

Advent of the Modern Economies

It is true that modernity was conceived in the 1780s. . . . [But] the years 1815–30 [are] those during which the matrix of the modern world was largely formed.

PAUL JOHNSON, *The Birth of the Modern*

OVER MOST OF HUMAN EXISTENCE, the actors in a society's economy seldom did anything that expanded what may be called their economic knowledge—knowledge of how to produce and what to produce. Even in the early economies of Western Europe, departures from past practice that might have led to new knowledge and thus to new practice, or innovation, were uncommon. Ancient Greece and Rome made some innovations—the water mill and bronze casting, for example. Yet it is the dearth of innovation in the “ancient economy,” especially over the eight centuries after Aristotle, that is striking. The Renaissance made pivotal discoveries in science and art and brought riches to royalty. Yet the resulting gains in economic knowledge were too meager to elevate the productivity and living standards of ordinary people, as the historian of everyday life, Fernand Braudel, observed. Familiarity and routine were the rule in these economies.

Was that because the actors in these economies did not desire to depart from past practice? Not exactly. Humans, it has been found, were exercising imagination and displaying creativity as long as a thousand generations ago.¹ Participants in the early economies, we can safely assume, did not lack the desire to create—they invented and tested some things for their own use. But they lacked a capacity to develop and provide new methods and products for society: early economies had not acquired institutions and attitudes that would enable and encourage attempts at innovation.

1. Researchers at the University of Tübingen recently unearthed some flutes fashioned from bones by the cave dwellers that colonized Europe 35,000 years ago. Nicholas Conard and colleagues reported the find in 2009 in the science magazine *Nature*.

The highest achievement of these early economies was the spread of commerce within each country and the spread of foreign trade with other countries. The commerce of 14th-century Hamburg and 15th-century Venice—two prominent city-states—stretched along Hanseatic trade routes, the Silk Road, and ocean lanes to increasingly far-flung cities and ports. With the establishment of the New World colonies in the 16th century, commerce spread within nation-states and foreign trade increased. By the 18th century, most notably in Britain and Scotland, most people were producing goods for the “market” rather than for their families or towns. More and more countries exported and imported at significant levels in distant markets. Business still involved producing, but it was also about distribution and trade.

This was capitalism, of course—to use a term that did not exist in those times. More precisely, it was *mercantile capitalism*: someone with wealth might become a merchant, investing in wagons or boats to transport goods to places where prices were higher. From about 1550 to 1800 or so, this system was the motor of what the Scots called a “commercial society.” In Scotland and England, at any rate, many admired this society unreservedly, while others felt it lacked “heroic spirit.”² In the mercantile age, though, these societies were certainly not lacking in aggressiveness. Merchants were pitted against one another in the struggle for supplies or market share, while nations raced to establish colonies. Military conflict was rampant. Perhaps with little to challenge people’s minds and to tempt big leaps in their business, the heroic spirit sought outlets in military ventures.

In the mercantile age, to be sure, business life exhibited a good deal less of the familiarity and routine that had been so pronounced in the middle ages. Finding and penetrating new markets—and being found and penetrated—must have provided bits of new economic knowledge from time to time. No doubt expansion of commerce often turned up a new opportunity for domestic producers, or a new opportunity for foreign competitors—thus new knowledge about what to produce. Such gains could be public knowledge, falling into the laps of people “in the business,” or could be hard-won and remain private knowledge. Less often, perhaps, the stimulus to switch to producing a good

2. Adam Smith in his *Lectures on Jurisprudence*, given in Glasgow in 1762–1763, saw “disadvantages” of the “commercial spirit.” “[T]he minds of men,” he wrote, “are contracted . . . education is despised or at least neglected, and heroic spirit is almost utterly extinguished.” (See Smith, 1978, vol. 5, p. 541.) In his 1776 classic *The Wealth of Nations* he says that “in barbarous societies . . . the varied occupations of every man oblige every man to exert his capacity. . . . [Thus] invention is kept alive” (p. 51). Adam Ferguson in his 1767 *Essay on the History of Civil Society* quoted admiringly the American Indian chief who said, “I am a warrior, not a merchant.”

not produced before might lead to advances in how to produce. By how much, though, did economic knowledge increase in the mercantile age?

Economic Knowledge in the Mercantile Era

Some scraps of early data from England's economy are revelatory. Increased knowledge of what to produce can be supposed, other things unchanged, to pull up productivity—to pull up output in relation to labor input. So if this know-how in the hands of the economy's participants, whether it was private knowledge or public knowledge, grew appreciably over the mercantile era, this would be manifested by *increased* output in relation to labor input between the era's start around 1500 and its end around 1800. If we see little or no such improvement in the relationship, that would be reason to doubt that there was important growth of production know-how during the mercantile era. What, then, does the evidence show?

Output per worker in England did not increase at all between 1500 and 1800, according to the estimates by Angus Maddison in his 2006 volume *The World Economy*, a trusted source. However, population, and thus labor force, increased enormously over that span—recovering from losses from the bubonic plague, or Black Death, of the 1300s. Conceivably that pulled down output per worker, through “diminishing returns,” enough to mask an upward pull on output per worker exerted by increasing knowledge, if there was any. However, decadal estimates by Gregory Clark show that output per worker was as high in the 1330s and 1340s, when population had not yet fallen much below its pre-plague peak, as it was in the 1640s, when population was nearly back to that previous peak. Some rare micro data suggest that output per farm worker was no higher even in the 1790s than in the early 1300s. Another study comes up with a one-third increase over that span.³ It is safe to conclude that available farming techniques did not improve

3. A study of grain output in England's Ramsey Estates found that average rates of output per man-day between 1293 and 1347 “either surpassed or met the literature's best estimates for English workers until 1800.” See Karakacili, “English Agrarian Labour Productivity Rates” (2004, p. 24).

A broader study reports no reductions in the labor required for threshing, reaping, and mowing. Yet its findings on overall productivity suggest that over a 4½-century span knowledge of how best to use farm workers did increase somewhat. Workers produced 58 bushels of grain per 300 man-days in the early 1300s and 79 bushels in the 1770s. But this is a meager gain over so long a period. See Clark's 2005 working paper, “The Long March of History,” figure 3 and table 6. Clark's figure 8 shows a single upward shift from the 1640s to the 1730s in the output-per-labor relationship—by about 20 bushels.

much over almost five centuries. (Yet measuring output per worker, product by product, misses the continual gains in aggregate output per worker from shifts of labor to production where prices or productivities are higher. In this respect, wages are more informative.)

Real wages per worker—the average wage in terms of a basket of consumer goods—reflects, among other things, knowledge of how to produce and what to produce. Start-up projects to develop new methods or products would create jobs and that would pull up wages sooner or later. New methods also tend to exert an upward pull. Did the mercantile economies see a strong lift in real wages, which would be consistent with important increases in economic knowledge? In English farming, real wages, like output per head, were falling during the first half of the mercantile age, 1500 to 1650, owing to population regrowth after the plague. Wages rose from 1650 to 1730, though about half of that gain was lost by 1800. The net result was that wages in 1800 were lower than in 1500. However, wages in 1800 *were* higher than in 1300—about one-third higher. But is that gain large enough to confirm increased economic knowledge through English innovations in products and methods? First, real wages were greatly increased by declining prices of imported consumer goods and the “arrival of new goods such as sugar, pepper, raisins, tea, coffee and tobacco,” as Clark in his 2007 book records (p. 42). So the one-third gain in real wages is not a sign of English innovation so much as evidence of discoveries by navigators and colonizers. Second, 1300 marked the end of a century of wage decline. Real wages in 1800, as Clark’s table 4 shows, were lower than in 1200! It is safe to “split the difference,” agreeing that England saw little progress in wages from the middle ages through the Enlightenment.⁴

We must conclude that the mercantile economies brought strikingly few advances in economic knowledge even in their heyday from 1500 to 1800. As population increased dramatically in the 18th century and still more over most of the 19th, with population levels setting record highs every year, it might be supposed that the fixity of land must have slowed the rise of productivity that growth of economic knowledge would otherwise have brought. But as Britain’s population grew rapidly, its economy devoted itself more and more to manufacturing, trade, and other services, which were activities

4. It is true that wages (and output per worker) in 1200 may have been pushed a little above the 1300 level by an abundance of land that was never matched again—a time when a Robin Hood could enjoy an entire forest. But land could hardly have been appreciably scarce in 1300 either. In neither period was labor pressed against the land. So there is no compelling reason to rule out 1200, with its good wages, as the base year from which to make comparisons.

requiring less land than farming did. For this reason, population growth mattered less and less for growth of wages and output per worker. The belief that rising population prevented or severely limited productivity and wages, thus thwarting and masking a rise of economic knowledge, is not persuasive. Something else was limiting growth of wages and output per head.

The remarkable similarity of economic development across the mercantile world is also a clue to what was driving them—and what was not. We now know that in the mercantile era 11 countries (or regions that become countries) were in the same club with respect to output per capita and wages per worker: Austria, Britain, Belgium, Denmark, France, Germany, Holland, Italy, Norway, Sweden, and Switzerland. (Even in the 1200s and early 1300s, England was not the backwater next to the European continent that it was thought to be.) By 1800, America had joined the club. We could say that these nations and others marched to the same drummer, though in a ragged way: each had its own fluctuations around roughly the *same trend path*—with Italy in the lead position in 1500 and Holland by 1600 (until the early 1800s). That fact suggests that their modest upward trend was the product of mercantile forces—global and felt about equally, at least within the club—not nation-specific forces.⁵

Anyone living in those times might have forecast that, once commercialization had spread as far as it could go, the national economies would settle into the routine of old, albeit in a more globalized way. As it turned out, however, the mercantile era would not be the last stage of economic development—not for these developed parts of the world, at any rate. In several of the commercial societies, the economy, while still engaging in commerce and trade, would soon take on a new character. Something happened that was strange for its time, something that would change everything.

Signs of Exploding Economic Knowledge

The indicators that were surprisingly trendless from 1500 (by some measures even from 1200) to 1800 took an astonishing turn within just a few decades. From the 1820s to the 1870s, Britain, America, France, and Germany broke out of the pack one by one. The trajectory of these countries' two indicators—output per head and the average real wage—was a phenomenal development in the history of the world.

5. The standard source is the rough estimates, drawn from a range of data, by Maddison, *The World Economy* (tables 1b and 8c).

Output per head in Britain, according to present-day measurements, began a sustained climb in 1815 with the end of the Napoleonic Wars and never turned back. It grew spectacularly from the 1830s through the 1860s. Output per head in America is now viewed as having gone into a sustained climb around 1820.⁶ In France and Belgium, it began a bumpy ascent in the 1830s, with Germany and Prussia following in the 1850s. These extraordinary climbs are indelibly associated with the first scholar to dig them up, the American economic historian Walt W. Rostow. He dubbed them *take-offs*—take-offs into sustained economic growth.⁷

The average real wage generally followed suit. In Britain the daily wage in the crafts for which we have data began a sustained rise in 1820 or so—not long after the time that output per worker took off. In America, wages took off in the late 1830s. The countries that saw, one by one, an explosion of their productivity saw an explosion of their real wages. (Chapter 2 will quantify the ascents.) The wage take-offs were discovered in the 1930s by Jürgen Kuczynski, a German economic historian of Polish birth. An extreme Marxist, he saw in the transformed economies only “deterioration of labor conditions” and “increasing misery.” Yet his own data, even after his adjustments, reveal wages to be taking off strongly by the middle of the 19th century in all of the countries he studied: America, Britain, France, and Germany.⁸

The countries pulled one another along. With the quickening of the four lead countries’ growth in both output per head and wages, every other

6. An attempted climb in 1800 ended in a crash. Despite years of fast growth until 1807, all of that growth and more was soon lost and was not regained until 1818. In contrast, the years from the mid-1830s to the mid-1840s showed a slowdown but no loss of previous gains. See the 1967 paper by Paul David, “The Growth of Real Product in the United States before 1840.”

7. The chief work is Rostow’s 1953 *The Process of Economic Growth*. See also his 1960 *The Stages of Economic Growth*. His discussion, involving “linkages,” of the causes of the take-offs was difficult and did not win over the profession. (That explanation of the take-offs does not resemble or appear to anticipate the one given here.) After a stint in the government in the 1960s he was not invited back to Harvard. Yet he deserved more recognition than he got, if only for calling attention to the take-offs.

8. Kuczynski’s early research is in his *Labour Conditions in Western Europe* (1937) and *A Short History of Labour Conditions* (1942–1945, vols. I–IV). In a life suitable for a film noir, he was not afraid of controversy. He made several novel adjustments to the raw wage data he had compiled, which succeeding investigators could not replicate. Yet, even his real wage for Britain “net” of lost time in unemployment goes from 57 in the “trade cycle” 1849–1858 to 99 in the cycle 1895–1903 (vol. I, part I, p. 67). The estimates cited above, however, are drawn from present-day sources: the 1995 international tables by Jeffrey Williamson et al. and tables by Broadus Mitchell, Paul Bairoch, Gregory Clark, and Diedrich Saalfeld. (Kuczynski’s calculations portrayed the nations he studied as starting off highly unequal and finishing the century with roughly equal wage levels, thanks to technology “transfer” and migration of workers. Calculations by Williamson show less convergence, even some divergence among the four nations.)

member in the pack was able to grow faster simply by continuing to trade with the leaders and by stepping up trade to capitalize on emerging differences—in short, by swimming in their slipstream, like fishes behind a whale.

The pioneering observations of the take-offs, made by our two Galileos of modern economic history, Kuczynski and Rostow, crystallized the extraordinary journey that the West embarked upon in the 19th century. What, historians and economists asked, were the origins of these unprecedented phenomena? Economists turned to traditional economic thought.

Many traditional economists supposed that the answer lay in the sharply increasing stock of *capital*—plant and equipment—in farms and factories during the 19th century. But capital formation could not plausibly explain—even in part—the ascent of output per capita in the United States from the mid-19th century into the 20th. In fact, the rise of capital and land in use accounted for only one-seventh of this rise.⁹ The growth of capital in the 18th century may have been sufficient to explain the somewhat meager and fitful growth of productivity in that period. But the growth of capital in the 19th century, though hastened, could not have powered the ascent of productivity and wages. Owing to diminishing returns, sustained growth of capital cannot singlehandedly yield sustained growth of output per worker and the average real wage.

Sensing that difficulty, some other traditional economists suggested that the answer lay in *economies of scale*. As labor multiplied and capital kept up, they suggested, output per worker (and per unit of capital) increased.¹⁰ But the near-tripling of productivity between 1820 and 1913 in America and Britain is far too large an increase to attribute to economies of scale resulting from the expansion of labor and capital. And if such an expansion worked wonders in that period, why did a similar expansion from the 1640s to the 1790s have no comparable effect—or, in fact, any effect? Moreover, if economies of scale raised productivity and wages so significantly, why did they

9. The span analyzed, 1869–1878 to 1944–1953, had the earliest start date possible with the U.S. data available to researchers at the time. Today, one could make rough calculations from as early as 1840 without much change in the results. See Abramovitz, “Resource and Output Trends in the United States since 1870” (1956).

Historical research on Britain concluded that although the lion’s share of 18th-century growth there was due to growth of capital rather than of knowledge, in the 19th-century growth it *was not*. See Crafts, “British Economic Growth, 1700–1831” (1983, p. 196). McCloskey’s remark, quoted below, appears in this paper.

10. This thesis was advanced in 1969 by an important economic theorist of yesteryear, John Hicks, in one of his lesser works, *A Theory of Economic History*. The theoretical work on how integrated markets work out these scale economies was initiated by Paul Krugman in his 1992 book *Geography and Trade*.

not provide the same effect in Italy and Spain? Those countries' excess populations fled to the Americas, North and South, in search of better economic opportunities. Furthermore, achieving new economies of scale must have been harder over the 20th century in the take-off economies. The increases in labor and the resulting increases in capital that could feed new economies of scale subsided. Yet output per worker and wages kept right on growing over most of the 20th century—right up to the early 1970s. (Productivity rose at a blistering rate between 1925 and 1950, even during the Great Depression of the 1930s, then again from 1950 to 1975.)

Other traditional economists supposed that the answer lay in ongoing expansions of commerce within countries and expansions of trade among countries over much of the century—the shifts of people out of self-sufficiency and the creation of new canals and railroads connecting markets. Of course, the broader horizons added to the knowledge in economies—the take-off economies and the others—of what to produce and even how to produce. But we have been here before. If *all* the commercialization and trade from medieval Venice and Bruges to 18th-century Glasgow and London was not sufficient to lift output per worker and wages, we can hardly believe that the last expansions of commerce and trade in the 19th century increased productivity and wages so spectacularly. Moreover, even if commerce and trade were important to one or another take-off economy, they could not power the boundless growth of output and wages that appeared to be unfolding. Trade as an engine of growth runs out of fuel once globalization is total.

Almost nothing in the social world is absolutely certain. But it would appear that only increasing economic knowledge—knowledge of how to produce and knowledge about what to produce—could have enabled the steep climb in national productivity and real wages in the take-off countries. As Deirdre McCloskey put it, “ingenuity rather than abstinence governed.” And, we might add, ingenuity rather than trade.

With time, the modernist emphasis on increasing knowledge—and the presumption that there is always more knowledge to come—triumphed over traditional emphases on capital, scale, commerce, and trade. But where did that knowledge come from? Whose “ingenuity” was it?

Finding the Wellspring of Economic Knowledge

Most historians coping after Rostow with the phenomenon of take-offs had no philosophical qualms about accepting the possibility that the mind can

produce new ideas and that new knowledge may result. Further, if much of the future knowledge of consequence for society was not inevitable, or determinate, the future of society was not determinate. And what is indeterminate is unforeseeable, as Karl Popper wrote in his 1957 book against “historicism”—the view that the future grows determinably out of the historical situation.

However, even these historians, though not wedded to historical determinism, based their view of economies—19th-century economies and the take-off economies included—on an 18th-century conception handed down by Smith, Malthus, and David Ricardo. In that classical conception, a “market economy” was always in equilibrium. And, in equilibrium, this economy incorporates all of the world’s knowledge potentially useful to its working: if the world discovers a new piece of knowledge, these market economies act at once to make use of it. In this view, there is no room for discovery within a nation’s economy—no room for what we may call *indigenous innovation*, or home-grown advances in economic knowledge—since, in this view, the economy is already as knowledgeable as it can be. A nation has to look outside its economy—to the state (the legislature or the crown) or privately endowed nonprofit institutions, at home or abroad—for whatever ideas or findings might bring it new economic knowledge. It follows on this view that the onset in the 19th century of unremitting growth in productivity and wages reflected some new external force rather than a new force in the economy itself.

This view of economic history was explicit in the works of the last generation of the German Historical School of Economics. They regarded all material advances in a country as driven by the force of science: the discoveries of “scientists and navigators” external to the national economies. Without these godlike figures, there would be no material progress or anything else to exclaim over. The dazzling Austrian economist Joseph Schumpeter, not yet 30, added just one new wrinkle to the school’s model: the need for an entrepreneur to develop the new method or good made possible by the new scientific knowledge.¹¹ In what became a hugely influential work published first in

11. The school grew famous and influential in Europe and America for its underlying theme that institutions are of central importance for economic performance—a theme going back to Wilhelm Roscher and even Marx. In the early 1900s the leader of this school, the German Arthur Spiethoff, and his Swedish successor, Gustav Cassel, were upstaged by the last member, Joseph Schumpeter. (Other notables were Werner Sombart, Max Weber, and Karl Polanyi.) Yet Spiethoff was important. The great British economist John Maynard Keynes traveled to Munich in 1932 for the *Festschrift* celebration marking Spiethoff’s retirement—an occasion organized by Schumpeter.

Austria in 1911, he set out the dogma of the school, which may be fairly paraphrased as follows:

What is knowable at present in the economy is already known. So no originality is possible within the economy. It is discoveries outside the economy that make possible the development of any new method or good. Though the opening of such a possibility is soon “in the air,” its realization, or implementation, requires an entrepreneur willing and capable enough to undertake the demanding project: to raise the capital, organize the needed start-up company, and develop the newly possible product—“to get the job done.” Though the project is onerous, the likelihood of the new product’s commercial success—the likelihood of an “innovation”—is as knowable as the prospects faced by established products. There is no chance of misjudgment, provided there is due diligence. An expert entrepreneur’s decision to accept a project and a veteran banker’s decision to back it are correct *ex ante*, even uncanny, though *ex post* bad luck may bring a loss and good luck an abnormal profit.¹²

Thus Schumpeter proposed a way to think about innovation while barely departing from classical economics. The two pied pipers, Schumpeter with his scientism and Marx with his historical determinism, profoundly misled historians and the general public. Economics remained mostly classical throughout the 20th century.

Difficulties with this mode of thinking quickly appeared. Historians relying on the German theory realized that by the time of the take-offs, the great navigators had nearly run out of navigable routes to discover. Historians depended on “scientists” to link the take-offs to the step-up in the pace of scientific discovery over the period of the Scientific Revolution from 1620 to 1800, which includes the Enlightenment (defined as the years from 1675 to 1800 or so). Some scientific successes of that period remain legendary: Francis Bacon’s 1620 *Novo Organum*, setting out a new logic to replace Aristotle’s *Organon* [*Logic*]; William Harvey’s brilliant analysis of the “motion of the blood” in 1628; Anton Leeuwenhoek’s work on microorganisms done in

12. These propositions express the main themes in Schumpeter’s 1934 *The Theory of Economic Development* and the 1912 German edition from which it was drawn, *Theorie der wirtschaftlichen Entwicklung*. Thus it serves as a window onto Schumpeter’s theoretical perspective in the 1900s—a decade or two before the “moderns” of the interwar years, notably Friedrich Hayek. Influenced by Hayek’s work, Schumpeter came around in his 1942 *Capitalism, Socialism and Democracy* to believing that companies in the business sector, not just scientists in royal courts and universities, could be creative in conceiving successful innovations. In his mind, though, they needed industrial labs employing scientists to do it.

1675; Isaac Newton's 1687 mechanics; Pierre Simon Laplace's mathematics work around 1785; and Eugenio Espejo's 1795 work on pathogens. Is it plausible, though, that the findings and subsequent research of a handful of scientists in London and Oxford, and a few other sites, were the forces that propelled the explosive take-offs into sustained growth?

There are ample reasons to be skeptical of this thesis. It boggles the mind to think that the scientific discoveries during and after the Enlightenment had applications so comprehensive and profound as to triple the take-off nations' productivities and real wages in less than a century—and in *most* industries, not just a few—when all the world's past discoveries could do almost nothing to raise productivity. For one thing, the new scientific findings were just additions to a vast storehouse already there. Newton himself insisted that he and all scientists were “standing on the shoulders of giants.” For another, the new findings may have had scant applicability to the economy's production; the scientists' discoveries enabled new products and methods only accidentally. Furthermore, most innovating—obviously in entertainment industries, fashion, and tourism—is remote from science. Where it is not, innovation often goes first: the steam engine preceded thermodynamics. The historian Joel Mokyr found that in cases in which entrepreneurs could have used some scientific understanding, the innovators typically ventured ahead of science, using their hunches and experimenting accordingly.

Schumpeter's scientism goes on to credit science with the rise of economic knowledge right through the 19th century. But this is equally problematic when tested against another kind of evidence. Any important new piece of scientific knowledge is accessible in scholarly publications at little or no cost—it is for this reason that it is called a public good. Scientific knowledge, therefore, tends to be roughly equalized across countries. So if we were to accept advances in scientific knowledge as the major explanation of the huge increases in economic knowledge in the take-off nations, it would then be very hard to explain the mounting disparities (starting from rough equality in 1820) in economic knowledge over the 19th century—the Great Divergence, as it has been dubbed. It would be necessary to string together a half dozen ad hoc explanations to account for Britain's early, unsustainable lead, followed by America's durable lead, Belgium's and France's advances, and Germany's progress late in the game. It would be necessary to explain from the perspective of scientism how America left France in its dust, then blew past Belgium and finally overtook Britain, when America was the country least schooled in science and, being exceptionally far geographically from the others, had least access

to scientific discoveries. It would be an even greater challenge to explain how the Netherlands and Italy remained at the starting gate, despite their sophistication in science. (Schumpeterian historians might hypothesize that those two nations fell short in entrepreneurial spirit and financial expertise. But Schumpeter himself could not have expressed such doubts after building his theory on the zeal of entrepreneurs and the knowledgeable ability of financiers.)

We must conclude that advances in science could not have been the driving force behind the explosion of economic knowledge in the 19th century.

Some historians give the credit to the inventions of the applied scientists emerging during the Enlightenment—the most famous being the headline inventions of the so-called First Industrial Revolution. In Britain, examples include Richard Arkwright's 1762 water-powered spinning frame; the 1764 multispool spinning machine credited to the humble Lancashire weaver James Hargreaves; the improved steam engine designed by the firm of Boulton & Watt in 1769; the method for producing wrought iron from pig iron developed by the iron mill of Cort & Jellicoe in the 1780s; and the steam-powered locomotive invented in 1814 by George Stephenson. In America, John Fitch's 1778 steamboat comes to mind. There is no reason for these historians to focus on headline innovations, however. The advances too tiny to be recorded may well have added up to an amount of innovation—measured by the gain in output or wages—far larger than the total innovation prompted by the standout inventions. We may assume that the historians of the Industrial Revolution recounted the headline inventions only to make vivid the restless inventiveness that began to spread in Britain starting in the 1760s. But can we really interpret these inventions as drivers of advances in scientific knowledge—advances scored on the ground, rather than in the ivory tower? And were they drivers of the explosions of economic knowledge in the 19th century?

A point against this thesis is the fact that nearly all the inventors, even the headliners, were not trained scientists, nor were they even particularly well educated. Watt was the exception, not the rule. Arkwright was a wig-maker turned industrialist, not a scientist or engineer. Hargreaves, a Lancashire weaver, was of humble background—too humble to have invented the spinning machine. The great Stephenson was virtually illiterate. Paul Johnson observes that the vast majority of inventors were born poor and could afford little education. It was enough to be creative and smart:

The Industrial Revolution, which first developed in the 1780s when Stephenson was a little boy, is often presented as a time of horror for working men. In fact it was the age, above all, in history of matchless

opportunities for penniless men with powerful brains and imaginations, and it is astonishing how quickly they came to the fore.¹³

This characterization of the headline inventors undoubtedly also applied to inventors of the myriad advances in methods that, being tiny, went unsung. So if the historians pointing to the famed inventions thought that their inventors were vessels bearing new scientific knowledge to the fertile field of 19th-century economies, they were sadly mistaken. Furthermore, this scientism does not explain why the explosion of inventions began early in the 19th century, and not before or after, and why the explosion occurred in some high-income nations and not others.

Some might think to say that gifted inventors, even if untrained, were adding to scientific knowledge when their tinkering led to an invention. But these inventors did not create *scientific* knowledge any more than bartenders inventing new drinks create chemical knowledge: they lacked the training to do so. An addition to scientific knowledge occurred if and when trained theorists managed to understand why the invention worked. (It took a musicologist to see how Bach's cantatas "worked.") If an invention at the proof-of-concept stage went on to be developed and adopted, thus becoming an innovation, it did create *economic* knowledge. (Failure also added knowledge of a sort—the economic knowledge of what apparently does not work.)

To regard inventions as the driver of economic knowledge is misleading by suggesting that they are exogenous forces acting on the economy. (Even an accidental discovery happens and has impact only if the discoverer is in the right place at the right time.) The inventions made famous by the major innovations they led to were not prime causes—not thunderbolts from outside the economic system. They were born out of perceptions of business needs or an inspired sense of what businesses and consumers would like to have—all drawn from the innovators' experience and guesswork in the business world. James Watt may have been a pure engineer at heart but his partner, Matthew Boulton, demanded a steam engine that would be widely useful. Invention and the curiosity and ingenuity behind it were nothing new, after all. What

13. Johnson, *The Birth of the Modern* (p. 188). Few would want to question the judgments made by this polymath in any of his several fields. Yet it is highly eccentric to conceive of the First Industrial Revolution as starting in the 1780s rather than the 1760s and unusual to conceive of it as stretching to the 1820s. (Some of the most important inventions and succeeding innovations of the Second Industrial Revolution, starting with the Bessemer process and the Siemens-Martin open hearth processes, were significantly science-based. But even here scientific advances were not generally the drivers of the inventions and certainly do not account for the greater part of aggregate innovation.)

was new, and tied up with the deeper causes, were the changes that inspired, encouraged, and enabled people to invent on a mass scale.

The headline innovations rarely move the mountain that is the economy. The brilliant innovations of Britain's 18th-century textile industry led to great gains in output per worker but, the textile industry being a small part of the economy, could not cause more than a very modest increase in output per worker in Britain's economy as a whole (so modest that output per worker barely increased, if at all, from 1750 to 1800). In the same vein, the economic historian Robert Fogel shook up his fellow historians with his thesis that American economic development would have proceeded as well without the railroads. The fruits of the Industrial Revolution are all one-off—one-time events rather than manifestations of a system or a process. They do not explain either the spectacular take-off in Britain or later take-offs. As Mokyr wrote, "[t]he Industrial Revolution itself, in the classical sense, did not suffice to generate sustained economic growth."¹⁴

We must conclude that neither the stirring voyages of discovery nor the splendid discoveries in science and the headline inventions that followed could be the cause of the steep and sustained climbs of productivity and wages in the 19th century in the take-off economies of Western Europe and North America. Rather, the explosions of economic knowledge in the 19th century must be the effect of the emergence of an entirely new kind of economy: a system for the generation of endogenous innovation decade after decade as long as the system continues to function. Only the structuring of these economies for the exercise of indigenous creativity and pathways from there to innovation—for what has come to be called "indigenous innovation"—could have put these nations on steep paths of sustained growth. If there was a fundamental "invention" here, it was the fashioning of economies that drew on the creativity and intuition that lay inside them to attempt innovation. These were the world's first modern economies. Their economic dynamism made them the marvel of the modern era.

14. He adds:

It is easy to imagine the economies of the West settling into the techniques [of producing throistles, wrought iron, coke-smelting, and stationary steam engines] that had emerged between 1750 and 1800 without taking them much further. Such a development would have paralleled the wave of inventions of the 15th century, with the printing press, the three-masted ship and iron-casting settling into dominant designs and the process of improvement slowing down to a trickle subsequently.

See Mokyr's 2007 Max Weber Lecture, "The Industrial Revolution and Modern Economic Growth," p. 3.

We do not have to infer from data on productivity growth the presence (or absence) of dynamism—as physics inferred the existence of dark matter and dark energy. The revolution in the societies possessing take-off economies went far beyond the unprecedented phenomenon of sustained—and apparently sustainable—growth. As pioneering entrepreneurs multiplied, ultimately overshadowing merchants, and as more and more people were tinkering with methods and products or dreaming up new ones, the experience of work changed radically for increasing numbers of participants. From retail trade to textiles to Tin Pan Alley, masses of people in society were active in conceiving, creating, evaluating, and trying out the new and learning from the experience.

In this way, the modern economies brought to a society something of the “heroic spirit” that Smith hoped to see, such as standing out from the crowd and rising to a challenge. These economies also brought to ordinary people of varying talents a kind of flourishing—the experience of engagement, personal growth, and fulfillment. Even people with few and modest talents—barely enough talent to get a job—were given the experience of using their minds: to seize an opportunity, solve a problem, and think of a new way or a new thing. In short, dynamism’s spark created modern life.

These modern economies, present and past—their rewards and costs, the preconditions for their rise, how some of them were unseated, their justification, and now, the weakening among the remaining ones—these are the subject of this book.