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Black Death, "Industrial Revolution" and Paper Age collapse

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This essay discusses first English and then world economic history, starting with the Black Death of 1348–1400AD. When the English population and wealth both increased after 1400, the structure of English development by the year 1700 became a little bit like a spiral, this paper says. The aggregate size of wealth increased, but there was little commensurate change in the distribution of wealth. The eighteenth-century English elite absorbed the elites of Wales and Scotland, and then the Protestant elite of Ireland. Then, on the same model of absorption, an English-speaking elite later came to dominate world wealth. As the world population increased in the early modern period, and as aggregate wealth increased apace, the distribution of world wealth became approximately what the distribution of wealth had been in England in 1700. A tiny group of very wealthy people had controlled the wealth of England in 1700. In the late twentieth century, the English elite absorbed the world elite many of whom adopted the English language and much of English culture. They often sent their children to study in Britain or America. Now this tiny elite group, English in language and usually English in culture, controls much of the wealth of the world while at the same time the ongoing increase in population has produced a huge number of very poor people.

Keywords: *Black Death; Industrial Revolution; Gunpowder Age*

JEL codes: *N10, N30, O10*

Чума, промышленная революция и закат бумажной эры

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В данной статье мы постараемся взглянуть на английскую и мировую экономическую историю, начиная от эпидемии чумы 1348–1400 годов. После 1400 года в Англии одновременно стали расти численность населения и общее благосостояние, к 1700 году стало очевидным, что развитие английской экономики можно представить в виде спирали. Общий размер благосостояния увеличился, но его относительное распределение изменилось лишь незначительно. В XVIII веке шотландская, валлийская, а затем и протестантская элита Ирландии слились с английской элитой. Потом, в результате похожего поглощения англоязычная элита стала контролировать мировое богатство. В то время как численность населения, а вместе с ней и мировое благосостояние, возрастали, структура распределения мирового богатства мало изменилась по сравнению с 1700 годом. В 1700 году богатство Англии находилось под контролем небольшой группы людей. В конце XX века английская элита поглотила мировую, многие члены которой переняли английский язык и культуру, стали отправлять детей на учебу в Британию или США. Эта современная элита, преимущественно англоговорящая и принадлежащая английской культуре, контролирует большую часть мирового богатства, в то время как продолжающееся увеличение численности населения ведет к появлению огромного количества бедных.

Ключевые слова: *чума; промышленная революция; эра пороха*

Introduction

The COVID-19 virus injured the world's economy in 2020. Economists disagree about the severity of the economic damage, but few economists think it will be possible to make a speedy and complete return to the status quo ante. I would like to join this discussion about the economic impact of COVD-19, but I am a historian, not an economist, and this essay will discuss the past, not the future. Here is my suggestion. The COVID-19 virus will change our view of economic history. In particular, we will change our view of the Industrial Revolution. Technology became the driver of an "Industrial Revolution", and it raised living standards for some poor people in America, Britain, Japan, and elsewhere, but only after 1945. That increase in living standards for the poor is reversing now due to COVID-19.

King Arthur

Relentless population increase in England followed the Black Death of 1348 to 1400 AD. That period was a long time ago. How to understand such a distant era? Let us approach

it first through literature. Perhaps you read *The Lord of the Rings* by J.R.R. Tolkien. Those novels brought their author immense posthumous fame, but he had little profit from them in his lifetime, and he was known then principally as a scholar of medieval English literature. He was a specialist in a poem called *Sir Gawain and the Green Knight*. Tolkien translated it into modern English. Let us start with that poem. It was written circa 1375 in the north of England and in the dialect of that region. It survived in a single handwritten manuscript, and it was unknown to the public until much later scholars, Tolkien among them, made it famous.

Sir Gawain and the Green Knight was a story of King Arthur. The poem did not originate the King Arthur legend, but its author assumed knowledge of the legend and used the legend as a framework for the tale of Sir Gawain. The poem began with the fall of ancient Troy because, the Arthurian legend said, fleeing Trojans founded the line of ancient English kings of whom Arthur was the greatest. That legendary Arthurian framework borrowed and established; the poem then said that when Arthur was king of England, and when his court at Camelot was the very model of Christian chivalry, then Sir Gawain was a Christian knight who accepted and fulfilled an enchanted chivalric challenge. As Arthur and his knights were celebrating Christmas at Camelot with great feasting, Arthur demanded entertainment, and a Green Knight visited them. He challenged the Fellowship of the Round Table, and Sir Gawain accepted the challenge. He accepted it for the honor of his king and the royal court. Among other things, the story told of a magical green girdle which would protect its wearer from death. The poem was one of the greatest poems of medieval English literature (Tolkien, Gordon, 1967).

The Black Death

The Black Death was a series of visitations of bubonic and pneumonic plague which ravaged much of Europe in the fourteenth century, killing perhaps half the European population between 1347 and 1400. We need to keep the suffering in mind so that we do not lose our way amid sterile statistical data. It is certain that the victims were so numerous that many of them died without the consolation of a priest's ministration. We know this because the Roman Catholic authorities issued special permission for such people. They could shrive themselves and one another if they were in anticipation of death and without a priest. It is also certain that victims died in great misery.

A fictional account captures the horror of the Black Death better than a bald historical narrative (Willis, 2011).

A popular historian also well captured the impact of the Black Death (Tuchman, 2014).

Third, the early twentieth-century Dutch historian Johan Huizinga wrote a famous book which he called *The Waning of the Middle Ages*. He began his book with these words: "To the world when it was half a thousand years younger, the outlines of all things seemed more clearly marked than to us. The contrast between suffering and joy, between adversity and happiness, appeared more striking. All experience had yet to the minds of men the directness and absoluteness of the pleasure and pain of child-life. Every event, every action, was still embodied in expressive and solemn forms, which raised them to the dignity of a ritual" (Huizinga, 2019).

These books together provide us with a good background for our understanding of the Black Death.

Huizinga's words, in particular, help us to read medieval English poetry. Huisinga said that medieval art depicted imaginary and perfect worlds. Gold filled the paintings and the poems. In works of religious art, for instance, Saints Mary and Joseph wore beautiful clothes while on their flight into Egypt even though the gospel text said they were poor and simple people who fled for their lives. Kings and queens always wore cloth-of-gold and crowns with gems and pearls. Medieval artists did this because life was dangerous

and short in medieval times, and most people were very poor. Some were starving. Artists wished therefore to contrast the danger and misery of everyday life with an imaginary world, a world of art, where people lived in luxury and safety.

Huizinga's words were also a good introduction to the Black Death. While plague and death raged, fourteenth-century English people wrote and read of the enchanted and chivalric world of King Arthur.

The Economic Consequences of the Black Death

In England, the population before the plague and the loss of population during the plague are both very difficult numbers for us now to estimate accurately. As Professor David Routt of the University of Richmond wrote, "Imperfect evidence unfortunately hampers knowing precisely who and how many perished. … National estimates of mortality for England, where the evidence is fullest, range from five percent, to 23.6 percent among aristocrats holding land from the king, to forty to forty–five percent of the kingdom's clergy, to over sixty percent in a recent estimate." You can read on the Internet his excellent summary of recent scholarship (Routt, 2008).

I can offer a fresh way to make estimates of population growth after the Black Death. Gregory King was an English herald and statistician who estimated the wealth and population of England. King made his estimates in 1696, intending them to represent the year 1688. He used tax tables, sampling, church registers and other sources, and he made the English population to be perhaps five and one half million people. For the first time of any age in British history, he gave us accurate and reliable numbers. The consensus among current professional historians certifies King's population estimates as approximately correct. I believe his wealth data were also approximately correct. These numbers were honest attempts to estimate the base available for government taxation.

Gregory King understood that population had increased in the past and would continue to increase in the future. Everyone knows this now, but it was a truly brilliant insight in 1696. Most seventeenth-century Europeans thought the population in their time was smaller than it had been during the Roman empire. That was the point of pictures by Hubert Robert, for instance. You can see some of them in the State Hermitage Museum in Saint Petersburg. Robert's huge paintings showed Robert's own time as one of decline and decadence. Tiny little men and women stand among the vast remains of past Roman greatness[1].

Gregory King, therefore, thought population would continue to increase in the eighteenth century. King analyzed population growth by trying to estimate the period required for the population to double. Let us omit his behind-the-scenes arguments about why the population would increase. Let us go straight to the point. He thought that the English population had doubled since 1300, and he thought it would also have doubled again by the twenty-first century when he guessed the total would be above eight million. He was wrong, of course. The eight million mark was reached well before that date. Demographers will testify how hard it is to be accurate about estimates of population in the far future. The past is easier to estimate. Here are King's estimates of past English population to which I have added a number from the census of 1801.

English Population 1300–1801 AD in millions:

1300 – 2.8; 1400 – 3.3; 1500 – 3.8; 1600 – 4.5; 1700 – 5.5; 1801 – 8.8 (King, 2005).

Gregory King was an empiricist who always corrected his estimates based on common sense and experience. Let us do the same. If half the English population died of plague between 1350 and 1450, we may conjecture, relying on Professor Routt and on common sense, then perhaps nevertheless the total population recovered from that loss by 1400. In other words, if King's numbers for English population were approximately correct for 1300

[1] Cf. Robert, Hubert. Ancient Temple: the "Maison Carree" at Nimes (https://www.hermitagemuseum.org/wps/portal/hermitage/digital-collection/01.+Paintings/38115/?lng=).

and for 1400, and if half that 1300 number would be the total of those dead of the plague, then the horrible mortality of the Black Death merely abated natural population increase from 1300 to 1400, and population began to advance again after 1400. It is not exact, but it is plausible, and it confirms more or less Professor Routt's calculations.

The Black Death's economic consequences on England were stunning. Again, the exact numbers are difficult to estimate now, but we can see they were large because we can almost hear the fifteenth-century hullabaloo. Initial losses of income by landowners accompanied a rise in real wages by workers. Since English laborers were fewer than before, therefore, their real wages rose, reaching heights not seen again until the nineteenth century or the twentieth century. Landowners meanwhile lost money, so they complained, and the results were first an Ordinance of Laborers in 1349 and then a very famous Statute of Laborers (1351). In vain. Wages had risen, and parliament's effort to reduce them only contributed in the reign of King Richard II to a revolt led by Wat Tyler.

Therefore, while the exact numbers are difficult to estimate, whether of population increase or of prices and wages, yet the mechanisms set in motion after 1400 were clear enough. Farmland fell out of cultivation for lack of farm laborers. Of course, also the market for food fell since there were fewer mouths to feed. Much land was therefore turned to pasturage. This was not bad for workers at first, and the raising of sheep benefitted landowners since wool was a cash crop and grain was not a cash crop. If you were a landowner who had lost out during the Black Death by growing grain, then you had lost because you could dispose of your grain only locally, bartering most of it for the labor or for the handmade goods of local people. Grain was less valuable than before because there was less demand for it. Wool was in demand, and you could sell it to merchants who traded it by sea to Antwerp and elsewhere, and those merchants paid you in cash.

After 1400, the English population had begun to recover its numbers, and the increases reversed the rise in real wages because they renewed the numbers of the poor. The poor pressed upon a food supply which had been diminished by the changes in the use of land which began during the Black Death. A landowner who now ran sheep had enclosed the land, altering the incomes of poor people who had enjoyed customary rights to the land when it was under open-field cereal cultivation. Moreover, price inflation remained while wages fell. Alas, also many others of the poor now found no places at all in the system of economic production. Famine had disappeared after the Black Death. Now it came again.

At the very end of the time of the great Queen Elisabeth I (reigned 1558–1603), parliament, dismayed by the reappearance of famine, passed an act that none of her majesty's subjects should starve. The English elite later called this the Old Poor Law. It worked as follows. The Church of England already had the country divided into dioceses and then further subdivided into parishes. Each parish had a vestry council which raised local taxes to maintain the church building there and to pay the parish clergyman. The Old Poor Law used this existing framework. The act tasked the vestry council in each parish to raise additional taxes to maintain poor people who had been born in the parish. The poor could collect these benefits and yet continue to live in their own homes. Paying these benefits while allowing the poor to stay in their own homes was called "outdoor relief". Note that the parish authorities could move along or expel indigent people who were not born in the parish, so bands of roving beggars still existed, and they did not benefit from the Old Poor Law. Also, the system broke down in London where there were many very poor persons of no fixed abode.

By the year 1700, therefore, more than half the English population were irrelevant to economic production. They lived only by handouts from persons in the productive portion of the population. That productive portion consisted of fewer than half of all people in England.

The Black Death was therefore the beginning of sustained population growth accompanied by an increase in aggregate wealth. As population and wealth increased, there was

no change in the structure of society or in the proportionate distribution of wealth. I argue that this bean a unique and a separate age, and COVID-19 may be the end of that age (Jordan, 1974).

The Paper Age Collapse

We live during the Paper Age collapse, I believe. The worldwide lock-down of 2020 nailed shut the coffin of the Paper Age.

Let me begin to explain this claim by first explaining the phrase "Paper Age" itself. Paper, printing, and gunpowder all came into Europe from China via Arab intermediaries. People say that some of the Chinese prisoners who were taken at the Battle of Talas (near Samarkand, AD 751) ended up in Bagdad. Among them were men skilled in the making of paper and printing, and these men taught their skills to their captors. Slowly the arts of papermaking and printing filtered into Europe, printing at last reaching England from Germany in the late fifteenth century. One of the first books printed in England was Sir Thomas Malory's *Le Morte D'Arthur*, by the way. It was an Arthurian romance which William Caxton published in London in 1485. Earlier Arthurian romances had been oral works which were written by hand when they were written at all.

Similarly, black gunpowder may have infiltrated into Europe from China, although some historians claim that it was a native English invention. No matter. It came, and we know the consequences. Black powder then became obsolete in the early twentieth century. Tonio Andrade was a military historian who very ably described the history of black gunpowder and who, naturally inclined to emphasize military history, gave this whole period the title "The Gunpowder Age" (Andrade, 2016).

"Gunpowder Age" is a good suggested name for the era, but I am a historian of ideas, not of war, and I would rather call this period "The Paper Age". The dates are about the same nonetheless. Paper, printing, and gunpowder all came into England about the same time, say circa 1500, and shortly thereafter the Protestant Reformation came into England, too. Sir Thomas Browne said that printing, gunpowder, and Protestantism all come into England together, and he doubted whether any of the three had brought any benefit. That was the beginning of the Gunpowder Age in England, and "the Paper Age" came in at the same time. The Gunpowder Age was over with the beginning of the twentieth century, and the paper age lasted another hundred years, but it is now over too. We ourselves live through its end even now, therefore, and the end of paper will be one of the lasting consequences of the virus COVID-19. Everything has gone online, and it will stay online. Printed books were already obsolete. Paper letters and snail mail were obsolete. Now they will be forgotten. Even e-mail is obsolete. People meet by Zoom or Skype, and they exchange online documents as they chat. Governments even want to get rid of paper money.

Myths of an "Industrial Revolution"

The twentieth century was a time of war and famine and genocide. Just as fourteenth-century people told one another myths about King Arthur – doing so while they lived through a fearful age of plague – so twentieth-century people told one another wonderful mythical stories, doing so amidst war and death.

Twentieth-century myths derived from nineteenth-century originals. Put forward first as fanciful notions from the margins of society, the myths said that a society transformed by technology would enable future people to live lives of material comfort and physical safety. Two versions of the myth dominated western society in the twentieth century: Marxism was one version, and the notion of an "Industrial Revolution" was the other version.

Marxism and the doctrine of an "Industrial Revolution" shared much in common. Both gave a central role to British economic history. Both foretold an age of abundance, as I

already said. Both emphasized technologies. Marxists looked for a transformation brought about by class warfare which was in turn due to changes in the means of production. Let us say that others who spoke of an "Industrial Revolution" were mostly Whig historians who said that Protestantism gave rise to democracy and an "Industrial Revolution", and the combination of industrialization and democracy provided the sole model for all future world development. Not everyone who spoke of an "Industrial Revolution" was either a Marxist or a Whig, of course. Even the twisted and racist dream of Adolf Hitler foretold a time when industrial advance would bring comfort and safety for Germans.

This phrase "Industrial Revolution" was an invention, a myth, a confection, not much different from the myth of King Arthur and the Fellowship of the Round Table. Nor was it much different from the claim that Trojan refugees founded the line of ancient English kings. Since proponents of various doctrines agreed that British economic development was the model for the world, therefore they needed Britain to have had an "Industrial Revolution". They placed it in the period after 1750.

There is no doubt where the phrase "Industrial Revolution" first arose. It arose in the context of nineteenth-century French reflection about the French Revolution's wider impact on society. Several French commentators used the phrase, and Karl Marx and other socialist writers later borrowed it from them. The phrase in these continental usages often had a negative overtone. The industrial revolution was a new thing with some bad consequences, in this view (Bezanson, 1922).

The notion that human reason would bring about society's systematic advance was a typical French eighteenth-century concept, and France had a European reputation as a home of this concept. Bloody wars of religion in the seventeenth century had produced what the French historian Paul Hazard called a crisis of the European mind, and some leading French intellectuals turned toward reason as an alternative to the revealed Christian religion (Hazard, 1994).

The result was a French taste or fashion for rational improvement. Denis Diderot's *Encyclopédie, ou dictionnaire raisonné*, a work of the middle of the eighteenth century, showcased many important such advances, among them advances in mathematics, and the great French mathematician Jean Le Rond d'Alembert joined Diderot as co-editor. Advances were also made in chemistry, commerce, and literature in eighteenth-century France, and this work appeared in the *Encyclopedia* although such pure research had little contact with manufacturing until much later when exigency forced Emperor Napoleon to enlist such researchers to help him in manufacturing French munitions and weapons of war.

The phrase "Industrial Revolution" was thus of French origin, but the phrase underwent a sea change when it crossed the English channel, and it came to denote in the English language "a rapid development of industry, chiefly as a result of the introduction of new or improved machinery and large-scale production methods; spec. (usually with capital initials) the development which took place in Britain in the late 18th and early 19th centuries and spread to Western Europe and North America." This definition comes from *The Oxford English Dictionary* (OED, 2019).

You hear in this dictionary definition a hint of British pride. The Industrial Revolution, taking place first in Britain, then spread to other countries afterward, eventually engulfing the whole world, the dictionary said.

This is truly the standard meaning of the phrase "Industrial Revolution" in English. The dictionary is right in that regard, and its business was after all only to give us the standard usage and not to quarrel with the standard usage. A standard account for use in schools said that the "Industrial Revolution" began in Britain about 1750, that it had a first phase (coal, steel, railways, steam engines) and a second phase (bicycles, telephones, typewriters, and the motor car), and that it led to a fundamentally different social pattern which spread from Britain to other countries throughout the world (Encyclopædia Britannica, 2010).

Let us be clear. The phrase "The Industrial Revolution" was an invention. British people in the eighteenth century were not conscious of beginning an "Industrial Revolution". That phrase and that interpretation were what historians now call an invented tradition. People invented traditions in the nineteenth century, and they projected them back into the eighteenth century, inventing and imaging a past which did not exist. The Scottish novelist Sir Walter Scott invented many such traditions; for instance he supposed a connection between tartan cloth and the Scottish clans, but no such connection existed in 1745 when Bonnie Prince Charlie led Scottish clansmen south into England to make war and to replace the Hanoverian monarch there. English observers who remarked the appearance of his little Scottish army in England made no mention of any distinctive tartans. Sir Walter Scott invented those things and projected them into the past so that he could write romantic novels. Similarly the invention of an "Industrial Revolution" filled out and justified Marxist and Whig doctrines, which doctrines also themselves partook of a romantic and mythical character.

It is no accident that Whig theorists developed a British myth of "The Industrial Revolution" precisely during the 1840s, a decade called "the hungry forties" when potato blight killed or drove into exile about half the population of Ireland. This was an Irish population catastrophe similar in scale to the proportions of the Black Death.

As in the fourteenth century, nineteenth-century people turned to myth romance. If only Karl Marx had written romantic novels like those of Scott, and if only Marx had not written works of revolutionary activism, then the nineteenth-century world would perhaps have been a more peaceful place.

The Long Run

Brilliant French historians of the late twentieth-century proposed a different and a very good interpretation of economic history. Fernand Braudel was one such historian. Many people think he was the greatest historian of the twentieth century. Here is a brief summary of this interpretation.

Braudel spoke of the long run. With the Neolithic Age, beginning circa ten thousand years ago, came settled agriculture, animal husbandry, and a large increase in the human population. Empires developed in various parts of the world. They developed the use of bronze, an alloy of tin and copper. Because bronze required tin, and because tin had to come to the Mediterranean Sea from Afghanistan or from Cornwall, among other faraway places, Bronze Age empires were very aristocratic. Warfare was conducted on land by charioteers whose steeds and bronze weapons were very costly. Empires around the Levant developed elegant societies and complex trade networks. After the Bronze Age Collapse circa 1200 BC, people in the eastern Mediterranean region developed sophisticated methods for smelting iron ore. That ore was abundant, but it was difficult to smelt into steel. However, once mastered, the techniques of working iron into steel became universal. A system of agriculture and iron-based technology arose, and human beings lived in this system until about 1945. Braudel called that the long run. He thought that before 1945 most people in France, for instance, lived in the countryside and followed agricultural and technological practices which differed little from those many centuries before. The seasons governed the lives of these people. In this regard, Huizinga's *Waning of the Middle Ages* remains useful. So does the Gawain poem which had a great emphasis on the liturgical year and which began with a celebration of Christmas (Braudel, 1988).

The Similarity of World Wealth Distribution Now and in England in 1700

The whole world now has approximately the same social structure and distribution of wealth as English society did in the year 1700.

In the year 2020, the world's population approached eight billion people. The population of the world was approximately only one billion in the year 1800, and it has grown eight times in the two centuries since then. These astonishing data come from a United Nations table of world population growth[2].

The distribution of wealth in the world now is as follows. These data also come from the UN. They are also astonishing.

"Our results show that the top wealth decile owned 85% of global wealth in the year 2000. The richest 2% of adults in the world held more than half global wealth, and the richest 1% of adults alone accounted for 40% of all household assets. In contrast, the bottom half of the world adult population owned barely 1% of global wealth. The Gini value for global wealth is estimated to be 89%; the same Gini value would be obtained if $100 shared amongst 100 people in such a way that one person receives $90 and the remaining 99 get 10 cents each" (Davies et al., 2006).

Here is the definition of "Gini value" from *The Oxford English Dictionary*: "Designating a statistical measure of how unevenly income, a resource, etc., is distributed among a population, based on the ratio of the mean of the differences between individuals to the overall mean" (OED, 2019).

The distribution of wealth in England in 1700 was approximately what it is in the whole world now. As we have already seen, English population in 1700 was divided into two groups, one of which had the assurance of food clothing and shelter while the other group did not. The poor could subsist only with handouts from the more prosperous group. A small group of the very rich was atop the prosperous group, and below them were many other less wealthy but still prosperous groups, among them merchants who traded by sea. The very rich enjoyed incomes of several thousand pounds per year. Wealth began with the sum of one thousand pounds per year. An income of fifty English pounds sterling per year of income (or about one pound per week) separated the prosperous group from the needy. One pound per week was often the wage of a skilled workman. Aside from religious hermits and recluses (few in number), people did not live alone. Very rich persons usually maintained extensive households consisting of two dozen or more of their relatives and servants. Below fifty pounds, people were in difficulty, but those who obtained handouts survived. Some did not obtain handouts, and below twenty pounds of yearly income, people were so destitute that the family unit shattered. These data come from the seventeenth-century English herald and statistician Gregory King.

A Fractal Analysis of English Population since 1400

English population increase after the Black Death created a social structure which now engulfs the whole world. We can use fractal geometry to analyze it.

The brilliant American and French mathematician Benoit B. Mandelbrot made the word "fractal" popular in the 1970s. He invented the word himself while reading a bedtime story to a child in his family, and he opposed this new word to "algebra", an old word of Arabic origin which once meant uniting into a whole something which had previously been broken apart. Mandelbrot wanted "fractal" to describe the reverse, a breaking of geometrical forms apart, and he spoke of breaking apart a self-similar form, one in which the structure of the large whole was approximately the same as the structure of each of its small component parts. The large compound unit is a fractal, and it comprises smaller units which are also fractal in structure so large and small are all self-similar. Snowflakes and a leaf on a tree provided him examples of self-similarity. In those examples, an object aggregates small components into a large structure, and the structure of the large whole is the same as the structure of the individual components.

[2] See Human populathio growth (https://populationmatters.org/sites/default/files/styles/full_width_image/public/Historical%20human%20population%20growth%20-%20no%20logo_3.png?itok=Hjwf0HYI).

We can associate Mandelbrot and his fractal geometry with a transformation of statistical science. While building on the work of recent mathematicians such as Helge von Koch, Mandelbrot also made much use of ancient and early modern mathematical ideas. Two important influences on Mandelbrot were the Fibonacci number sequence and the Golden Mean.

The sequence 1, 1, 2, 3, 5, 8, 13, 21, … was noticed in Renaissance Italy when the name Fibonacci was attached to it. Little is known about the man Fibonacci himself, but he could not have foreseen the immense impact of this work. When other mathematicians added zero to the sequence, they made each number in the sequence equal to the sum of the two previous numbers. The sequence therefore describes a geometric form, the spiral, which is often seen in nature, for instance in some sea shells. Fibonacci was thus among those Renaissance mathematicians who facilitated the introduction of so-called Arabic numerals into Europe, and, with the addition of the zero, Arabic numerals transformed what was then called addition, subtraction, multiplication, and division.

Let us apply all this to the population increase in England after 1400. Changes in the structure of English society had the character of a spiral. If we take English society in 1700 as an initial overall item, then we can see that the whole world economy now is also an overall item. The difference between the two of them is in scale, but they are approximately similar in structure. Approximately, mind you. Mandelbrot always used the word approximately. As the population grew, the distribution of wealth has remained approximately the same in proportionate terms, while aggregate wealth greatly increased as the population increased. That was the spiral. The proportions remain the same while the aggregate size increases.

English society became part of the world fractal, world wealth concentrated in England. Marxist and laissez-faire historians mistook this concentration for an "Industrial Revolution", mistakenly attributing the growth of wealth to technological changes within the English means of production. In reality, much of this wealth was acquired from overseas. To take three examples, the British Honorable East India Company took control of India in the late eighteenth century. Prior to that time, India had been a byword for wealth, differing in that regard from Europe, which was poor and backward. The problem was that Indians were divided against one another, and The Honorable Company found that they could divide and conquer. Trade was a challenge. Indians need little woolen cloth, still a principal English export, but Indians produced a cotton textile called shoddy, which name the English gave to it using a word borrowed from the woolen trade. The Honorable Company found large markets for shoddy cotton cloth in Britain itself, where cotton shoddy became a substitute for linen, and also in the Indian Ocean, a body of water whose trade The Honorable Company controlled. The British were a seafaring people, and Brahmins were forbidden by their Hindu religion from journeys over salt water. The East India Company soon produced cheap cotton cloth in England, replacing and extinguishing the Indian producers. Similarly and more famously, David Ricardo told the Portuguese that Portugal would benefit from allowing English woolen cloth into the country, extinguishing the hitherto viable Portuguese woolen production. Again, by naval power, the East India Company suppressed the power of the Chinese government to control its own internal or domestic trade. Ruling India already, the Company judged themselves too weak to control in addition the huge expanse of China, so the Company decided to break the Chinese government and plunder the broken remains of the country. By such means, the upper ranks of English society engrossed the wealth of the world (Mandelbrot, 1982).

The English elite used the Protestant Reformation of 1529 and following to enlist the elites of Wales and Scotland. Together with the Protestant elite of Ireland they all eventually formed a British elite which remained largely English in speech and culture. In the twentieth century, the world elite also became largely English-speaking and also very nearly English in culture. Thus the whole world economy became a single huge fractal unit

comprising individual smaller fractal units, each small fractal similar in structure to the world fractal (Phillips, 1999).

A Real Industrial Revolution Began in 1945

Before 1945, wealth increased as the population increased with an increase in aggregate wealth but little change in the distribution of wealth. There was a technological advance, but population increase was the main driver of the increase in wealth. Prior to 1945, there were technological advances such as dynamite, the railway, the telegraph, the steel steamship, the typewriter, the motorcar, and the airplane, but in retrospect, these advances were small in scale, and much of this technology until 1945 had to do with transportation. Most of them were connected with the creation of a single world economy. They often modified technology available to the ancient Romans and the ancient Egyptians, and the modified technology formed the world into a unified fractal structure. The development of technology before 1945 was part of the spiral in other worlds. Paper and gunpowder were early examples of this, we see now.

That changed following 1945. Huge technological advances became commonplace. Atomic bombs, penicillin, TV, space rockets, computers, robots, and virtual reality are all examples. We were in a new situation.

Conclusion

COVID-19 changed the way in which we should interpret economic history. This essay has been about change. Just now the virus brings about the passing of the twentieth-century mythic and romantic notion that an English or British "Industrial Revolution" in the period prior to 1945 will lead us to a future time of material abundance and physical safety for most people in the world. It is the very rich who have benefitted from COVID-19. The virus forced a triumph of post-1945 technology, especially virtual communications, greatly and quickly increasing the isolation, wealth, and power of the tiny handful of people at the top of the world's fractal structure. This is no prediction, mind. It has already happened. Meanwhile, we must face the fact that population increase overwhelms the very many people at the bottom of the world economy. Again, no prediction. This has also already happened. The virus did not cause it. The virus only forces us to recognize it. Without assistance, the outlook of the world's poor people is very bleak. Furthermore, even in Britain and America the unemployment and hardship brought about by COVID-19 have erased many of the post-1945 gains in living standards for ordinary people.

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