and collapse. The rise of the carrying capacity itself is governed by the innovations in agriculture that come out of collective learning, which is in turn a Darwinian process of cultural evolution. In this chapter we shall look at how collective learning raises the carrying capacity. As a result of the Industrial Revolution, the agrarian states of the world were liberated from the population cycles that we have explored. A combination of collective learning and population cycles produces a comprehensive theory for the broad trends of the ancient, medieval, and modern eras of human history. In this chapter, we shall also explore the link between collective learning and humanity in the Palaeolithic and also the link of collective learning to the wider rise of complexity in the Universe.

I. How Collective Learning Fits into the Darwinian Algorithm

Throughout the history of the Universe there was a gradual rise in complexity in two ways. First, complexity increased in the degree of free energy density that can be held within a given space, that of plant or animal being much greater than that of a star. Second, there was an increase of variation and the intricacy of the webs of processes that drive biology and human culture. Collective learning is essential to the continuance of that process by increasing the number of humans in the system and also the free energy they are capable of generation. Culture (any ideas, beliefs, attitudes, and innovations that are passed down from generation to generation) exists in an even greater number of variations. A single human mind is capable of generating thousands of cultural variations in a lifetime, employing a brain 75,000 times more complex than a star and has more synapses than there are stars in the galaxy.[604] And humanity is capable of transmitting those ideas to members of the same generation, and also to have them stored and tinkered with by succeeding generations.

While culture can produce all sorts of variations, from innovations in language, to entertainment, to art, to simple patterns of daily manners and dress, for our purposes we shall focus on the two most significant cultural variations that enhance collective learning. Innovations that enhance either population numbers or connectivity, increase the speed of collective learning by either producing more innovators or facilitating the exchange of their ideas. Collective learning raises the carrying capacity, allowing for more variation, allowing for larger societies with even more intricate frameworks, and allows human beings to harness energy on almost unprecedented scales. In the story of rising free energy density and variation in the Universe, the story of cultural evolution and collective learning has opened a new threshold for complexity. We do not yet know where this process will lead or how many other thresholds lie ahead. We simply know that in our short lives on our clump of dirt hurtling round an aging third-rate star of a numerically marginal galaxy, we are all witnesses to something quite remarkable in the cosmic story, and what is more, for the briefest of moments and in the smallest of ways, we are part of it.

In this chapter we will survey some of the key turning points for collective learning in the era of agrarian civilisations. We shall look at the development of wet rice farming in China and the spread of the Flanders method in Europe, both of which raised the carrying capacity and increased the number of potential innovators in a population. We shall also look at innovations that enhanced the transmission of knowledge between innovators, from the invention of learning to the development of printing. Collective learning is aided by both the

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[604] Chaisson, 139 & R. Marois and J. Ivanoff, ‘Capacity limits of information processing in the brain’ *Trends in Cognitive Sciences* (2005) 9:296-305.

increase of potential innovators and the increase of the efficiency with which innovations are transmitted. We shall look at how breakthroughs in the fields of numbers and connectivity led to some 'great divergences' between the world civilisations: in the case of Song China and the case of the Industrial Revolution. Collective learning ties into the agrarian cycles we looked at in the last chapter because it gradually raised the carrying capacity. It ties to cultural evolution because it involves a form of variation and selection, with those innovations that enhance either numbers or connectivity being selected. In turn, collective learning builds and further accelerates the process of cultural evolution. And, as stated above, this fits into the universal tale of the Darwinian algorithm by increasing the free energy rate density of our little corner of the Universe and also the numerous variations that are available for further evolution. We do not yet know where this process will take us, though it seems clear that if there is going to be another rise of complexity in the Universe, it will be due to animate rather than inanimate processes.

II. Collective Learning & Population

a) Overview of Population Growth in Human History

For the long stretch of the Palaeolithic from approximately 250,000 to 10,000 years ago, humans lived in small populations of a few dozen to a hundred at most and 12% of humanity or 9.6 billion people lived in that long stretch of time.[605] The nature of hunting and gathering meant that human groups had to range across a relatively wide area, exhaust resources in one place and then move on to another area while it replenished itself naturally. This meant that a small band of humans was also fairly disconnected from the other small groups that they occasionally encountered and enter-married with. The wide ranging extensification of hunting and gathering also meant the carrying capacity of the Earth

[605] Livi-Bacci, 31 & 33.

amounted to no more than 8 million.[606] It is a reasonable hypothesis that the pace of collective learning was much slower where information was exchanged between and within small nomadic groups.

Nevertheless, humans over the course of tens of thousands of years were extremely adept at accumulating knowledge and improving their toolkits, hunting methods, and forms of symbolic expression. We ranged across the Earth, exploited a variety of new ecosystems from the jungle to the Arctic, and brought about mega-faunal extinctions and possibly even outcompeted and aided the extinction of other hominines. The emergence of agriculture 10,000 years ago can be seen as the extension of the same process of humans improving their ability to harvest energy from their environments. When wheat, rye, cattle, goats, and camels were domesticated in the Middle East, when wild rice was domesticated in Southeast Asia, when the transport power of horses was harnessed in south Russia, when sugar originated in India, and when maize, potatoes, squash and beans were adopted in the Americas, humans developed a way to gather resources from the environment in a way that could be replenished by their own hands year after year, rather than letting nature do the work for them.[607] With increased control over natural resources, much more food energy could be gathered from a much smaller area of land. The surplus of agriculture eventually enabled specialised labour and cities that housed denser populations and acted as trading hubs between populations. Whereas some 9.6 billion people lived during the 200,000 or so years of the Paleolithic Era, agriculture raised the carrying capacity so high that some 53 billion humans lived just in the 10,000 years from the appearance of agriculture to 250 years ago.[608] This was 5.5 times the amount of Palaeolithic innovators who lived in period 24 times the length of the agrarian era.

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[606] Livi-Bacci, 31.
[607] Daniel Headrick, *Technology: A World History*, (Oxford: Oxford University Press, 2009), 81-82.
[608] Massimo Livi-Bacci, *A Concise History of World Population*, trans. Carl Ipsen, (Oxford: Blackwell, 1992), 31 & 33.

Not all cultural innovations are useful ones, but the fivefold increase in the amount of potential innovators over a decidedly smaller time period increases the probability that some useful adaptations will stick. As we have already said in relation to rising complexity in biology, never mind shooting fish in a barrel, if you put enough bullets into a barrel, eventually you hit a fish. The Darwinian algorithm produces increasing amounts of variation, some of which produce higher levels of complexity in a constant and ubiquitous rolling of the dice in our Universe. In the space of a few thousand years, c.12,000-6000 years ago, domestication led to agriculture and bred larger groups of innovators all over the globe from the Middle East, to East Asia, to the Americas.[609] Instead of a carrying capacity of 6 million, by 3000 BC it had increased to 50 million and by 1000 BC 120 million and by 0 AD this number doubled 252 million.[610] Both the Palaeolithic and Holocene experienced waves of shortage, crisis, population crash, and Tasmanian Effects, but the overall trajectory was up. More innovators and more cultural variations were being produced in a positive feedback cycle. More energy was harnessed and humans achieved a higher rate of complexity, moving from an average of 40,000 erg/s/g in hunter-gatherer societies, to 100,000 erg/s/g in agriculture, to 500,000 in the industrial era, to an average of 2,000,000 in the present 'technologist' era.[611]

b) Wet Rice Farming & the Carrying Capacity of Song China

The past 2000 years have witnessed two 'Great Divergences' between two world zones: Europe and East Asia, first in China in the tenth and eleventh centuries and second in Europe in the nineteenth century. Kenneth Pomeranz coined the term to describe the second

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[609] Neil Roberts, *The Holocene: An Environmental History*, (Oxford: Blackwell, 1998), 136.
[610] J.R. Biraben, 'Essai sur l'évolution du nombre des hommes' *Population* (1979) 34:13-25.
[611] Chaisson, 'Complexity', 36.

Great Divergence between industrial Europe and the rest of the world.[612] In both divergences, however, the carrying capacity was raised and the technological output of the world zone increased suddenly and dramatically. In the sixth century BC, the carrying capacity of China was already ahead of ancient Europe. China was already growing crops in rows, paying attention to weeding, and frequently employing iron ploughs. All of these innovations would not be employed in Europe for centuries. The Chinese also used horse harnesses by the third century BC, avoiding the risk of strangulation by a horse and permitting them to carry ploughs and heavy equipment. The seed drill was in use by the second century BC. In the first and second century BC, types of mouldboard ploughs that only became available in Europe after Charlemagne were already in use in China.[613] At the time, the majority of the Chinese population centred on the north in the Yellow River valley where they farmed millet and wheat – not rice.[614] Even before the explosion of wet rice agriculture in China, these innovations served to create a higher agricultural output and carrying capacity compared with Roman Europe centred on the Mediterranean, both in the East and especially the sparsely populated backwater that was the Roman West.

Up till the first millennium AD, both world zones had supported themselves mainly on grain products, with the Chinese sustaining a higher carrying capacity than Europe due to better agricultural practices. Even further divergence happened between 500 and 1000 AD with the spread of wet rice production in China, which has a much higher yield than grain. Per hectare, traditional varieties of rice support around 5.63 people compared to 3.67 people on a

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[612] Kenneth Pomeranz, *The Great Divergence: China, Europe, and the Making of the Modern European Economy*, (Princeton: Princton University, 2000). Ian Morris, in *Why the Rest Rules for Now*, conversely treats the Western lead over China as consistent for 90% of history since agriculture, according to his social development metric.
[613] Robert Temple, *The Genius of China: 3000 Years of Science, Discovery, and Invention,* (New York: Touchstone, 1986), 15-20.
[614] Clive Ponting, *A Green History of the World: The Environment and the Collapse of Great Civilisations*, (London: Penguin, 1991), 93.

hectare of wheat.[615] Rice evolved as a form of grass on the Gondwana supercontinent 130 million years ago. Ancestral forms wound up in West Africa, South, and Southeast Asia, where in the agrarian period they were domesticated and provided a mainstay for the agrarian civilisations that developed there.[616] Wild Asian rice emerged and was initially domesticated on a strip of land between Assam in India, across upper Burma, Thailand, to northern Vietnam.[617] Rice spread to China from Southeast Asia, where carbon dating tells us it was farmed as a dry crop around 8000 BC. Excavations in India put the first use of rice somewhere between 6500 and 4500 BC.[618]

Dry rice farming came first. However, it has a carrying capacity that is not much higher than wheat. The problem is that dry rice farming requires constant weeding.[619] It was also ill-suited to the climate of northern China. In the north, millet farming in the Yellow River valley began 6000 BC.[620] By 200 BC, the Han north was sustained by the farming of millet and wheat in an inefficient two-crop rotation. The inhospitable soils and temperatures of the Yellow River valley in the north usually permitted only one crop a year. From 0 AD, wheat was immediately planted after millet or soy to increase crop frequency. In order to avoid too much loss of nutrients from repeated planting, the crop was often planted in alternating furrows, with new furrows being planted in between the old ones. The Han plough had limited depth of ploughing. Overseeding was sometimes used to save labour at the expense of the yield.[621] Until the tenth century AD, the bulk of the Chinese population dwelt

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[615] Felipe Fernandez-Armesto, *Food: A History*, (London: Macmillan, 2001), 105.
[616] Te-Tzu Chang, 'Origin, Domestication, and Diversification' in *Rice: Origin, History, Technology, and Production*, C. Smith and Robert Dilday (eds) (London: John Wiley, 2003), 4.
[617] Bray, 8-9.
[618] Chang, 12.
[619] Michael Woods and Mary Woods, *Ancient Technology: Ancient Agriculture from Foraging to Farming*, (Minneapolis: Runestone Press, 2000), 50.
[620] B.Higman, *How Food Made History*, (Chichester: Wiley Blackwell, 2012), 23.
[621] Cho-yun Hsu, *Han Agriculture: The Formation of Early Chinese Agrarian Economy, 206 BC-220 AD*, Jack Dull (ed), (Seattle: University of Washington Press, 1980), 112-114.

in the north, farming millet, wheat, soy, mulberries, and pigs.[622] China is frequently associated with dense populations and rice, but the largest and densest area of China thrived on a grain culture until relatively late in Chinese history.

Meanwhile in southern China, rice was domesticated in 7000 BC along the Yangtze River and by 3000 BC, large scale wet rice farming was present.[623] For several thousand years, the yield was still relatively low because farmers did not employ terracing and paddy systems. Instead wet rice was grown beside streams and in small irrigated plots.[624] This is the reason why northern China held the bulk of the population despite a long history of wet rice farming in the south. Nevertheless, wet rice farming even without terracing and paddies was fairly productive. Slowly but surely the carrying capacity was being raised. Finally, labour intensive methods of terracing and paddies caught on in south China in 200 AD.[625] Similarly, in India along the Ganges, wet rice farming with paddies being employed began to gain importance c.100 AD, and yields from wet rice achieved higher population densities there too.[626] The employment of a crop with much higher yields than grain and that can sustain higher population densities, might go some way to explaining the higher rate of collective learning and innovation that set these civilisations ahead of other world zones in terms of population and cultural complexity.

At the fall of the Han dynasty, barbarian attacks forced more Chinese south to the Yangtze River basin. Reunification under the Sui in 589 AD made the region more stable, and rice expansion and the migration of the northern population to the south continued in

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[622] I.G. Simmons, *Changing the Face of the Earth*, 2nd edition, (London: Blackwell, 1996), 99.
[623] Z. Chi and H.C. Hung, 'The Emergence of Agriculture in South China' *Antiquity* (2010) 84:11-25 and Y Zheng, et al., 'Rice Fields and Modes of Rice Cultivation between 5000 and 2500 BC in East China' *Journal of Archaeological Science* (2009) 36:2609-16.
[624] Simmons, 99.
[625] Chang, 16.
[626] Simmons, 109.

earnest.[627] Gradually, migration between 500 and 1300 AD transformed the agricultural output and population distributions of China, particularly intensifying in the Song dynasty (960-1276 AD). The Song government initiated a set of policies to shift agricultural production from the northern millet and wheat regions to the wet rice producing south because they were being squeezed by rivals (the Jurchen) in the north. In 1012, the Song introduced a strain of rice from Vietnam that allowed for multiple harvests per year, or the alternation of rice in the summer and wheat in the winter. The government appointed 'master farmers' from local communities, who were to disseminate new farming techniques and knowledge of new tools, fertilisers, and irrigation methods. The Song also introduced tax breaks on newly reclaimed land and low-interest loans for farmers to invest in new agricultural equipment and crops.[628] The Song encouraged terracing, created fields that were evenly flooded and trapped fertile silts from being washed away. In 1273, the Chinese government distributed 3000 copies of *Essentials of Agriculture and Sericulture* to landowners in order to improve crop yields. Wet rice farming by this method produced 2-3 crops a year compared to the meagre one-crop harvest of the millet producing north.[629]

The adoption of wet rice farming and the migration of many people to the south had a profound impact on collective learning in Song China. In 0 AD, the population of China was around 50-60 million and did not exceed that number level prior to the tenth century.[630] During the 900s and 1000s under the Song dynasty, migration to the Yangzi river valley to farm rice raised the carrying capacity of China from 50-60 million to 110-120 million, with

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[627] Ponting, 93.
[628] Francesca Bray, *The Rice Economies: Technology and Development in Asian Societies*, (Oxford: Basil Blackwell, 1986), 203.
[629] Headrick, 51-52 & 85.
[630] Evan Faser and Andrew Rimas, *Empires of Food: Feast, Famine, and the Rise and Fall of Civilisations*, (Berkeley: Counterpoint, 2010), 118.

record high population densities like 5 million people farming an area of 40x50 miles.[631] By 1100, this constituted 30-40% of the population of the globe, compared to all Europe's 10-12% as it just entered its 'Great Leap Forward'.[632] The population was raised, so was the density, and so the number and connectivity between potential innovators was increased.

This really constitutes the first 'Great Divergence' between East and West, when Chinese collective learning advanced by leaps and bounds by a much higher carrying capacity. It is no coincidence that the Song dynasty was one of the most technologically advanced and industrially prodigious societies in pre-modern history, almost to the point that the late Song dynasty could conceivably have had an Industrial Revolution of their own. For instance, the annual minting and use of coin currency was increased by an average 4500% under the Song.[633] Farming techniques improved: use of manure became more frequent, new strains of seed were developed, hydraulic and irrigation techniques improved, and farms shifted to crop specialisation.[634] Coal was used to manufacture iron and iron production increased from 19,000 metric tons per year under the Tang (618-907 AD) to 113,000 metric tons under the Song.[635] The Song dynasty was the first to invent and harness the power of gunpowder.[636] Textile production showed the first ever signs of mechanisation.[637] Some surprisingly modern innovations in Song China did not arise in conjunction with an increased population, but eleventh and twelfth century innovations followed after the initial rise of the Chinese carrying capacity between 500 and 1000 AD. The adoption of wet rice farming and the migration of Chinese farmers from the northern grain producing region to the Yangzi River valley triggered a rise in the number of potential innovators and a Great Divergence that placed China as one

[631] A Korotayev, A. Malkov, and D. Khalturina, *Laws of History: Mathematical Modelling of Historical Macroprocesses*, (Moscow: Komkniga, 2005), 186-188, and Headrick 53.
[632] Biraben, 'Essai sur l'évolution' 16.
[633] Valerie Hansen, *The Open Empire: A History of China to 1600*, (New York: W.W. Norton, 2000), 264.
[634] Mark Elvin, *The Pattern of the Chinese Past*, (Stanford: Stanford University Press, 1973), 88.
[635] Hansen, 264.
[636] Arnold Pacey, *Technology in World Civilisation*, (Cambridge: MIT Press, 1990), 47 and Elvin, 88.
[637] Pacey, 24-26.

of the largest, densest, and most productive regions of the globe from 900 to 1700 AD – at the very least. Collective learning in the first millennium thus adds a second Great Divergence to the one of the nineteenth century.[638]

After about 1500 AD, New World crops served to raise the Chinese carrying capacity even further. Maize had emerged in Mesoamerica c. 6000-5000 BC and had spread to Venezuela by 800 BC and southeast North America by 800 AD. After the Columbian exchange, maize spread to China and Europe.[639] The maize, potatoes, squash, and beans from the Americas came into widespread use in China and India in the seventeenth century, where land ill-suited to rice farming was turned over to them.[640] The combination of European countries adopting the Flanders method, the proliferation of maize and potatoes ('ready-made bread') into Eurasia, raised the carrying capacity and the population of the world from 461 million in 1500, to 680 million in 1700, and 954 million in 1800.[641]

Despite periods of strain all over the Eurasian supercontinent 1550-1650, with sluggish carrying capacities that often changed little on the scale of a few centuries, the overall trajectory was up. After that, there was a second 'Great Divergence', whereby Europe gradually saw population growth that was sustained throughout the agricultural and industrial improvements of the nineteenth century. The populations of the Middle East and China on the other hand, experienced a period of vigorous growth between 1650 and 1780, then more population strain and sociopolitical instability 1780-1850. Evidently after 1650, in China, there is 'no new evidence of any significant increases in yields and, although the area under cultivation rose, the amount of food available per person was about the same in 1850 as it had

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638 Kenneth Pomeranz, *The Great Divergence: China, Europe, and hte Making of the Modern World Economy*, (Princeton: Princeton University Press, 2000).
639 Simmons, 111.
640 Headrick, 82.
641 Biraben, 'Essai sur l'évolution', 16.

been 300 years earlier.'[642] Agricultural output kept pace with Chinese population growth until c.1780, when peasants suffered from increasingly harsh famines and bad harvests, landlessness increased, and landlords saw a decline in their rents.[643] The ground was laid for another Great Divergence in human history.

c) Spread of the 'Flanders Method' in Early Modern Europe

Another set of innovations that raised the carrying capacity was the spread of the 'Flanders Method' into the rest of Europe in the sixteenth, seventeenth, and eighteenth centuries. This raised the carrying capacity, relieved some of the pressure from s-curves, and produced a higher number of innovators who could continue to accumulate collective learning into the Industrial Revolution. Europe in the early medieval period employed a two-crop rotation, where half the field was farmed while the other was left fallow to regain some nutrients. After Charlemagne, we see the wider proliferation of the heavy plough, the sickle, the threshing flail, horseshoes and better harnesses for horses and oxen.[644] The innovation of not tying horses by the neck and risking strangulation, but rather giving those horses harnesses held at the shoulder, meant they could pull heavy ploughs. This allowed the tilling of heavier soils, resulting in the great land clearances of the eleventh and twelfth centuries profiled in chapter four. The heavy mouldboard plough had a primary blade that cut deep, a second horizontal blade that cut through roots under the surface, and a slop that churned the soil up alongside the machine. It was expensive but a single pass could create longer tracts, with more nutrients from dead plant material being churned up to feed crops.[645] In the high medieval period, three-crop rotation became more common, with one third growing wheat, one third

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[642] Ponting, 95.
[643] Bray, 207.
[644] Wilhelm Abel, *Agricultural Fluctuations in Europe: From the Thirteenth to the Twentieth Centuries*, 3rd Edition, trans. Olive Ordish, (New York: St. Martin's Press, 1978), 24.
[645] Evan Faser and Andrew Rimas, *Empires of Food: Feast, Famine, and the Rise and Fall of Civilisations*, (Berkeley: Counterpoint, 2010), 21-22.

peas, and one third fallow.[646] In the 900s, millions of acres of moorland, forest, and swamp in Europe were converted to arable farmland.[647] This medieval revolution in agriculture roughly doubled the carrying capacity of north-western Europe, making it a little less of the sparsely populated backwater it had been in the days of Rome. For instance, the carrying capacity of Gaul/France increased from a high watermark of 9 or 10 million under the Romans in the second century AD to about 20 million in 1300. Nevertheless, the three-crop system did not raise the carrying capacity much further and in most of Europe it remained the same for at least three centuries.

Only in Flanders in 1300 did they learn to grow legumes, allowing cattle to graze and fertilise fields and avoid leaving the fields fallow.[648] This lifted the carrying capacity. In the mid-fourteenth century in Flanders, the higher carrying capacity enabled the formation of larger urban economies. And the people of the Low Countries did not suffer the pre-Black Death population crisis as badly.[649] The Flanders method spread throughout the Low Countries, including modern day Belgium and the Netherlands. In addition, the use of coleseed, buckwheat, clover, and hops may have originated in the north Netherlands.[650] These new techniques became widespread in the Low Countries and sustained more population growth compared to other European countries. For instance, in 1500 the population of the Netherlands was one million people, growing to 1.5 million by 1600, and 1.9 million by 1650, a full century after countries like England and France began to stagnate or decline.[651] In 1550, Flanders had such a high population density that 50% of the peasantry had less than a hectare

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[646] Headrick, 56.
[647] Faser and Rimas, 21.
[648] Pierre Charbonnier, 'Economy and Society of France in the Later Middle Ages: On the Eve of Crisis' in *France in the Later Middle Ages: 1200-1500*, ed. David Potter, (Oxford: Oxford University Press, 2002), 51.
[649] Jan Bieleman, 'Dutch Agriculture in the Golden Age, 1570-1700' *Economics and Social History in the Netherlands*, (1991) 4:162.
[650] G.E. Fussell, *Farming Techniques from Prehistoric to Modern Times*, (Oxford: Pergamon Press, 1965), 90.
[651] J.A. Faber, 'Population Changes and Economic Development in the Netherlands: A Historical Survey' *Afdeling Agrarische Geschiedenis Bijdragen* (1965) 12:47-133.

of land. Nevertheless, we do not see the same kind of population crisis as in France.[652] In the 1570s and 1580s, while grain prices were rising elsewhere in Europe due to overpopulation, the legume method allowed the Dutch to maintain low grain prices and to diversify into other livestock. In the 1590s, the use of peas, beans, and manure became widespread. Dutch crop yields were very high and were not drastically improved until the technological innovations of the nineteenth century.[653] The Dutch coped with growing population numbers, density, and rent prices, by reclaiming land from the sea. Between 1600 and 1650, reclamations in Holland and Utrecht were 12 times as high as in 1550-1600.[654]

The Dutch provided the 'vanguard' of legumes into the rest of Europe. The first collective learning of the four-crop method was transferred by Dutch refugees to England in the 1560s, and a decade later by English soldiers serving in the Netherlands.[655] England was the first to adopt them in the sixteenth and seventeenth centuries. Much of Western Europe had begun to adopt them in the eighteenth century.[656] Nevertheless the 'Flanders method' did not really take off in England until the intervention of printing. Sir Richard Weston in 1645 published his *Discours on the Husbandry used in Brabant and Flanders*, the first written description of the four-crop legume based method in any language. During the years that followed, Hartlib also published on the subject multiple times in the 1650s. Walter Blith's *English Improver Improv'd* in 1652, Gabriel Reeve's direct plagiarism of Weston in 1670, and Roger North's similar act in 1726, all lent a hand to the spread and selection this particular method.[657] The efforts of printed authors between 1660 and 1740 contributed to the growth of

[652] Bieleman, 175.
[653] Bieleman, 162 & 163-164.
[654] Bieleman, 170.
[655] G. Fussell, 'Low Countries: Influence on English Farming' *The English Historical Review* (1959) 74:611-622.612-613.
[656] Simmons, 116.
[657] Fussell, 'Low Countries', 611.

the practice of four-crop rotation. The use of legumes finally became widespread in England by the end of the eighteenth century.

In the early sixteenth century, England was still under the carrying capacity of about 5 or 6 million that had existed since c.1300 and the three-field system that predominated.[658] England c.1480-1600 was in the middle of population recovery and the three-field system sustained an agricultural output that was significantly below that of the seventeenth century. The land was mostly a place for grazing livestock, particularly sheep, with wool being one of England's only major exports at the time. The Midlands in the early 1500s produced the majority of the country's grain, compared to the predominance of the south in the eighteenth century. But in the sixteenth century, the Midlands were better suited to the old three-crop method. Yields for Leicestershire for example were 12d/acre, while in Devon the yield was 1.8 d/acre.[659] Enclosure in sixteenth century England only added 2% to what was already enclosed.[660] Around the mid-sixteenth century, there are signs that English yields began to increase.[661] The rise in population seemed to prompt a focus on grain growing.[662] Between 1550 and 1600, a great deal of pasture was ploughed up for fields, making use of the nitrogen there to produce grain.[663] Turnips were introduced into England from Holland initially as a garden vegetable.[664] Potatoes were introduced into England in the 1590s and came into widespread use by the 1700s. These had a slight but nascent effect on agricultural output.[665] By 1551, that output had only increased by 11% from 1520. But by the end of Elizabeth's

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[658] Mark Overton, *The Agricultural Revolution in England: The Transformation of the Agrarian Economy, 1500-1850*, (Cambridge: Cambridge University Press, 1996), 26.
[659] Jack Goldstone, 'Regional Ecology and Agrarian Development in England and France' *Politics and Society* (1988) 16: 297.
[660] Goldstone, 'Regional', 301.
[661] Gregory Clark, 'Yields per Acre in English Agriculture, 1250-1860: Evidence from Labour Inputs' *The Economic History Review* (1991) 44:445-460.
[662] Joan Thirsk, *Agricultural Regions and Agrarian History in England, 1500-1750*, (London: Macmillan, 1987), 58.
[663] Overton, *Agricultural Revolution*, 107.
[664] J. Beckett, *The Agricultural Revolution*, (Oxford: Basil Blackwell, 1990), 12.
[665] Beckett, 17.

reign, when the first major famines and population strain occurred, we see the output increased to 80% of that of the 1700 index.[666] Part of this is due to population growth, part of this is due to the clearing of more land and the employment of nitrogen-fixing methods. While many places in England, like in the north, did not see the planting of legumes until the 1700s, in East Anglia, for instance, the spread of these improvements took hold from the 1580s.[667]

Date	English Population (Millions)	Agricultural Output (1700 Index of 100)
1520	2.35	47%
1551	3	58%
1601	4.11	80%
1651	5.23	101%
1661	5.14	101%
1700	5.06	100%
1741	5.58	114%
1751	5.77	121%
1761	6.15	124%
1781	7.04	136%
1791	7.74	147%
1801	8.66	159%
1831	13.28	226%
1851	16.74	272%

(**Table 6.1** From Overton 1996, 75)

In the seventeenth century, both population numbers and agricultural output stagnated. England during 1650-1750 saw fairly weak population growth, while Europe saw a net fall.[668] By 1651, the population had reached peak levels, but agricultural productivity had also peaked. In this same period of population stagnation, we witness the increased instability of the Civil War and Cromwellian Republic. By the overthrow of Richard Cromwell and the Restoration, the English population had declined slightly and would continue to do so until 1700, as agricultural innovations got off to a halting start. We must not underrate, however, the impact of the agricultural improvements in the seventeenth century. In the 1590s, population pressure made famine a problem and there were some severe famines in the final

[666] Overton, *Agricultural Revolution*, 75.
[667] Thirsk, 60-61.
[668] E.L. Jones, *Agriculture and the Industrial Revolution*, (Oxford: Basil Blackwell, 1974), 129.

years of Elizabeth I's reign. In the late seventeenth century, however, even though food prices were increasing, famines did not occur and the mortality rate did not rise accordingly.[669] The carrying capacity was being raised.

The period 1600-1650 was characterised by the clearing of marshes and fens, converting them into more arable cropland.[670] The four crop rotation and legume technique spread to England by many landowners and royalists who observed the Flanders method in their Cromwellian exile.[671] We have already discussed the explosion of printed literature on the 'Flanders method' after 1645. When English farmers increasingly began to adopt the four-crop 'Flanders' method in droves from the 1660s onward, the former pastoral and sheep-farming lands of the south were converted to grain producing regions. The increased nitrogen being fixed in the soil made the south the major grain producing region in the late seventeenth century, operating at prices at which the Midlands could not produce. The latter then was converted to pasture because of an inability to compete.[672] The latter half of the seventeenth century saw farmers hard at work. Labour productivity was stagnant between 1520 and 1600, but between 1650 and 1700, labour productivity was steadily on the rise, with more threshing, hoeing, and overturning of pasture.[673] As noted, from 1650-1750 there were stagnant and declining populations in Europe. The consequent drop in grain prices caused the English to focus on livestock to compensate, which in turn increased manure and grain yields.[674] The fall in grain prices after 1650 also allowed families a larger disposable income and greater tastes for manufactured goods. This fed into the domestic textile industry, lace manufacture, paper mills, and the linen industry, the stirrings of demand for manufactured goods that spawned

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[669] Roger Schofield, 'The Impact of Scarcity and Plenty on Population Change in England, 1541-1871' in *Hunger and History: The Impact of Changing Food Production and Consumption Patterns on Society*, (Cambridge: Cambridge University Press, 1985), 92.
[670] Overton, *Agricultural Revolution*, 89.
[671] Jones, 71.
[672] Goldstone, 'Regional', 301.
[673] Overton, *Agricultural Revolution*, 121.
[674] Beckett, 30.

attempts at increasing manufacturing output.[675] Though sustained growth in population and agricultural output would have to wait until the eighteenth century, the seeds were both literally and figuratively sown in the seventeenth.

Nevertheless it is only in the eighteenth century that we begin to see the consistent and widespread adoption of four-crop rotation and legumes. Correspondingly, we see a flurry of population growth and modest gains in agricultural productivity. Between 1700 and 1800, the population grew from 5 to over 8.5 million and agricultural output increased by nearly 60%.[676] Turnips and clover replaced unproductive fallow with a crop that could be used for feeding livestock and by extension manure production, which contributed nitrogen to the soil. Clover also fixed nitrogen to the soil. Turnips meanwhile smothered weeds and provided winter fodder for animals. Using 4000 probate inventories from farms in Norfolk and Suffolk, Mark Overton has gauged the spread of new agricultural techniques. The percentage of farms using turnips and clover were negligible until the 1660s. By 1670, 10% of farms were employing the turnip and 3-5% were using clover. By 1700, 10% of farms were using clover and 30% were using the turnip. By 1740, farms using clover amounted to 20% and turnip use dwelt around 50%.[677] All told root crops increased from 5% of farms in the 1580s to 1660s and over half of English farms by 1740.[678] Potatoes were introduced into England in the 1590s and came into widespread use by the 1700s.[679] Also in this phase, enclosure really came into its own, with 28% of England was enclosed by 1760, compared to 2% in the sixteenth century.[680]

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675 Jones, 139.
676 Overton, *Agricultural Revolution*, 75.
677 Mark Overton, 'The Diffusion of Agricultural Innovations in Early Modern England: Turnips and Clover in Norfolk and Suffolk, 1580-1740' *Transactions of the Institute of British Geographers* (1985) 10:208.
678 Overton, 'Diffusion', 211.
679 Beckett, 17.
680 Goldstone, 'Regional', 301-307.

Legumes continued to be adopted in large order and bulk of the rise of eighteenth century agricultural productivity happened after 1750.[681] A campaign of ploughing up pasture, similar to the one that occurred in the sixteenth century, was waged in England after 1750, making use of the nitrogen there to produce grain at a high yield. Lime and marl were added to the soil to increase nutrients.[682] Animal feeding crops cut the need for fallow: legumes, turnips, clover, sanfoin, trefoil, and lucerne all added nitrogen to the soil. In turn, manure from grazing animals also increased the nitrogen in the soil. All this permitted higher yields.[683] All told, English food production in the mid-eighteenth century fed twice as many people but also provided a surplus to be exported.[684] Aggressive population growth took off the 1740s, when England became increasingly freed from Malthusian shackles. The population increase, like in the sixteenth century, encouraged a returned focus to grain production, which had a reciprocal effect on the carrying capacity.[685] The population grew rapidly, increasing by 60% in just 30 years, but with real wages keeping pace with only a slight stagnation at the end of the century before English agriculture and industry got a second wind.[686] This sets eighteenth century England apart from most periods of population growth in the agrarian era, and it is foreshadowing of the same trend that dominated industrialisation. The modern era was dawning.

By 1801 the population had risen to 8.66 million, and England ended the nineteenth century of agricultural improvements, mechanisation, importation, and industrialisation with a population of 30 million.[687] The fastest rate of growth in productivity was in the nineteenth century, not in the eighteenth, when agricultural output only increased by a third of

[681] Jones, 68-69.
[682] Overton, *Agricultural Revolution,* 107-108.
[683] Beckett, 12.
[684] Schofield, 75.
[685] Thirsk, 58.
[686] Schofield, 77.
[687] Overton, *Agricultural Revolution*, 63.

seventeenth century levels. Mechanised drainage of marshes, the conversion of pastures and heaths, particularly 1800-1830, plus increased importation of agricultural produce from Ireland all played their role in freeing the English population from Malthusian tyranny.[688] Thomas Malthus indeed formulated his theory in 1798 at the beginning of an age where it no longer applied. The seed drill was introduced in 1731 by Jethro Tull, a unique invention, already seen in China for several millennia, which reduced the number of seeds for the same output by 70%. However, it was not adopted rapidly until after 1810.[689] Turnips and clover covered 12.5% of English acreage in 1720. By the 1850s, they covered nearly 40%.[690] Prior to 1815 in England, the increased agricultural output came from the introduction of new crops. Afterward the rising output came from mechanisation and better fertilisers. In terms of agricultural output the average yield increased from 37 bushels/acre in 1820 to over 55 bushels in the 1840s.[691] The long stretch of scientific, technological, and industrial innovation and that characterised Britain in the eighteenth and nineteenth centuries arose at the same time as the population multiplied sixfold.

Meanwhile in Europe after 1760 the adoption of legumes and potatoes became more widespread, particularly in Normandy, the Ile-de-France, the Rhine valley, Saxony, Holstein, and Mecklenburg. But the adoption was not as thorough or as impressive as England in the eighteenth century. It was only in the late nineteenth century that the Continent caught up, seeing 20% of its total acreage in 1880 devoted to legumes.[692] This laid Europe open to one final phase of Malthusian strain between 1760 and 1850. Even England between 1760 and 1790 experienced a shrinking real wage due to dramatic population increases, but such strain

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[688] Overton, *Agricultural Revolution*, 84 & 90.
[689] Overton, *Agricultural Revolution*, 122.
[690] Beckett, 17.
[691] Jones, 187.
[692] G. Chorley, 'The Agricultural Revolution in North Europe, 1750-1880: Nitrogen, Legumes, and Crop Productivity' *The Economic History Review* (1981) 34: 72-73.

was not half as bad as it was for France, for instance.[693] There are multiple reasons why the agrarian revolution was not as thorough in France. In the sixteenth century, the plains of the north and east France were suitable for grain production, while the central and western regions were for grazing and pasture. Many places in the south were not good for grain or pasture.[694] France's pastoral regions in the centre and west in the seventeenth century were turned over to wine production, to be sold on the market, with the farmers then buying their food in exchange rather than living on subsistence. These pastoral regions were not suited to the Flanders method, and did not adopt it. The north and east continued to be France's grain producing region, thus faced no market competition, and thus had no incentive to switch from the medieval three-crop rotation system.[695] It is only after 1730 that France's agriculture expanded again. Even then the increase in productivity was lower than that of England.

During the eighteenth century, the adoption of legumes and a better rotation system across France improved agricultural productivity by 25-40%.[696] The use of legumes and fertiliser ended the 'disgrace of fallow' that had reigned for centuries, and instead began a regime of 'stolen fallow' that robbed the field of its repose. It is important to note that the use of fallow was first abandoned in regions where the population was densest. This explains Flanders, but the same trend arises in Normandy and Provence in the adoption of better agricultural methods.[697] These were places where collective learning could do its work most efficiently. A denser population allowed the idea of stolen fallow to advance much faster. In addition, literate French theorists were aware of the work of Sir Richard Weston and in 1760 the first great French work on the subject was published by Duhamel du Monceau. The

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[693] R. Jackson, 'Growth and Deceleration in England: Agriculture, 1660-1790' *The Economic History Review* (1985) 38:333 & 341.
[694] Goldstone, 'Regional', 298.
[695] Goldstone, 'Regional', 309.
[696] Lewis, 63.
[697] Marc Bloch, *French Rural History: An Essay on its Basic Characteristics*, trans. Janet Sondheimer, (London, Routledge and Kegan Paul, 1966), 213-216.

Enlightenment saw the rise of the *physiocrat* and the idea that all wealth derives from land which, while incorrect, fostered analysis of agricultural methods and yields and an environment of innovation.[698] The big change of the eighteenth century is that French agricultural production allowed more people to sell food for the market rather than just farm for subsistence. As a result, the French population increased by roughly one-third in the eighteenth century.[699] After the catastrophic famine of 1709-1710, the population stayed low until about 1720, then experienced growth during the 1720s, with a slower rate of growth in the 1730s and 1740s. The last serious agricultural crisis was in 1739-1743. Then there was a rapid expansion of the population in the 1750s to 1770s. The population of France in 1740 was approximately 24.6 million, and 28.6 million in 1790.[700] In 1700, there were 59 cities in France with more than 10,000 people – by 1780 there were 88.[701]

Town	**Population 1700**	**Population 1780**	**Change**
Paris	510,000	604,000	+ 18.4%
Lyons	97,000	152,000	+56.7%
Marseille	75,000	85,000	+13.3%
Bordeaux	50,000	83,000	+66.0%
Rouen	64,000	75,000	+17.2%
Lille	55,000	69,000	+25.5%
Nantes	42,000	57,000	+35.7%
Toulouse	38,000	54,000	+42.1%
Amiens	30,000	45,000	+50.0%
Nancy	15,000	35,000	+133.3%
Montpellier	25,000	31,000	+24.0%
Besançon	17,000	25,000	+47.1%
Grenoble	20,000	25,000	+25.0%
Tours	30,000	23,000	-23.3%

(**Table 6.2** Data from Lewis 2005, 92-93)

Yet it is clear that even by 1765, French population growth had once again outstripped the rate of increase of the carrying capacity, and grain prices rose sharply thereafter. Growth

[698] Bloch, 217-218.
[699] Dewald and Vardi, 26.
[700] Dupâquier et al, 2:6.
[701] Lewis, 8.

slowed in the north, while in the south it continued prosperously until around 1775. In Brittany in the 1770s, the population had already begun to shrink. There were agricultural crises in 1771 to 1775 concurrent with price strain and industrial depression that mimic the symptoms of the 1550s. It is even possible 1779-1784, that many areas saw the population shrink, with deaths exceeding baptisms. While the agrarian revolutions of the eighteenth century made outright famine no longer a serious factor (the next massive wave of famine would occur in 1795, caused by sociopolitical instability) there were numerous bad harvests 1775-1789, with prices remaining high and the standard of living poor in comparison to previous decades, in addition to which there were minor declines in some areas due to epidemics. French agriculture struggled from 1782 until 1785, when it entered a full blown crisis due to poor climate conditions and livestock disease.[702] There was an increase in peasant revolts and unrest after the 1760s, reaching an all new levels during the Flour War of 1775.[703] The sociopolitical instability of the time is directly related to rising costs of grain and the reduction of the real wage. During times of dearth, approximately 50-70% of people living in cities teetered on the margins of impoverishment, while 30-50% of the countryside suffered on the poverty line, with greater chance of starvation than in the cities. Over 50% of agricultural labourers in 1780 did not own enough land to support a family of four or five.[704]

Unlike England, the transition towards increasing productivity and a higher carrying capacity from standard s-curves in France was not yet complete by 1789 and the countryside was still full of manorial systems with large numbers of peasants still living for subsistence.[705] These peasants were still bound by the regular Malthusian dynamics that had so far governed everyone but the elite. It was this class of people who would suffer most from the shortages of

[702] Lewis, 216.
[703] Lewis, 218.
[704] Jean-Joseph d'Expilly, *Tableau de la population de France*, (New York: Kraus Reprint, 1979 [1780]), 6.
[705] Konnert, 61.

the Revolutionary period, particularly in the 1790s. Yet even without famine, the same series of popular revolts followed by elite factionalism occurred in the 1770s and 1780s. It would appear that this was down to the decline in the standard of living relative to the preceding decades. In France, there was no appropriate soil region in the west, centre, or south to expand grain production from the northern plains. Profit could still be made even with three-crop rotation, with no competition undercutting those prices. Widespread adoption of the potato and legumes in the north did, however, increase the French carrying capacity from roughly 20 million in 1700 to 30 million by 1800, a 33% increase. In the same space of time the carrying capacity of England rose by at least 80%. In fact, there was no staggering advance in French productivity until after 1850, as a result of railways allowing the transport of fertilisers to the west and centre in order to cultivate wheat. Meanwhile France continued to experience periods of high prices, overpopulation, and rising instability in the 1770s and 1780s, and even famine in the 1790s. Even in the 1840s there was strain.[706] The real progress was only made by French grain yields in the mid-nineteenth century: in 1750 they were only 11 hectolitres per hectare, in 1800 this had increased only by 12%, but by 1862, 54% and by the end of the century 67%.[707]

The one thing that could have rescued France from relapsing into secular strain in the eighteenth and early nineteenth century was industry, already underway in Great Britain. Unfortunately, annual industrial growth lagged behind French agricultural growth, averaging 1.1% between 1700 and 1780.[708] French industrial growth was not as impressive as Britain's. The amount of coal mined in 1789 was 750,000 tonnes, while Britain was producing ten times

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[706] Goldstone, 'Regional', 318-319.
[707] George Grantham, 'The Growth of Labour Productivity in the Production of Wheat in the Cinq Grosses Fermes of France, 1750-1929' in Bruce Campbell and Mark Overton (eds) *Land, Labour, and Livestock: Historical Studies of European Agricultural Productivity*, (Manchester: Manchester University Press, 1991), 348.
[708] Lewis, 93.

as much.[709] In 1789, there were only a few dozen engines and a few hundred spinning jennies in the whole of France. This was not good. However, the French did manage a few technical innovations: Vaucansan's silk loom or Saint-Gobain sheet glass, but most of France's specialisation was on luxury goods, and where it counted – coal and iron – early French production was abysmally low. And at the end of the day French agriculture still constituted 75% of the GNP.[710]All seems to indicate that from the 1760s onward, France entered a stagflation phase. The crisis phase was kicked off by the agricultural troubles of the 1780s and a decline in the incomes of the lower elite, while the Revolution itself took on an appearance of elite infighting between the stratified orders.

Therefore it appears that the old theory still applies for the French Revolution. This should not be surprising considering the sluggishness of French industrialisation during the eighteenth century and the continued dependence of the French on agriculture. This dependence did not cease until the French were heavily engaged in the industrial revolution after the mid-nineteenth century. The nineteenth century dynamics of revolution that followed the fall of the *ancien régime* have been well explored by Jack Goldstone in this light.[711] The economy picked up 1740, with a rise in manufacturing and trade. More farmers were indeed farming for the market. But there was a marked disjuncture between the economic boom for mercantile, industrial, and landholding segments of society after 1760 and the labouring classes who saw a sharp decline in their real wage due to the rise in prices. It is odd how this time of declining incomes coincided with a vast expansion of consumer goods, like the increased availability of coffee and tobacco. The crux of the eighteenth century where the carrying capacity is lifted is whether the rise in wages can keep up with the rise in prices. In

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[709] Lewis, 97-98.
[710] Lewis, 98.
[711] Jack Goldstone, *Revolution and Rebellion in the Early Modern World,* (Berkeley: University of California Press, 1991), 285-348.

the industrial era, of course, the rise in wages vastly outstripped the rise in the price of food. That is our concern for France in the eighteenth century, where the agrarian revolution raised the carrying capacity but probably not fast enough to keep the real wage expanding on a level comparable to the late fifteenth century or the Industrial Revolution.

Relief of the strain of population s-curves and the end of the conventional *longue durée* happened first in the Netherlands and England, only to later to take hold on the Continent in the late eighteenth and nineteenth centuries. Everywhere the ‘Flanders method’ was widely adopted saw the rise of the carrying capacity. A rising carrying capacity and agricultural output kept the population growing, but without the strain of the real wage seen in previous waves of the agrarian era. Collective learning gradually circulated better agricultural techniques around Europe. Printing of books by Weston, Hartlib, Monceau, and others aided this process. So did the eighteenth century spread of agricultural journals and farmers’ clubs.[712] Innovation built upon innovation, the population continued to grow, as did living standards and real wages. The innovations of agriculture were coupled very closely with the nascent innovations of industry. It is by this process that great inventors do not stand on the shoulders of giants, but on the shoulders of countless other tinkerers from generation to generation. All told, in the eighteenth and nineteenth centuries, the population of Europe increased from 125 million to 422 million, and growing to 25.8% of the total world population.[713] The increase of the number of innovators accelerated the pace of collective learning into the Anthropocene. At last cultural evolution had freed humanity from the *longue durée*.

[712] Thirsk, 60-61.
[713] Biraben, ‘Essai sur l’évolution’ 16.

III. Collective Learning & Connectivity

a) The Oral Tradition & the Written Word

This section will look at how certain improvements in connectivity improved collective learning through the invention of writing and the development of printing. Connectivity can have a profound impact on the acceleration of collective learning to an equal or greater degree than even an increase in population. Gradually, over 250,000 years, not only has our population increased, but so has our ability to transmit innovations and knowledge. In the Palaeolithic and early agrarian era (250,000 to 6000 years ago), collective learning was transmitted by oral tradition and physical demonstration of the old generation to the new. Like a game of 'telephone' the accuracy of these transmissions can be faulty, and the scale of information that is transmitted is not particularly high. The invention of writing takes human knowledge and stores it in a tangible object that can be accessed by thousands of people and not just passed from person to person, although, of course, for many centuries writing was confined to the elite. Nevertheless knowledge is stored as long as the document lasts rather than having to be constantly shared and stored from living individuals from generation to generation, rather than depending on word of mouth. Also, more complex and abstract ideas can be transmitted by writing.

The first writing took on the form of lists for bureaucrats and accountants, with a limited scope and for a limited audience. They were mostly stock takes of cattle and agricultural produce, and later historical events. As Anthony Giddens says, these early lists and accounts were very different from speech in a conventional way. Even early histories of Sumer amount to no more than 'event lists'. The first writing amounted to no more than the storage of the most basic data, available to those scribes and elites who knew the code.[714]

[714] Anthony Giddens, *A Contemporary Critique of Historical Materialism*, (London: Macmillan, 1981), 95 and again in *The Nation State and Violence* (Berkeley: University of California Press, 1985), 41.

Around 3100 BC, we see the first evidence of pictographic writing in Mesopotamia, consisting of symbols acting as a code, allowing states to keep records and speed up communication.[715] Pictographs and hieroglyphs employ a symbol that stands for a particular word or idea.[716] It is not very efficient in that it does not directly correspond to spoken language and requires many symbols to express a full vocabulary. Furthermore, education in the meaning of those symbols was intensive and restricted to a select few scribes who could 'break the code'.

Cuneiform emerged after 3000 BC, starting with the Sumerians. Each sign corresponded to a single word. It was more efficient in the sense that it was closer to spoken language. Multiple symbols could be used to form a larger word phonetically, in the way the English words 'tree' and 'tea' could be used to express the word 'treaty'. Nevertheless it was not much more efficient than pictographs. In 3000 BC cuneiform had over 2000 signs in Sumerian. By 2350 BC, this had been streamlined to 600 signs, but it still was largely a code for the established few: scribes, elites, historians, bureaucrats.[717] Initially cuneiform was used for lists of accounting, frequently symbolising bushels of grain, sheep, goats, and jars of oil. Later it was employed for histories, laws, and legends.[718] On the other side of Eurasia, the Chinese began the creation of symbols for an individual word somewhere between 4000 and 2500 BC, with each symbol representing a word, the early vocabulary containing about 50,000 symbols with 6000 in the most literate use.[719] In 1400 BC, scribes at 'Ugarit' somewhere in Syria-Palestine, invented 30 cuneiform symbols to write the local Semitic language. This became the ancestor of all alphabetic scripts.[720] This increased the efficiency of writing by reducing the number of symbols one has to learn to be literate. A slightly wider population

[715] Bernard Knapp, *The History and Culture of Ancient Western Asia and Egypt*, (Chicago: The Dorsey Press, 1988), 46.
[716] Knapp, 53.
[717] Knapp, 47 & 58.
[718] Headrick, 33.
[719] James Gleick, *The Information: A History, a Theory, a Flood*, (London: Fourth Estate, 2011), 32.
[720] Knapp, 189.

could be educated to write with a slightly less intensive education. The alphabet was then transmitted into the Arab world, North Africa, Europe, and Asia and transformed into Hebrew, Phoenician, Indian Brahmi, Greek and Latin.[721] State infrastructure also aided the rate of circulation of written knowledge. For instance, the Assyrian Empire from the tenth to sixth century BCE built road networks for long distance communication, involving horse couriers, which were the fastest mode of land communications until the modern age. The Persians extended these roads, running a vast 1,677 miles across their empire. In China, the emperor in the second century BCE built special roads for couriers only. The Romans connected their empire with 50,000 miles of road.[722] Until the modern era, couriers were the fastest mode of transportation for collective learning.

Certainly, the development of writing is important in that it allowed human knowledge to be written down and stored, without it having to constantly pass through a game of telephone from mouth to mouth, as it did for 250,000 years in the Palaeolithic and early agrarian era. Writing also allowed for the communication of more complex and sometimes abstract ideas, like architectural methods or war tactics. Some complex ideas were useful, some were not. Along with intellectual, scientific, and agricultural doctrines came a certain amount of dogma about religion and the rule of autocratic regimes. But even as the past hundred years of academic scholarship has pointed out, a complex idea is not necessarily particularly useful or right. The greatest limitation to written knowledge from the perspective of collective learning is the circulation of writing in this early period was abominably low. The vast amount of collective learning was still done orally, with all the slowness and flaws that method produces. Literacy still remained in the hands of the few until the modern era. It was the province of scribes, bureaucrats, philosophers, and the elite. Written works remained

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[721] Gleick, 33.
[722] Headrick, 43-44.

relatively scarce until the printing press. Transmission of the vast bulk of cultural innovations, from farmer to his son, or from artisan to apprentice, still was done by the oral tradition. Printing, however, allowed ideas to circulate among a wider and wider circle of innovators.

b) Circulation of Written Works in China, Korea, & the Ottoman Empire

Prior to woodblock printing in the Han period, the Chinese wrote on bone or bamboo. Then with the introduction of printing, the Han began to make paper out of silk, rice straw, and wooden pulp. The cheaper paper became, the more output of works and documents there was.[723] Original Chinese printing was done with woodblocks, emerging in the Han period (206 BC-220 AD). Each page had to be carved into the blocks, slowing efficiency. Woodblocks were also extremely bulky and hard to store and transport. The carver did not necessarily have to be literate, though a certain degree of artisanship was required, with every new copy or variation being started from scratch. In 1045, Bi Sheng invented movable type, where words were placed into clay tablets then imprinted on the page. However, the 1000s of individual characters in the Chinese language made moveable type impractical for most printers. Until the twentieth century, Chinese printing was still dominated by the woodblock.[724] The expansion of printing in the Song period in China (960-1279) made literacy and books fairly universal among the elite and bureaucracy of the time.[725] As opposed to the West in the early medieval period, with its largely illiterate kings and nobility, even Charlemagne could not properly read or write. Chinese woodblock printing on paper and silk began in the seventh century AD, with the first surviving specimens from the eighth. By the tenth century numerous philosophical, scientific, and agricultural works were regularly produced. Some books had a

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[723] Headrick, 49.
[724] Cynthia Brokaw, 'Commercial Woodblock Publishing in the Qing (1644-1911) and the Transition to Modern Print Technology' in Cynthia Brokaw and Christopher Reed (eds) *From Woodblocks to the Internet: Chinese Publishing and Print Culture in Transition, circa 1800 to 2008*, (Leiden: Brill, 2010), 41.
[725] Cynthia Brokaw, 'On the History of the Book in China' in Cynthia Brokaw and Kai-wang Chou (eds) *Printing and Book Culture in Late Imperial China*, (Berkeley: University of California Press, 2005), 3.

circulation of thousands, especially those sanctioned by the government, while frequently woodblock editions had a print run of a few hundred.[726] Bureaucrats and the gentry dominated book consumption until the late Ming period. From 1644 onward, however, books became available to the middling and lower orders, provided they were literate.[727]

The Koreans in the 1200s used a metal moveable type.[728] The first book using it was the 50 volume *Code of Etiquette* (1234). The Korean metal moveable type was not as efficient as Gutenberg's design. The Koreans did not use a press of any kind. They laid thin paper over inked type and took the impression by rubbing it with a wooden spatula. This was painfully slow.[729] Nevertheless, even in a state of woodblocks or metal moveable type applied by spatulas, the impact of early printing in China and Korea was to reproduce more copies of written knowledge at a faster rate than could be done by hand, increasing the number of books in circulation and the array of knowledge that could reach any one person who was literate.

In the Middle East printing did not catch on until much later. 751 AD, the Arabs acquired paper from the Chinese and by 900 AD, the book trade in the Middle East grew by leaps and bounds.[730] After that point, Islamic society did enjoy a fairly efficient dissemination of hand-written knowledge, however, the point is that printing undeniably copies and disseminates knowledge wider, faster, and more efficiently. This was crucial to collective learning. The Arabs did not fully adopt printing techniques from the Chinese, though woodblock techniques were used to stamp amulets and playing cards, a practice that was later passed to Europeans in the Crusades.[731] When Gutenberg's ideas reached the Middle East, printing was banned for religious reasons. The handwritten nature of the Quran set a

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[726] Temple, 110-112 and, Jonathan Bloom, *Paper Before Print: The History and Impact of Paper in the Islamic World*, (Yale: Yale University Press, 2001), 91.
[727] Brokaw, 'Commercial Woodblock Publishing', 41.
[728] Headrick, 85.
[729] Albert Kapr, *Johann Gutenberg: The Man and His Invention*, (Aldershot: Scolar Press, 1996), 114.
[730] Headrick, 84.
[731] Joel Mokyr, *Twenty-Five Centuries of Technological Change*, (London: Harwood, 1990), 31.

precedent, one reinforced by the sacredness of the text.[732] Muslims did not use printing until the eighteenth century, and then only tentatively.[733] After 1500, Muslim lands largely stopped mass-producing paper of their own and relied on European imports, particularly from Russia.[734] The reasons why the Ottomans failed to adopt printing after 1450 were: i) Arabic writing is cursive, which created typographical problems, although in the fourteenth century woodblock printing was used for minor artistic works like amulets, and moveable type printing of Arabic writing was done by Europeans in the sixteenth century, particularly in Italy, ii) Muslims had a religious reverence for the handwritten word, iii) Scribes and calligraphers held a high position in Ottoman society and opposed the introduction of printing for numerous centuries, and Ottoman sultans accordingly passed edicts in 1485 and 1515 forbidding the printing of Arabic characters, though Jews and Armenians were permitted to print their own languages.[735] By the eighteenth century, however, Ottoman ambassadors to Europe began to recognise the loss of opportunity for learning that the absence of printing in the Middle East caused. They started to encourage the use of printing, but still ran into vicious opposition from copyists and calligraphers. Ibrahim Muteferrika established the first press at Constantinople in the 1720s, but his exploits were resisted, printing still got off to a slow start, and it was not until the end of the eighteenth century that printing began to make ground. The invention of lithography by Senefelder in Munich aided this, because it could produce full pages of handwriting, rather than relying on moveable type. It was widely accepted in the Ottoman Empire in the first few decades of the nineteenth century.[736] Nevertheless, widespread printing with moveable type still took a much longer time to reach the scale achieved by Europeans shortly after Gutenberg.

[732] Headrick, 85.
[733] Bloom, 91.
[734] Bloom, 217.
[735] Bloom, 218-222.
[736] Bloom, 222-224.

c) Circulation of Written Works in Europe

There remains the recovery of collective learning in Western Europe after the Tasmanian Effects of the mid-first millennium which put it far behind either China or the Middle East. In the High Medieval cycle there were two breakthroughs that were occurring to vastly improve the state of collective learning in Western Europe. The first was the recovery of old classical knowledge in the Renaissance, the slow revival of antique learning that had disappeared in the West during the Tasmanian Effect and been safeguarded in Greek and Arabic and transferred through Spain beginning in the twelfth century and translated by Western scholars on an increasing scale. While active knowledge had deteriorated in the West after the fall of the Roman Empire, much knowledge of antiquity was preserved in the vessel of the written word. In the twelfth century, *de facto* groups of educated individuals began to form themselves into universities and engaged in lectures, seminars and debates. Once again, however, the question arises about circulation. The existence of written knowledge is not enough, in itself, to foster connectivity. Gutenberg's printing press c.1450 utterly revolutionised the transmission of knowledge: both Renaissance translations of antiquity and new ideas of contemporaries.

To give an idea of the scale of the revolution that swept Europe, and later the world, after the invention of the printing press, it is well to look at some numbers. During the Tasmanian Effect of the sixth century, Benedictine monasteries made a rule of housing around 50 books.[737] And Benedictine monasteries were more conscientious than most. The monasteries were of course vital to the preservation of knowledge and literature from Antiquity that survived to be handed down to the West. The largest library in the mid-fifteenth century West was that of the Vatican. It contained around 2000 books. That was the largest

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[737] Richard Abel, *The Gutenberg Revolution: A History of Print Culture*, (London: Transaction Publishers, 2011), 5.

library in medieval Europe before Gutenberg – a few thousand – while after the printing press a private scholar of middling rank could easily acquire that many in the seventeenth or eighteenth century.[738] There were perhaps half a dozen libraries with 500 books or more in the possession of kings or prominent noblemen in the early fifteenth century. In addition there were libraries of 50-100 books in a few dozen locations, either aristocratic or ecclesiastical.[739]

By contrast, there was an abrupt increase in the number of books after c.1450 – an influx of books that was by no means gradual.[740] There were an estimated 8 million copies of books published in the short period 1450-1500, based on an approximation of 40,000 different works then in circulation and an average 200 copies each. In just the space of 50 years this quite likely exceeds the entire amount of books that were hand-copied since the reign of Charlemagne.[741] This utterly staggering flood of books, that outstrips the largest library in Europe by four thousand times, was the result of a 'Cambrian explosion' of printing presses that continued to change and be perfected in efficiency until printers narrowed it down to a few select designs by the seventeenth century, not unlike the explosion and subsequent refinement of bicycle designs in the nineteenth and twentieth centuries examined by Mark Lake and Jay Venti.[742]

In the 1460s, while printing technology was still its infancy, three men could make 200 copies of a book in 100 days with a Gutenberg-style printing press. The same amount of copies would take 45 scribes two years.[743] To give you a better idea of how revolutionary this improvement of pace was, immediately after Gutenberg it would take 6.7% of the manpower

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[738] Neil Rhodes and Jonathan Sawday, 'Paperworlds: Imagining the Renaissance Computer' in *The Renaissance Computer: Knowledge Technology in the First Age of Print*, (London: Routledge, 2000), 3.
[739] Abel, *Gutenberg Revolution*, x. Elizabeth Eisenstein, *The Printing Revolution in Early Modern Europe*, 2nd edition, (Cambridge: Cambridge University Press, 2005), 22-23.
[740] Abel, *Gutenberg Revolution*, 23;
[741] Abel, *Gutenberg Revolution*, 40.
[742] Mark Lake and Jay Venti, 'Quantitative Analysis of Macroevolutionary Patterning in Technological Evolution: Bicycle Design from 1800 to 2000' in Stephen Shennan (ed), *Pattern and Process in Cultural Evolution*, (Berkeley: University of California Press, 2009), 147-162.
[743] Rhodes and Sawday, 4.

to make 200 copies in 13.7% of the time. In 1470, the first printing press in France was set up at the Sorbonne in Paris.[744] It is with some irony that the benefits of the printing press in France were exploited by theologians at the University of Paris who soon would have the most reason to lament the widespread publication of numerous Protestant tracts. By 1480 there were printers working at eight other towns in France: Caen, Angers, Poitiers, Chablis, Lyons, Vienne, Albi, and Toulouse.[745] By 1500, there were forty such towns and Paris alone had over 75 presses.[746] The circulation of ideas in the Scientific Revolution and Enlightenment all benefited from the printing press. It goes beyond just the easier proliferation of knowledge. A document previously had to be hand-copied in order to circulate and gain widespread currency. This made it easier for crown or clergy to suppress undesirable points of view.

Of the 8 million books printed 1450-1500, approximately 3.6 million books were published on theology, since early printers most frequently accommodated the traditional users of books. They printed bibles, missals, scholastic works, contemporary theological tracts, and religious education books for the masses. 2.88 million books were printed for all kinds of secular literature, including the classics and philosophy, with a vast reproduction of classical texts that were to animate the liberal educations of the sixteenth century of monarchs like Francis I or Henry VIII. 880,000 of the books printed 1450-1500 were dedicated to the legal system. Finally, a fairly small selection of books, but one ultimately crucial to the development of collective learning, was printed on science: 640,000 in all. Spread across all of these categories were an estimated 1.5 million books produced for popular consumption.[747] The prevalence of theological books in this period was the result both the traditional culture of

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[744] Francis M. Higman, 'French-speaking regions, 1520-1562' in *The Renaissance Computer: Knowledge Technology in the First Age of Print*, (London: Routledge, 2000), 104.
[745] Eisenstein, 17.
[746] R.J. Knecht, *The Rise and Fall of Renaissance France: 1483-1610*, 2nd edition, (Malden: Blackwell Publishers, 2001), 6.
[747] Rudolf Hirsch, *Printing, Selling, and Reading 1450-1550*, (Wiesbaden: Otto Harrassowitz, 1967), 129.

the literate belonging to the clergy and the fact that books remained fairly expensive to produce. A printing press in itself was in expensive. It would cost between 20 and 40 *livres tournois*. By contrast new fonts cost 250-600 *livres*, paper constituted 40-50% of production costs, wages of the printers cost about 50% leaving a possible 10% for additional expenses.[748]

There is no question that the printing press contributed to the vast advances of the Renaissance, whether it was the revival of classical knowledge or the inception of unique innovations. The problem of the translation of classical texts of the Twelfth Century Renaissance was that works had to be translated from Arabic or Greek to Latin and then the hand-copying process was a long and tedious process that could only be done by a select number of people who were familiar enough with the subject matter to avoid copious mistakes.[749] The transition from hand-copying to the printing press also reduced errors. In a printed volume, a mistake would be the same in every volume and would be easy to spot and correct in the next edition. In a hand-copied book, a potential army of errors and misprints could exist in every volume, each set of mistakes being different from the next. Both the Carolingian and Twelfth Century Renaissances were driven by small self-contained communities of a few learned men who had access to the extremely rare supply of literature. The average professor at a twelfth century university might have perhaps five books at his personal disposal. The printing press allowed the rapid proliferation of knowledge not only among traditional universities but also to individuals across Europe, allowing people like Desiderius Erasmus to write independent of any institution.[750]

Of the prominent 640,000 copies of scientific works printed 1450-1500 were Euclid's *Elements*, Ptolemy's *Almagest* and *Cosmographia*, Aristotles' *De Caelo*, Dioscorides' *Materia*

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[748] Jean-François Gilmont, 'Printing at the Dawn of the Sixteenth Century' in *The Reformation and the Book*, ed. Jean-François Gilmont, trans., Karin Maag, (Aldershot: Ashgate, 1998), 18.
[749] Abel, *Gutenberg Revolution*, 15.
[750] Abel, *Gutenberg Revolution*, 26-27.

Medica, and Pliny the Elder's *Historia Naturalis*. In addition Ptolemy's *Cosmographia* was particularly influential when disseminated in the 1470s and 1480s and was employed by Portuguese, Spanish, and Italian navigators. Modern works also owe their widespread proliferation to the printing press: Regiomontanus of Nurnberg's Ephemerides and his collaboration with George von Purbach in *Theoricae Planetarum Novae.* The sixteenth century saw the widespread proliferation of Conrad Gesner's *Historia Animalium* and Vesalius' *De Humani Corporis Fabrica*, which falsified much of Galenic anatomy, and of course, the widespread publication of Copernicus' *De Revolutionibus Orbium Celestium* after his death in 1543.[751] Given the church's later treatment of Galileo, one has to admire his caution. In short, the printing press used less labour in copying and bridged the gap between scholars and practitioners. Classical knowledge retrieved from the archives of the monasteries was rapidly disseminated after 1450 and then increasingly surpassed.[752]

Gutenberg's innovation was to take the same idea and string several symbols together in a sequence to produce many imprints, not just one.[753] Combined with his expertise as a goldsmith and his small but crucial innovation of the hand-mould, the technologies of block-printing, wine-presses, and metalwork were combined into an invention of dynamic proportions. All of this is connected to the crucial idea put forward by Richerson and Boyd that all human innovation is incremental, with successful combinations building up over time in a Darwinian process.[754] The hand-mould was the key to producing metal moveable type. That was Gutenberg's contribution to the incremental process of technological innovation and the broader process of collective learning. Occasionally, incremental steps add up to a veritable 'Cambrian explosion' when they cross a certain threshold. And indeed this seems to

[751] Abel, *Gutenberg Revolution*, 51-56 & 68 & 113-114.
[752] Eisenstein, 87 & 152-153.
[753] Kapr, 120-122 & 124.
[754] Richerson and Boyd, *Not By Genes Alone*, 51.

be the case with Gutenberg's printing press. Like so many human inventions, the design and concept were simple – the significance revolutionary. 8 million copies printed in the space of 50 years, outnumbering the handwritten copies of the last 700, and coinciding with a vast advancement in the revival of classical knowledge during the Renaissance and the stirrings of the onset of the Scientific Revolution, certainly attest to that revolution. By 1480, there were 380 printing presses in Europe. By 1530, more books were printed than in the previous 1000 years.[755] 140-200 million books were printed in Europe 1500-1600.[756]

Of course, much of the dissemination of knowledge that contributed to the Renaissance, Scientific Revolution, and the Enlightenment did not affect the carrying capacity, which did not rise significantly until the eighteenth century. But the printing press also helped the dissemination of the works of Weston, Blith, Reeve, North, and du Monceau, which encouraged the Flanders method and *did* raise the carrying capacity.[757] Furthermore, countless works circulated by the printing press, like Newton's *Principia Mathematica*, played a direct influence on the development of physics and the scientific method which was to be vital to the industrial development of the later nineteenth century. Finally, there is no contradiction between the tremendous results achieved by an increase in connectivity in Europe in the early modern period and the dramatic increase in population in Song era China. Both were capable of tremendously enhancing the level of collective learning and contributing to the great divergences that occasionally resulted from it.

In comparison to the 100-200 million books printed in Europe between 1500 and 1600, Chinese woodblock printing produced 250,000 separate titles, with half of them being produced between 1644 and 1911.[758] The abysmal pace of woodblock printing was not

[755] Mokyr, 31.
[756] Headrick, 85.
[757] Fussell, 'Low Countries', 611, Bloch, 217-218.
[758] Tsuenhsuin Tsien, *Paper and Printing*, vol.5, (Cambridge: Cambridge University Press, 1986), 190.

improved until the twentieth century, seriously hampering diffusion of knowledge compared to Europe, which by the nineteenth century had adopted the even more efficient roller press. Similarly in the Middle East, which did not adopt printing until 300 years after Gutenberg, relatively few handwritten documents survive from the period before 1500. Between 1500 and 1700, at least 600,000 hand-copied manuscripts are known to have been produced.[759] Even if this number is only part of a greater number of manuscripts that did not survive, 600,000 painstakingly hand-copied works pale in comparison to the 8 million works printed in the fifty years after the advent of the Gutenberg press. In the case of printing, Gutenberg's designed allowed for millions upon millions of books to be printed and distributed throughout Europe after 1450. This made a major impact on the dissemination of Graeco-Roman knowledge in the Renaissance and ultimately facilitating the spread of the Scientific Revolution and the Enlightenment. Meanwhile, during this production and expansion of connectivity, the Middle East missed out on the Gutenberg revolution completely and the Chinese continued to labour at woodblock printing and inefficient clay tablets. This was a major blow for collective learning in the two major empires of Eurasia that is not often recognised.

IV. The Short-Lived Divergence

This section looks at the 'short-lived' divergence of Europe over the rest of the world, compared to China's many centuries-long lead over Europe. The first Great Divergence when the carrying capacity in China was doubled by wet-rice farming kept it ahead of a Europe still recovering from a Tasmanian Effect for about 800 years. The second divergence has lasted only two centuries. Thanks to the unification of world zones and the continued improvement of communicating knowledge that divergence is already being made good. The real material disparities between Europe, the Middle East, and China did not arise until the Industrial

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[759] Bloom, 93.

Revolution was well underway, hence the thesis of Ken Pomeranz that the ‘divergence’ was a fairly recent thing.[760]

However, viewed from the lens of collective learning, the seeds of that divergence may have been sown as far back as the 1400s, with the emergence of efficient printing in Europe while woodblock printing remained prominent in China until the twentieth century. Printing was non-existent in the Ottoman Empire until the eighteenth century. That leaves 300-500 years in which Europe had the edge in widespread, efficient, and cheap dissemination of written knowledge. Potential innovators had wider access to knowledge and could compare and tinker with ideas in philosophy, agriculture, and science. This advantage should not be underestimated even though it took a few centuries for accelerated learning to culminate in a Great Divergence between an industrialising West and a non-industrial rest. Otherwise the seeds of divergence might rest in the agricultural improvements 1600-1850 in the West, while China had relatively few and the carrying capacity remained more or less the same. The combination of slower dissemination of knowledge, lower connectivity for complex ideas, and a stagnant carrying capacity, may have been the seeds of the Great Divergence that became apparent in the nineteenth century. But this was really only a second Great Divergence between Europe and East Asia. A previous one was triggered by the increase in rice yields and population in the Song dynasty, catapulting China well ahead of Europe, which remained a sparsely populated and technologically stunted backwater for centuries. It is in this sense that the influence of population and connectivity on collective learning has a huge impact on human history.

The Industrial Revolution was born out of a collection of small innovations that were selected and spread, combining into a feedback effect that significantly increased the carrying

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[760] Kenneth Pomeranz, *The Great Divergence: China, Europe, and hte Making of the Modern World Economy*, (Princeton: Princeton University Press, 2000).

capacity of the human species. In 1709, Abraham Darby used coke to manufacture iron, inefficiently, until tinkering made the practice efficient enough in the 1760s to be selected and spread across Britain. Henry Cort invented a process in 1784 to create bars of iron without use of coke, further increasing efficiency.[761] Denis Papin seventeenth century France revived an invention that was known to the Romans, the Chinese, and many other cultures using atmospheric pressure, later worked on my Englishman Thomas Savery, and eventually producing Thomas Newcomen's steam engine in 1712. More tinkering and the harnessing of a steam engine to power a blast furnace for iron production in 1742 also raised production. From there James Watt tinkered with the steam engine in the 1760s making it even more efficient.[762] It made available to humanity the energy stores that were built up over several hundred million years.

In textiles, Dutch innovations using waterwheels, Italian factory plans, were brought into England and further innovated into textile production in the 1730s. Three more innovations in the 1780s: the waterframe, the spinning jenny, and the spinning mule, all built on these innovations, transforming cotton to a common commodity rather than a luxury good.[763] Once the steam engine was brought into these innovations, production efficiency advanced even more. From here the steam engine was also brought in to enhance locomotion. The nineteenth century saw this advanced capacity for production and innovation spread into almost every industry and across Europe and the globe. Much of the initial practices that led to the spark of industry were familiar in medieval China, but it was these cultural variations that

[761] James McClellan and Harold Dorn, *Science and Technology in World History: An Introduction*, (Baltimore: Johns Hopkins University Press, 1999), 279 & 280-281.
[762] McClellan and Dorn, 282.
[763] Joel Mokyr, *The Lever of Riches: Technological Creativity and Economic Progress*, (Oxford: Oxford University Press, 1990), 96-98 & 111.

came together at the right time in the right place to raise the carrying capacity and produce a Cambrian explosion of further innovation.[764]

In many ways, the occurrence of variation and selection is the key to the advance of cultural evolution – the conditions have to be just right, there has to be an available niche, and certain cultural variations have to be able to combine to produce material breakthroughs. What is more, there needs to be a certain degree of connectivity between innovators, both in the sense of international exchange and the availability of printed materials, for all those innovations to come together and accumulate. In the eighteenth century, numerous innovations for the exploitation of fossil fuels, the more efficient exploitation of iron, the mechanisation of textile production, came together at the right time to form a niche that allowed for further innovations: railways, the factory system, and the cheap mass production of goods. It may be that it was not so much the cultural or institutional differences between Song China and eighteenth century England that made or broke the prospect of an industrial Cambrian explosion (though those factors undoubtedly had influence) so much as the generation of the right variations of innovation combining at the right time.

Certain structural conditions, like commercialism, can foster innovation, but nevertheless specific ideas that can open such an industrial niche have to be produced by individuals. Variations have to arise before they can be adopted. And sometimes, like in biology, the generation of those variations can just be the 'luck of the draw'. At any rate, it would be too deterministic to think that any particular set of political, geographic, economic or cultural conditions automatically spawns industrialisation. All the physical processes that can expand industry depend on the tinkering and innovation of individuals on *specific designs* that

[764] Arnold Pacey, *Technology in World Civilisation*, (Cambridge: MIT Press, 1990), 113, Mokyr, 84-85, and Joseph Needham, *Clerks and Craftsmen in China and the West*, (Cambridge: Cambridge University Press, 1970), 202.

are successful. Similarly, a large population of potential innovators can increase the *probability* of a successful innovation arising, but do not necessarily guarantee it.

The ultimate outcome of this process of tinkering and increase in variation, innovation, and connectivity was that humans were able to harness more and more resources and energy from their environment. The average per capita production in industrialised society also surged ahead of per capital production in an agrarian society. In terms of population, the East has always had an advantage. Below is a chart that demonstrates that China and India's large traditional societies still constituted a huge chunk of industrial output well into the nineteenth century:

Country	1750	1800	1830	1860	1880	1900
UK	1.6	4.1	9.8	19.9	22.8	18.5
Germany	3.2	3.4	3.8	4.9	8.4	13.1
France	3.9	4.1	5.4	8.0	7.8	6.8
Italy	2.4	2.7	2.2	2.7	2.5	2.6
Russia	4.7	5.4	5.4	7.1	7.8	8.9
USA	-	0.7	2.7	7.1	14.7	23.7
Japan	3.9	3.4	2.7	2.7	2.5	2.4
China	33.1	33.3	29.9	19.5	12.5	6.3
India/Pakistan	24.4	19.7	17.9	17.9	2.8	1.7

(**Table 6.3** Total industrial potential in terms of percentage of global total, from Headrick 1990, pg. 58 and modified in Christian 2004, pg.408)

From this perspective in 1830, even Britain's share of total world industrial output is pitifully small compared to China and India, totally diluted by the per capita output of much larger populations. However, as the second chart shows, when one calculates the industrial efficiency by dividing that output per capita amongst each country's population, a new pattern emerges where even the most nascent industrialisation surges ahead of traditional production:

Country	1750	1800	1830	1860	1880	1900
UK	33	55	110	195	246	270
Germany	24	20	24	29	59.7	126
France	20	21	30	50	64	92.5
Italy	21.4	23	20	27	28.5	42.4
Russia	24	23	18	22	26	36
USA	-	19	39	64	95	168

Japan	16	16	15	18	22	29
China	16	16	14	12	11	8.5
India/Pakistan	20	11	13	7	3.6	3.3

(**Table 6.4** Industrial Efficiency from percentage of global output divided per capita for each population multiplied by 100)

Relative to population size, production efficiency even with the most nascent forms of industrialisation adds a significant advantage. Note not only how industrial efficiency surges ahead of the more traditional agrarian economies of the East but also how Britain's early start in industrialisation keeps it ahead of European countries and the United States until the late nineteenth century, corresponding with what we know of the history of the period. Even in 1750, nascent industry in Britain permitted it a higher efficiency rating than other traditional economies. Industrial technology and methods enables humans to exploit a new niche and harness more energy.

Industrialisation also has the effect of keeping the real wage reasonably stable even in times of population growth. In the nineteenth century, as a general rule, wages kept ahead of rises in prices, even as the European population expanded by leaps and bounds. Previously, in the agrarian era, we only see this phenomenon in periods of population recovery after a catastrophic decline, such as France from 1450-1520. Eventually strain sets in and causes a decline in living standards. Advances in the rate of production of common consumer goods, however, are better able to keep prices in check and keep the real wage fairly stable in periods of population growth. The Malthusian tyranny of the *longue durée* was for Europe in the industrial period at least momentarily suspended. In terms of the carrying capacity, the agrarian economies of India and China carried on feeling strain in the nineteenth and early twentieth centuries, culminating in several severe famines, like the particularly monstrous one in Bengal in 1943. It is possible that the lack of agricultural improvements in China between 1650 and 1850 was that agriculture there had already attained such a high level of efficiency in being able to support very large populations, that the ability to exploit the agrarian niche further could only be obtained by significant advances in chemistry and genetics.

However, even China and India were not to remain under the yoke of the *longue durée* for very long. The introduction of chemical fertilisers, pesticides, and crops with greater yields allowed the developing world to grow by leaps and bounds and attain the gigantic proportion of the world population that it has today. That is why the United States passed a declaration stating that Norman Borlaug has saved more lives than any other person who has ever lived. His development of a grain hybrid, Norin 10, grows on very short stalks but has very large seeds, and the stalk is strong so that it does not topple over. Improvements also happened in rice, where, following the Second World War, a new variety, IR8, permitted higher yields, responded well to chemical fertilisers, and multiplied the yield by up to ten times. A subsequent variety, IR36, cut down the growing time to 105 days.[765] This rescued billions of people from the brink of starvation and permitted the birth of billions more. While China and India may have been on the brink of another round of conventional s-curves in the early twentieth century, the Green Revolution has seen their already large populations expand by leaps and bounds. Meanwhile industrialisation raised both output again and industrial efficiency of these regions.

The second Great Divergence that had lasted only a few centuries and indeed the entire agrarian period and conventional *longue durée* were coming to an end. Beyond lies an entirely new period of enhanced connectivity and innovation and ever-increasing power over the energy and resources of the planet. We are entering the Anthropocene, where one species for the first time in the history of the Earth wields tremendous influence over the biosphere. It remains to be seen whether collective learning has freed humanity from the strain and

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[765] Christopher Lloyd, *What on Earth Evolved? In Brief: 100 species that have changed the world*, (London: Bloomsbury, 2010), 202-205 & 236-240.

devastation of the conventional *longue durée* forever, or whether modern societies will exhaust the resources of the planet in the same way that agrarian societies exhausted the resources of the field.

V. Discussion

In chapters four and five we surveyed how population cycles and a sluggish carrying capacity influenced micro-scale historical events: faction, civil wars, government crises, intra-elite competition for resources, and the cyclical rise and decline of the standard of living. In this chapter we looked at how in the long term accumulated knowledge and innovation in agriculture and communications raised the carrying capacity. Any innovation that enables population growth or the increase in connectivity has a positive feedback for collective learning, which proceeds apace with more potential innovators. This is how collective learning relates to the agrarian cycles that so concerned Ladurie and are at the core of the theories of my colleague Peter Turchin. When certain innovations like those of Song dynasty agriculture or the Industrial Revolution come together it can have staggering results for production, population levels, and the carrying capacity. Taken together, collective learning and agrarian cycles explain some of the broad trends of human history and how they relate to even the minutest historical events. It is in this sense that the Braudelian metaphor comes alive: historical events form the swirling foam at the crest of the waves, and they in turn are driven by the deeper tides of the ocean.

In our conclusion we shall link this once again to what we discussed in the first two chapters: the Darwinian algorithm of random variation and non-random selection in the history of the cosmos and non-human life. Taken as a whole, population cycles, collective learning, cultural evolution, and the Darwinian algorithm create a comprehensive framework for the history of 13.8 billion years. This framework goes beyond the conventional *longue* *durée* of a few centuries that concerned the *annalistes*. Yet in the same spirit we have sought unifying patterns that influence the long march of history and a coherent shape beyond a mere catalogue of events. Broad trends in history connect the very large with the very small.

Conclusion: The Shape of History & the *Plus Longue Durée*

As seen in the first two chapters, the prevailing trend in the history of the Universe is the gradual rise of free energy rate density or 'complexity' due to various manifestations of the Darwinian algorithm. In the last 250 years, the accumulation of cultural innovations has lifted the human carrying capacity and provided an explosion of innovation. This accumulation of varying ideas could not have happened without the collection of several generations' work from hundreds of inventors and thinkers. We do not stand on the shoulders of giants. We stand on the shoulders of other ordinary people like us. For instance, the use of the steam engine for iron work was spread to textiles, to locomotion, to mechanised agriculture, and sparked an interest in harnessing other forms of energy for industrial production. Each small idea was devised for a specific purpose or niche, was selected, and brought to bear on further change.

The same can be said for innovations in agricultural practices from 10,000 years ago to the eighteenth century, although the improvement of agrarian yields did not proceed nearly fast enough to keep pace with population. The result was the s-curve, periods of ebb and flow, population strain and sociopolitical instability, periods of conflict and the proverbial 'golden ages' of kingdoms and empires, things that characterise the historical events of agrarian civilisations. This is how the Darwinian algorithm ties into the population dynamics of Le Roy Ladurie and the *longue durée*. The state of collective learning and our ability to exploit resources from our environment to slowly raise the carrying capacity had a direct impact on the ebb and flow of sociopolitical instability, the course of political events, and, in some cases, the rise and fall of empires. The cresting waves at the top were indeed driven by deep ocean tides.

Periods of strain and population decline had a deleterious effect on cultural evolution and collective learning. When the population was lowered it reduced the number of potential innovators. If more learning was kept from each secular cycle to another, this difficulty was survivable. However, if the population declined too far, certain innovations and learning were lost completely like in the late Roman and early medieval periods. The number of variations was reduced, those already selected were erased, the carrying capacity was lowered, and collective learning had to start all over again. Nevertheless, Tasmanian Effects in the agrarian period were few and far enough in between that on the whole the carrying capacity was gradually raised over 10,000 years.

A similar consistency was maintained in the Palaeolithic, even where populations were small and sparse enough that Tasmanian Effects probably occurred more often. Even then, the trend of the human population was up, from a few thousand after the Toba super-eruption, to nearly 6 million at the dawn of agriculture, when the variations of ideas for animal domestication, plant domestication and clustering habitation slowly spread and were selected by other peoples. Even with the disasters of population decline, whether natural or manmade, whether resulting in the stymieing of cultural evolution or a full blown Tasmanian Effect, the human capacity for collective learning has ultimately allowed our population to increase since we appeared on the face of the Earth around 250,000 years ago. The free energy rate density (erg/s/g) of this complexity has been many times the average product of plant or animal evolution. It also amounts to be 4 million times the free energy rate density of a galaxy. This is down to the many billions of cultural variants that can emerge in the space of a generation of a human population. The number of potential variations produced by culture is far greater and proceeds far faster than biological evolution. *The level of complexity seems to increase with the number of viable selection paths*. Like a highway overpass looming over older roads, cultural evolution can blaze along at a much faster rate of speed.

Generic Structure	Average Free Energy Rate Density (erg/s/g)
Galaxies	0.5
Stars	2
Planets	75
Plants	900
Animals	20,000
Australopithecines	22,000
Hunter-Gatherers (i.e. 250,000-10,000 y/a)	40,000
Agriculturalists (i.e. 10,000-250 y/a)	100,000
Industrialists (i.e. 1800-1950)	500,000
Technologists (i.e. present)	2,000,000

(**Table 7.1** Amount of free energy running through a gram per second, and the australopithecine and human free energy rate density is determined from the average energy consumption of an individual, Chaisson 2010: 28 & 36)

Not that biological evolution is sluggish or is lacking in many diverse and complex forms. Far from it, random variation and non-random selection in biology is capable of producing millions upon millions of diverse eukaryotic species, to say nothing of single-cell organisms. Like the products of culture, biological evolution seems capable of producing diverse forms without limit, under the right Goldilocks conditions, in the mere space of a few hundred million years. It shall be interesting to see what variations and complexity cultural evolution is capable of producing once it is permitted to be around for the same space of time. Also, at a slower pace than the biological or cultural, with only a few thousand variations in the space of the Earth's history, geological evolution nevertheless wields a free energy rate density that is 1500% that of a galaxy. Without it life could not have existed to produce eukaryotic forms that are 1,800 to 300,000 times more complex, nor culture to harness energy to produce forms in even more impressive magnitudes.

The reason why the Darwinian algorithm seems to raise the level of complexity in the Universe is fairly straightforward, even though it is a blind process of random variation and non-random selection. The production of variations in atoms, chemicals, organisms, and cultural ideas in the Universe is constant. Some of those variations find niches within the laws of physics and are selected. *While many variations are selected for their simplicity, the* *constant generation of variations in the Universe means that some variations will fill niches that are complex.* Those variations have a higher free energy rate density, and building upon those systems even more complex variations and higher rates of density can emerge. In this work I have used the metaphors of a constant rolling of the dice that eventually pays off and putting enough bullets in a barrel (from the cliché 'shooting fish in a barrel') means you will eventually hit a fish. Generate enough variation and some will emerge that are more complex. This is how a seemingly directional and deterministic rise of complexity results from a blind process.

The cultural, the biological, and the geological all stretch back to the evolution that began in the bellies of stars, and the physical laws of the Universe that permitted those stars to come into being. Whether or not other sets of physical laws exist or if there is nothing beyond our cosmic horizon, recent science in the form of M-theory asserts that the number of variations of those sets of physical laws is 10^{500}. Our single variation from this vast number has permitted even more variations to be created in the form of elements cast out from the bellies of stars, chemical compounds composed of those elements, biological replicators formed from those compounds, and cultural innovations that spring from the evolution of those biological replicators. All are geared toward harnessing ever more energy and complexity in the universe. In a strange, blind, inexorable process that seems to be the trajectory in which the physical laws of the cosmos tend.

In this sense, the grand narrative of 13.8 billion years is really quite seamless. Nothing is created or destroyed, thanks to the first law of thermodynamics – we have merely been transformed by patterns of variation, selection, and further variation, in a rising crescendo of complexity. We do not yet know where it will lead. One thing is certain: the next rise of complexity in the Universe will likely be due to animate, rather than inanimate, forces. And it is for this reason that a humble species of savage psychotic apes, whose prefrontal lobes are too small and adrenal glands are too big to behave completely rationally, and who dwell on a tiny rock in a suburban solar system of a rather inconsequential galaxy, can feel, despite all our cosmic insignificance, a sense of pride and belonging.

In a secular, rather cold, cruel, and indifferent Universe, which does not owe us a sense of meaning or purpose, such sentiments are hard to come by. Our local star is middle-aged and will last only another 5 billion years and will boil the Earth's surface dry well before then. If the human race does not destroy itself in the meantime, it has hundreds of millions of years to exist and evolve on Earth, after which time we could venture out into other solar systems and long outlast the death of our own. We could huddle around the fires of hundreds of thousands of stars in the habitable section of the Milky Way. But unless we somehow learn to create stars ourselves, in 100 trillion years every single last dim little star will have flickered out and the universe will become a cosmic graveyard, where the corpses of cosmological giants will wander in pitch black. Until, of course, the energy that creates matter itself (which, remember, is really just a congealed form of energy) in 10^{40} years will grow feeble and matter will cease to exist, and then after a period of 10^{100} years, even black holes will cease to exist, and the universe will become an empty orb of weak cosmic radiation.

Physicist Paul Dirac (1902–1984), who predicted the existence of antimatter and whose brother Felix committed suicide in 1925, wrote his entire philosophy of life on three pages of a notebook in 1933, in which he said:

> My article of faith is that the human race will continue to live forever and will develop and progress without limit. This is an assumption that I must make for my peace of mind. Living is worthwhile if one can contribute in some small way to this endless chain of progress.[766]

[766] Paul Dirac, private papers, quoted in Graham Farmelo, *The Strangest Man: The Hidden Life of Paul Dirac, Mystic of the Atom*. (London: Faber and Faber, 2009), 221.

There is, of course, absolutely no guarantee that humanity or our descendant species will not become extinct, and much to indicate the contrary as we enter the bottleneck of the twenty-first century. But perhaps Dirac is right, despite this assumption. Perhaps, within the Darwinian algorithm, life is worthwhile if we can contribute in some small way to the rise of complexity in the universe – a strange, blind, but inexorable process that has been proceeding for 13.8 billion years. In that sense, perhaps the 'meaning of life' is a rather simple question.

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