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Economic Progress and its Discontents.

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Since at least the seventeenth century, Europeans have been committed to the concept of "progress." Rather than seeing history as a process cycling up and down but with no clear direction as in "there is nothing new under the sun" as the book of Ecclesiastes famously had it, most of the intellectuals known as *philosophes* in the Age of Enlightenment believed in progress in one form or another. A belief in historical progress does not come naturally to us — most civilizations seem to have very little belief that life would get better — at best they believed, as my Jewish forefathers did, that at the end of history there would be some cosmic and abrupt "coming" that would make life better. But rarely did they believe in a gradual, cumulative process in which life would improve year by year, generation by generation.

All this changed in the period Europeans call "early modern" roughly book-ended between Columbus's voyages and the death of Isaac Newton in 1727. Intellectuals of various sorts came to believe in progress. By that I mean three different things: First, that progress was *possible* and that indeed it had occurred and was still occurring. Second, that it was *desirable* — not quite the same thing — because it would improve the state of humanity and the quality of societies in which people lived. And third, in the age of Enlightenment intellectuals created a detailed *agenda* how to bring it about. Of course, not every philosopher believed this, but slowly it became the dominant theme in European thought.

A good example is a highly influential French intellectual, now little known outside France, named Bernard LeBovier Fontenelle (1657-1757). In 1688, Fontenelle published a short essay titled *Digression sur les Anciens et les Modernes* in which he postulated that scientific progress, and the economic progress that will go with it, were not just possible but in fact inevitable. He asserted that in his age a truth (*justesse*) ruled that had been hitherto unknown. He predicted that in the future this would go much further, and that one day the current generation would themselves be ancients and it would be fair and reasonable for posterity to outdo them. His little pamphlet was part of an intellectual movement that emerged in the seventeenth century and reached its zenith with Turgot and Condorcet. Fontenelle was no towering intellect, but he was eloquent, well positioned, and influential. He became secretary of the Académie des sciences in 1697 and held that position for more than four decades.

His contemporary, Abbé Saint Pierre (1658–1743), represents an even more progressive agenda for society, including perpetual world peace and free education for men and women. These *philosophes pointed* to the kind of phenomena that in Britain were associated with Bacon: printing, academies, and the organized division of knowledge that advanced science and technology. A sense of "improvement" became the rage in Britain, where such luminaries as Robert Boyle felt it was their responsibility to make the world a better place and do so applying his knowledge to practical issues. He wrote that "I shall not dare to think myself a true Naturalist till my skill can make my garden yield better herbs and flowers, or my orchard better fruit or my field better corn or my dairy better cheese than theirs that are strangers to physiology [natural philosophy]."

As we realize today, the problem with the Enlightenment program of improvement is that it was never made quite clear *what* will be improved, and how. Presumably, economic improvement may seem comparatively simple at first blush: who would object to a higher income, to eliminate poverty, and do things that improve economic welfare by increasing knowledge. But a closer look shows the pitfalls of the program for improvement. Would we prefer a high average income, or one which is lower but more equally distributed? Would we want more public goods such as better roads and schools or more private goods? And should we prefer to invest in heavy industry or in consumer goods? Once those questions are raised we realize immediately that we don't really know the answer. In economics we sometimes postulate a mythical figure, the "omniscient benevolent dictator" who maximizes social welfare. In history we have no such illusions.

Of course, once we leave economics, it gets worse. We would like a more just and liveable society, presumably democratic, free, and secure. But as the critics of the Enlightenment such as Adorno and Horkheimer have pointed out, once you commit to this vague idea of progress, you pave the way for a totalitarian dictator who can decide what progress consists of and then to bring it about. What about a demented lunatic who thinks that progress consists of making a country *Judenrein*? What about another insane dictator who decides that progress is eliminating the debt owed to foreigners at all costs? In the early twentieth century some of the most progressive and highly educated thinkers in society supported eugenics. Inspired by the works of Darwin, Mendel, and Galton, eugenics sought to breed better humans through selective reproduction, encouraging those were considered superior to procreate while sterilizing the "unfit". The United States led the early application of eugenicist ideas to policy, resulting in the passage of eugenic sterilization laws in thirty-two states. More than 60,000 individuals were forcibly sterilized as a result. The belief in progress can and did badly misfire.

But let us stick with what economists know and that is economic growth. The great progressive thinkers of the Enlightenment had no doubt of where growth was to come from: the growth of what they called useful knowledge — an understanding of natural phenomena that could be harnessed to increase material well-being. In other words, more knowledge ("natural philosophy" as they called it) would bring about technological change that led to economic growth. Although the connections between technological progress and economic growth were only fully recognized by nineteenth and twentieth century economists, the intuition that innovations would improve the material condition of humanity is obvious enough.

Furthermore, enlightenment thinkers proposed a program that would stimulate technological progress, a body of thought substantial enough to earn the term "Industrial Enlightenment." Among the proposals that these *philosophes* supported were to create incentives to invention through patent systems and other rewards for inventors who helped enrich the nation, and encouraging the communication between *savants* — people who knew things — and *fabricants* — people who made things. Organizations and academies that brought such people together (the most famous being the Lunar Society of Birmingham) sprung up all over Europe.

The enlightenment program of material progress was a monumental success, beyond the wildest dreams of its propagators. Western Europe in the nineteenth century and beyond experienced what is now widely known as the Great Enrichment, during which every indicator of living standards rose by orders of magnitude, life expectancy ended up doubling, and every good and service consumed by humans, from red wine to dentistry, became immeasurably better and cheaper. The sudden acceleration of economic growth and economic welfare driven by the Industrial Enlightenment was so abrupt that scholars have relied on metaphors such as "take-off" and more recently of a "hockeystick." Especially after 1850, when the full effects of "the invention of invention" started to be felt throughout the economies of the West, material life improved not just for the rich but for the great majority of working people.

What could go wrong? Economic growth driven by technological progress has one big drawback: the full effects of something novel are by definition never fully known in advance. Such is the nature of innovation: the full costs and benefits are by definition unknowable when the innovation first emerges. Hence there is always a risk that what we may call "unknown unknowns," that is, unanticipated consequences, will eventually emerge that may endanger the achievements of innovation. These phenomena are sometimes known as "bite-back" effects after a famous book published by Edward Tenner. More technically, if such bite-back effects exist, they imply that past production may have utilized inputs that were costly but not paid for because of some market failure. Hence the "gains" or "productivity growth" associated with the innovation are exaggerated, and what we may call "true growth" is lower that we believed.

Examples are easy come by. The widespread use of *asbestos* as a miracle building material in the first half of the twentieth century is striking. Its popularity was primarily due to its desirable properties such as fire resistance, sound absorption, tensile strength, and affordability. Only in the 1960s were the full health risks of asbestos recognized (by a crusading New York doctor named Irving Selikoff), and a whole generation had to repair the damages at high cost. Another example is the introduction of tetraethyl lead (TEL), a neurotoxin, as a gasoline additive in the 1920s to improve engine performance. The substance caused widespread brain damage. For fifty years or so, people were exposed to the baneful effects of lead additives. A 2022 metanalysis showed that the use of lead in gasoline and paint affected behavior as well as cognitive ability and may well have been in part responsible for the rise in crime in the 1990s.

Allow me two more examples of such technological bite-back, very different but equally telling. The surprising discovery of "omitted inputs" is particularly interesting in the case of one of the most important inventions of the 20th century, the Haber-Bosch process for making ammonia from atmospheric nitrogen invented in 1912 by Fritz Haber. One immediate biteback effect was that it allowed Germans to continue producing explosives after August 1914, something that a French audience will surely realize. But in the longer run, nitrates were a source of fertilizer as well as explosives. There can be no doubt that in the absence of the Haber process, existing supplies of nitrates from mineral sources alone would not have been able to provide enough fertilizer to feed a rapidly growing humanity. By the year 2000, half the nutrients supplied by the world's crops and 40 percent of proteins consumer by humans can be traced to Haber-Bosch.

Until fairly recently, however, it was not suspected that the unrestrained application of nitrates to agriculture threatened the environment. Fertilizer runoff has become a serious threat to aquifers coastal ecologies. Man-made eutrophication has led to massive algae blooms and the appearance of large “dead zones” in coastal waters. The dead zone in the Gulf of Mexico was estimated by NOAA in June 2023, NOAA forecasted a below-average sized hypoxic zone of 4,155 square miles (the record of 8,776 square miles was set in 2017). Similar effects are known for phosphorus, another essential ingredient of fertilizers (and thus plant life).

Unintended consequences come from unexpected corners. The history of sugar is a case in point. For much of human history, sugar was highly desirable but rare and expensive. Its consumption was limited to the very rich. However, after the Europeans reached America, cultivation of sugar cane on New World plantations, and later, the development of sugar beets that flourished in cooler climates, meant that cheap sugar became available to all. The result was a precipitous increase in tooth decay in the industrialized world. Thus part of the added output of dentists needs to be subtracted from the national accounts because dentistry in large part was necessitated by easy

access to sugar. Quantitatively tooth decay was a second-order effect, but the concept scales up to technological progress in farming in general as human food consumption changed thanks to progress. The growth of agricultural productivity since 1890 has increased the consumption of calories from proteins and fat. While this was at first a desirable outcome, it eventually exacerbated the sugar-driven epidemic of obesity and associated health problems. Junk food is cheap because we are very efficient at producing and distributing it. And it is not just an American problem: in 2014, 62% of all overweight and obese people live in developing countries, ironically even as others must still worry about widespread malnutrition. Seventy five percent of all Mexicans are overweight, and a third are clinically obese. A recent study by the Overseas Development Institute estimates the number of overweight people in developing countries to be around 900 million, three times the figure in 1980.

Interestingly, a technological solution for tooth decay emerged: fluoridization of drinking water, which turned out to be a miracle "technological fix"without any proven bite-back effects. Growth-optimists would argue that such unanticipated missteps are the inevitable price we pay for venturing into the unknown, but that on balance the gains of progress outweigh the costs and that bite-back can usually be fixed. Alternatives to the harmful substances or techniques have been found, or some other "technological fix" was applied. Human ingenuity, the argument goes, can recognize cases of bite-back and act to correct them. The famed 1987 Montreal protocol to ban CFC's that threatened the Ozone layer and replace them with other substances serves as an example. The path toward progress may not be invariably upwards-pointing, but on the whole progress in marching ahead. For many of the bite-back effects of technology, optimists argue, there are working technological fixes that science can help us discover. Even obesity can be reduced by new appetite-reducing drugs such as Ozempic.

Let me give you one more example: One of the biggest bite-backs of agricultural technology is the salinization of soils and ground water resulting from water overuse in growing thirsty crops such as cotton in dry soils. The problem is particularly acute in Africa and the Middle East, but also serious in Texas and China. Genetically modified saline-tolerant crop varieties have now been developed, in which a gene from a plant that grows well on saline soils has been inserted in a rice variety. Genetically modified organisms may also be the answer to nitrate pollution: some plants, such as clover, are able to produce their own nitrogen fertilizers by cultivating symbiotic bacteria that convert atmospheric nitrogen into fertilizer. Genetic research is trying to “teach” other plants to do the same by inserting into them the appropriate genes from nitrogen-fixing plants. The GMO frontier is huge. Among other advances to date: Soybeans and rice modified to resist insects without the use of pesticides and “golden rice” fortified with vitamin A. If you love the environment, you should like these new plants. More than anything else, they will help humanity clean up the mess left by earlier innovations.

To be sure, GMOs may generate bite-back, too. Precisely because the science of genetic modification is very young, we do not know whether it may not have any bite-back effects itself. It is those effects that some of the people who object to GMO’s are concerned about. Right now, it seems unlikely that the bite-back effects involved are so huge that the costs that exceed their benefits (the "asbestos-syndrome"). The nightmare scenario in which some fiendish "frankenfood" wipes out other crops or causes some unanticipated disaster is fanciful. As our knowledge of molecular genetics increases exponentially with time, such risks seems manageable. In short, techno-optimists argue that, yes, the benefits of economic growth have been overstated, but there is nothing that human ingenuity cannot deal with.

This optimism is now sorely tested by the worst and most unanticipated side-effect of technological progress. Economic growth requires energy — this is hardly controversial. A large part of economic growth since the eighteenth century was driven by the growing knowledge of finding, extracting, and utilizing fossil fuels, both as a source of heat and — thanks to the invention of engines — a source of motive power. For many decades people knew about one negative side effect of this advance, urban air pollution. But only in the past decades have we come to fully realize the true threat of climate change, and by now the threat is becoming a reality. Was energy-driven economic progress illusory? More than three decades ago, *the Economist* magazine asked rhetorically if the internal combustion engine had from the start been charged its full environmental cost, whether it would have adopted at all. The same question could be asked about the steam engine.

The low price and high energy efficiency of coal, oil, and natural gas made high-grade fossil fuels an irresistible source of power. For a long time, hydrocarbons from fossils were a seemingly inexhaustible input into growth and prosperity, with the true social cost inflicted on our planet largely unsuspected. But the relentless slide toward a warmer world, with its melting glaciers, rising sea levels, and worsening floods, droughts, and storms, have taught us a hard lesson. Would humanity have been better off without fossil fuels?

Is there a fix? Essentially two classes of solutions exist. One is political: taxing or altogether limiting the use of fossil burning techniques, or subsidizing alternatives as President Biden's misnamed Inflation Reduction Act involves. In a competitive global market economy a high level of enforcement and international coordination is needed to ensure that nobody cheats. After all, for each single actor — whether a nation or a firm — cheating makes sense if their impact on the environment is small but the profits from cheating are large. If everyone thinks that way, the agreement will unravel quickly.

Could an agreement to limit using fossil fuels now be achieved? The Montreal protocol is a hopeful sign, but the international community was more cooperative in 1987 than in 2023, and the stakes were far smaller. Opportunistic leaders such as Donald Trump could withdraw from the little there was without penalty. What we are looking at is what economists call the dilemmas of collective action. Free riding and opportunistic behavior are hard enough to control within a single country, but a strong and decisive government can bring it about and enforce it internally. But on a global level, such cooperation is exceedingly unlikely, especially given the sharp worsening of international relations due to the Ukraine War and the rise of populist ultra-nationalism in many countries.

Needless to say, a strong and grower constituency is pushing for measures to arrest climate change through curbing fossil fuel, and I wish them luck. One danger is that as the costs of climate change accumulate and become harder to bear, more and more people will realize that climate change has been driven by human ingenuity and that technological progress is a double-edged sword that can create great prospeity as well as great mayhem. This could turn many against technological progress altogether, tossing out the baby with the bathwater. That would be bad news. Such technophobic sentiments are as old as technology itself. People are scared of things that are radically new, and as I have argued, sometimes with very good reason. The resistance to vaccination serves as an example.

All the same, I will argue here that precisely because we cannot rely on international cooperation to come up with an agreement to sharply reduce the use of fossil, our *only* hope is more, not less ingenuity. What the planet needs, with rapidly growing urgency, is the mother of all technological fixes: a way of producing energy that is cheap, efficient, and clean and that dominates fossil fuels in every dimension: cheaper, cleaner, easy to store and transport, and user-friendly. If we come up with that fix, we may have saved our planet and the bipeds that control it.

Once fossil fuels become too expensive, it will not be necessary to tax or prohibit them; the mistake made during the Industrial Revolution will go away by itself. Oddly enough, much of the technological knowledge for such a fix (excepting nuclear fusion) already exists: wind power and water power are remarkably low-tech; solar power has experienced a sharp decline in cost in the past decade. Nuclear power, as France has shown the world, can easily provide most of the electricity needed. Producing hydrogen from water through electrolysis has been known since 1800. All the same, the shift out of fossil fuel will not be cheap: much of the world's electric grids and the transportation fleet will have to be replaced. Major infrastructural investments will be inevitable, and it is here where policy comes in: much like the construction of nineteenth century railroads, private enterprise and government will have to make the transition jointly and cooperatively. If we do not, much of the progress we call the Great Enrichment may become undone.

The human species has been on a wild techo-ride for millennia, as innovation after innovation disrupted business-as-usual. Since the Industrial Revolution of the eighteenth century this ride as become hugely faster. It's hard to deny that both its speed and it direction should create worry. Bite-back is common, and in some cases disastrous. Yet, while technological progress is never riskless, the risks of technological stasis are far more troubling. Getting off the roller-coaster mid-ride is not an option.