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DELIVERY DRAFT – NOT IDENTICAL TO PRINT VERSION

Investing in Disaster: Technical Progress and the Taboo of Diminishing Returns

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"An affluent society, that is also both compassionate and rational, would, no doubt, secure to all who needed it the minimum income essential for decency and comfort."

-- John Kenneth Galbraith

In some ways, science now resembles a religion in the West, commanding an uncritical faith that new technologies will solve all manner of social, environmental, and economic problems. Although rational science has certainly improved humanity's lot in life, organized science is no longer strictly rational, and needs new criteria for "progress."

The catechism teaches the following: humans are tool-making technologists; rational science is the pinnacle of human achievement; methodological inquiry can uncover and control all secrets of nature; science and technology always improve; every new technological development supersedes whatever came before; increased investments in organized science repeatedly improve our lives with new innovations; if only our barbarous ancestors had discovered science sooner, their hellish lives wouldn't have been so "solitary, poor, nasty, brutish and short."[1]

As with many belief systems, the dogmas of organized science interfere with critical inquiry. “Revolutionary” new gadgets appear daily, but technology journalists never write: “If you’re most concerned with a long, healthy life, this new product is just so-so compared to what is already available, but hey, so is more or less *everything invented since 1950!*” Whatever any “upgrade” may purport to “revolutionize” on behalf of consumers, reporters routinely celebrate gadgets, but are rarely historians, economists, or computer scientists.

The idea that Western societies might be better off with *less* technology is rarely discussed. Instead, “faith” in science as the infallible engine of technology tends to preclude the idea that global challenges like hunger and climate change might be best resolved *without technical innovation*. Yet it is more important now than ever to examine the role of technology in Western society, and to evaluate the role of *diminishing returns* in our social relationships with technology.

I. The Social Consequences of Diminishing Returns

Diminishing returns predicts that repeated investments yield proportionally fewer benefits. The idea is straightforward: if somebody eats five ice cream cones in a row, the first may be delicious, but the fifth may cause a stomach ache. Because organized science is a social enterprise bound up with organized industry and structured finance, the *economic law* of diminishing returns implies limits on the efficiency of technology research.

In economics, diminishing returns is a scientific *law*, which means it is *descriptive* rather than *explanatory*. While in casual speech, *theory* implies “conjecture” whereas *law* implies “certainty,” within scientific disciplines, laws are not categorically superior to theories, but assert a different kind of knowledge. Newton’s laws of gravity do not *explain* why gravity is invisible, or *why* bodies attract, but this law *describes and predicts* gravitational interactions quite precisely; Darwin’s theory of evolution *explains* the differentiation of species *in terms of* natural selection, but cannot be used to *calculate* what the biosphere will look like in 10,000 years.

Consider an analogy: the *laws* of physics may *describe* the trajectory of a football, but cannot *explain* why the football makes some spectators cheer while others groan. The practice of *explaining* involves crafting a *description* of some phenomenon that captures relevant generalities, and which *connects* observations to relevant *laws*.[2]

In this chapter, I will explore *diminishing returns* where organized science meets industrial food production, modern medicine, and the computer industry. I will also discuss *why* organized science – under its current techno-centric ideology – is improperly equipped to address the problems humanity faces in the next century. Many of the problems human societies face at this juncture in history are better resolved through policy measures, and the West's emphasis on technological solutions marginalizes effective investments in simpler strategies.

II. A Closer Look at the Problem

In a 2017 appeal for financial contributions, Susan Hockfield – President of the American Association for the Advancement of Science (AAAS) – wrote to her members:

> "With the world population predicted to grow to more than 9 billion by 2050, we face daunting challenges, including the need for improved access to sufficient food, clean water, sustainable energy and health care. These needs will only be met through fundamental scientific and engineering research, accompanied by the translation of that research into market-ready applications." [3]

With government officials, industrialists, and academics among its ranks, the AAAS speaks for organized science in the US. Their advocacy, however, furthers the needs of industry more than the search for scientific truth. While the AAAS's appeal for more "scientific and engineering research" may sound straightforward, on closer inspection, many of the challenges above may have effective non-technical solutions.

As I will discuss, a relatively small number of policy changes could provide for many people. The major impediments are not technical, but entrenched Western cultural habits and organized industry's control over those habits. Westerners need a way to think clearly about options rarely discussed in the commercial speech of organized industry – or its echoes on commercial social media.

In the United States, Americans face rational and moral choices about how to best use available resources, but many important choices are not on the AAAS's advocacy agenda. Americans could feed and clothe millions by sharing industry's surplus production with the developing world (even though sharing is un-American). The default approach – in the name of "progress" – addresses humanitarian problems by investing in uncertain new technologies like CRISPR gene editing, atmospheric re-engineering, and vat-grown meat, despite unresolved ecological, consumer safety, and ethical concerns.

While Western science as "the search for truth" has a long history, winding through Medieval monasteries, Moorish Spain, and Pythagorean mystery cults, "progress" is a relatively recent idea, and "making progress in the name of science" is a largely untested basis for social organization.

For millennia, Westerners viewed the future skeptically and the remote past idealistically. In Antiquity, Greeks and Romans considered humanity to have degraded since a lost Golden Age; Abrahamic peoples bewail a lost Eden; the Renaissance venerated Antiquity; and then, somewhere between the European Enlightenment and Modernity, the past suddenly began to look exceedingly barbaric, and the future seemed increasingly tractable through rational control.

To frame a big-picture view: the human genus is roughly 2.5 million years old, behaviorally-modern humans appeared perhaps 50,000 years ago, and agriculture appeared with civilization about 10,000 years ago.[4] Human societies changed little until about 250 years ago, after the West rediscovered Roman knowledge and started burning coal because of deforestation. These and related developments – often called "progress" – have brought the planet to the brink of ecological catastrophe in an evolutionary split second. Given that the average mammal lasts about 1 million years,[5] our modern, civilized, tool-making brains may yet be a failed evolutionary experiment, more liability than survival advantage.

If we are to think about the future and work for better outcomes, another approach is needed. Increasing investments in technical "progress" are unlikely to be effective or efficient, and I would like to discuss *why*.

III. The Rise of Industrial Food Production

Throughout the Twentieth Century, organized science – allied with organized industry – promised food security through technical innovation. Thomas Malthus's 1798 *Essay on Population* influenced modern concerns about food security on a growing planet; in line with these concerns, technical innovations in early Twentieth Century agriculture – including industrial fertilizer, mechanized farm equipment, and rural electrification – increased crop yields dramatically.

Yet, remarkably, fears of global food shortage persist into the Twenty-first Century – even though most of the basic problems of *production* were solved in Charlie Chaplin's time. Harvard Economist John Kenneth Galbraith considered it a "modern paradox" that "as production has increased in modern times concern for production seems also to have increased."[6]

Paradoxically, dramatic increases in industrial output helped precipitate the Great Depression, which involved a price collapse alongside the famous stock market collapse (Figure 1). Given how indelibly cultural memories of the Great Depression linger in the American psyche, it's also remarkable to note that the most hungry years of the Depression were years of unprecedented agricultural abundance.[7] Technically, the 1929 market failure was a failure of distribution, not production: the market-based price system failed to get food to the hungry.

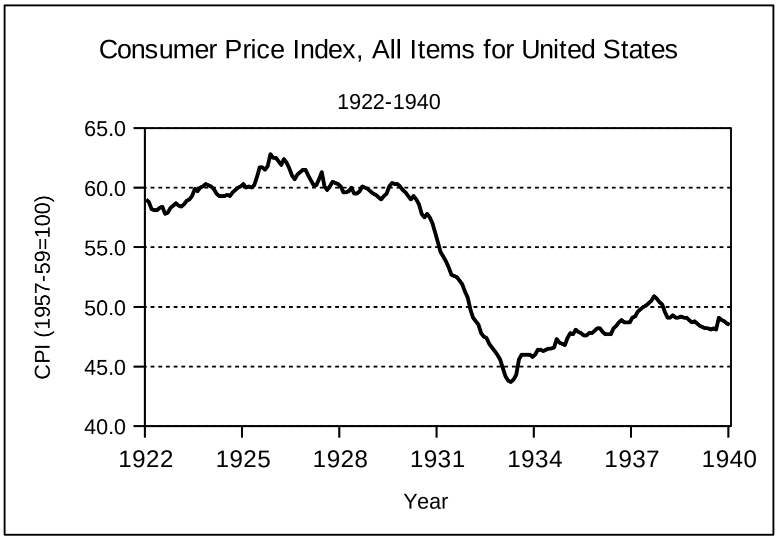

Figure 1: US Consumer Price Index (CPI), 1922-1940. Widespread overproduction during the "roaring 20's" contributed to a price collapse. Source data from National Bureau of Economic Research series M04128USM350NNBR and Federal Reserve Bank of St. Louis.

Many factors contributed to the 1929 economic disaster, including geopolitical strife, unregulated economic forces, organized industry expanding into agricultural markets, and a price bubble. The cultural movement known as Modernism also exerted influence on both sides of the Atlantic, fetishizing the miracles of industry along with anything new in art or society.

These factors converged on the US economy during World War I. Because the war ravaged European farmlands, US grain exports increased: wheat exports peaked twice, once at 37.3% of production in 1914, and again at 37.1% in 1920.[8] Throughout World War I, annual US wheat production averaged 812,932,000 bushels. With an average 27.36% dedicated to exports, annual domestic supply averaged 590,118,000 bushels.[9] As Europe recovered, wheat exports fell to 16.6% of production in 1928; by 1933, exports stood at just 4.6%.[10]

Wheat prices peaked in 1925 and hit bottom in 1932; over this period, production averaged 837,329,000 bushels annually and exports averaged 15.3%, with domestic supply averaging 709,217,000 bushels. Although peacetime output was comparable to the boom years, exports declined.

Because farmers never slowed production as exports declined, domestic supply increased considerably, contributing to a price collapse. Because farmers held mortgages they suddenly couldn't afford, other areas of the economy were threatened, causing panic to spread. After the 1929 price collapse, wheat farmers increased production through 1931, before realizing that it is impossible to outproduce the problems of overproduction.

When Congress finally acted in 1933, total wheat stocks stood at 377,942,000 bushels – nearly *four times* the 108,401,000 bushels in stocks when prices peaked in 1925.[11] But the market failed to deliver this unprecedented abundance to those in need, families lost their land, and millions went hungry.

IV. Agricultural Productivity and the Great Depression

Alongside dramatic increases in the quantity of basic goods manufactured, organized industry also increased its *productivity,* a term economists use to measure labor efficiency. As agriculture underwent a wave of industrialization between 1920 and the 1929 crash, the US population increased by roughly 15 million, from 105,711,000 to 120,694,000; in this same time, however, farm populations *dropped* by roughly one million, from 31,614,000 to 30,220,0000.[12] Amidst all the starvation and declining farm populations, where was the over-abundance coming from?

Some clues can be found in the Agricultural Adjustment Act of 1933. Attempting to rein in the collapse, Congress sought to stabilize farm prices, regulate aggregate demand, and protect the financial system connecting agriculture to industry. In the 1933 Act's "Declaration of Policy," Congress established a standard for agricultural prices – excepting tobacco – calculated from pre-bubble "base period" data between 1909-1913.[13]

Congress recognized that "the present state of acute economic emergency" was "in part the consequence of a severe and increasing disparity between the prices of agricultural and other commodities, which … has largely destroyed the purchasing power of farmers for industrial products," and "broken down the orderly exchange of commodities." Consequently, the economic downturn "seriously impaired the agricultural assets supporting the national credit structure."[14]

Understanding the role of *diminishing returns* in the 1929 disaster requires critically appraising agricultural industrialization and mechanization. In discussing his policy objectives for agriculture in 1916, President Woodrow Wilson advocated a "generous provision for the improvement of farm production."[15] Additionally, some three years after the Federal Reserve System was created, President Wilson took "particular note of the special needs of the farmer by making larger provisions for loans through national banks on farm mortgages."[16]

As policy wove together agriculture, finance, and industry, war came and went. Wheat exports declined between the First and Second World Wars, while policy encouraged increased output. In 1927, exports declined to 21.7%, and to 15.6% in 1928. Purchases of industrial farm equipment, however, increased.[17] Between 1922 (just after the war boom) and 1927 (just before exports fell off sharply), farmers purchased an annual average of $126,729,000 in motorized tractors, combines, power hay pressers, and the like.[18] Farmers purchased $183,862,000 worth of powered farm equipment in 1928, and, in 1929, purchases increased to $223,308,000.[19]

In agriculture and across industry, much of the increase in output during the first half of the Twentieth Century "can reasonably be imputed to technological improvement in capital and parallel improvement in the people who devise the better capital equipment and operate it."[20] The result of unbridled “progress” in farm technology, however, struck a point of diminishing returns, where repeated investments yielded proportionally fewer benefits. The market price of agriculture’s output could no longer support repeated investments in industrial technology. As Congress observed in the Agricultural Adjustment Act, the result was a decline in the “purchasing power of farmers for industrial products” which threatened “the national credit structure.”

Too much technology proved disastrous, creating second-order problems requiring their own – increasingly complex and costly – solutions.[21]

V. Issues In Contemporary Agricultural Productivity

Diminishing marginal utility is not unique to technical “progress.” In the US dairy industry between 1850 and 1910, labor productivity declined by 17.5% due to the inherent “costliness of animal husbandry” combined with other demands of bureaucratic modernity: new sanitation requirements, adapting dairy farming to winter months, and changes in industrial feeding practices.[22]

Organized industry amplifies diminishing returns, however, because industry is complex and costly. Industrial agriculture costs more than subsistence farming in part because it is more resource-intensive.[23] According to archaeologist Joseph Tainter, whenever it “becomes necessary to use less economical resources marginal returns automatically decline.”[24] The industrialization of agriculture was characterized by *diminished marginal returns* because expenditures on industrial farm equipment, fertilizer, and energy increased, as did the cost of infrastructure and management.

Rationally, it seems unlikely, as Hockfield and the AAAS advocate, that additional investments in “fundamental scientific and engineering research, accompanied by the translation of that research into market-ready applications” will be the most efficient way to address “access to sufficient food” for a “world population predicted to grow to more than 9 billion by 2050.”

The West does not need to tolerate hunger anywhere now or in the foreseeable future. Developed nations waste somewhere between 30-50% of annual food production.[25] Industrial food waste, by tonnage, is nearly identical to the projected need of sub-Saharan Africa,[26] where UN statistics place most population growth in the next half century.[27] The means to end hunger have existed for a long time and the cost of doing so is marginal, but it simply isn't a serious policy objective in the West.

Since 2005, when the US Congress required ethanol blended into gasoline, fuel now accounts for roughly 40% of US domestic corn production, the artificial demand for which increases the price of a key food staple in "developing" nations.[28] Roughly 70% more calories could be made available for direct human consumption if diverted from current use for biofuels and animal feed, potentially yielding enough calories to provide a subsistence for approximately 4 billion people.[29]

On average, livestock are fed 6kg of plant protein to produce 1 kg of meat, and the fossil fuel energy inputs for producing animal protein are roughly 11 times greater than grain.[30] Given that industrial agriculture accounts for 17% of US fossil fuel use,[31] a simple and cost-effective measure available to typical Americans who want to reduce their carbon footprints and fight global hunger may simply be to reduce meat consumption and rely less on industrial agriculture. Unfortunately, current policy encourages the current state of affairs.

VI. Progress in Modern Medicine

The requirements for bringing effective medicine to the world's poorest residents are quite modest in terms of technological needs, though made formidable due to Western preferences for solutions that are organizationally complex, technologically sophisticated, costly to administer, and therefore profitable to supply and finance.

As with other areas of socio-economic activity, repeated investments in modern medicine exhibit *diminishing marginal returns*. MRI scans, Viagra, and electronic record-keeping all have their place, but many of modern medicine's most potent innovations – from surgery to preventive medicine – largely depend on a few basic innovations: hygiene, anesthetics, antibiotics, and immunization.

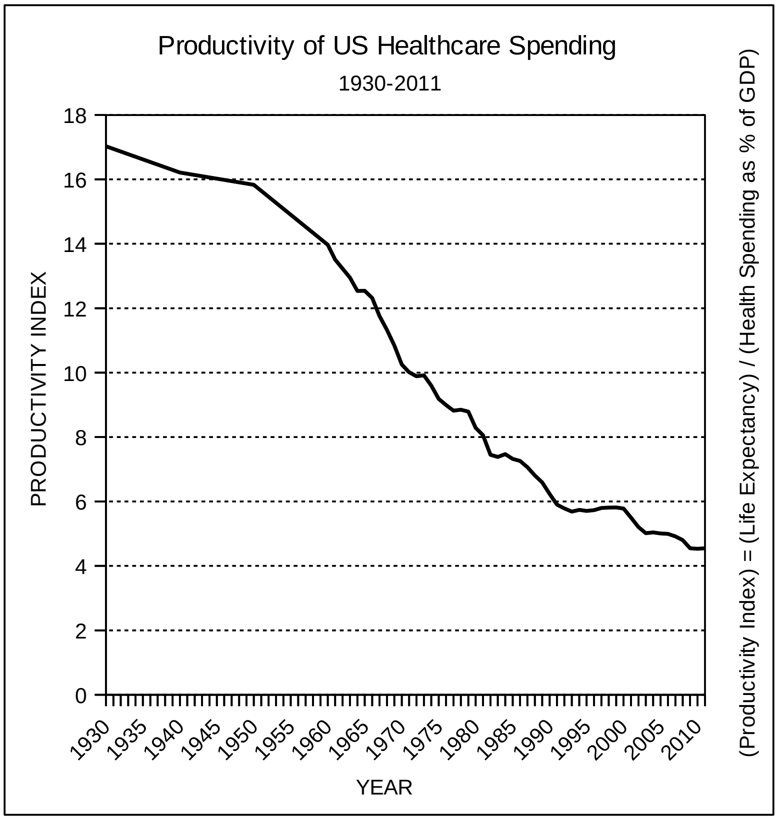

Figure 2: Productivity of the US Health Care system, 1930-2011. After Joseph Tainter, The Collapse of Complex Societies (1988), ch. 4, fig. 11. Life expectancy data acquired from from Clio Infra (EU), compiled by Richard Zijdeman and Filipa Ribeiro da Silva (IISH Dataverse). Healthcare expenditure and GDP data from US Census Bureau and World Scientific Handbook of Global Health Economics and Public Policy (ed. Richard M. Scheffler, 2016), P. 198, Table 5: "Decennial employment and expenditures 1850-2010."

After the polio vaccine became widespread in 1955, modern medicine's productivity declined precipitously (Figure 2).[32] This happened partially because easier problems get solved first; in the words of physicist Max Planck: "with every advance the difficulty of the task is increased."[33] As the law of diminishing returns predicts, solving more difficult technical problems costs more because it requires specialized training and higher-paid executives to finance and administer it all.[34] Accordingly, many disciplines today are dominated by highly trained specialists concerned with extremely esoteric problems, resulting in an increasing cost per solution.[35] This is why increasing investments in medical technology do not continue to yield proportionally greater increases in life expectancy (Figure 3).

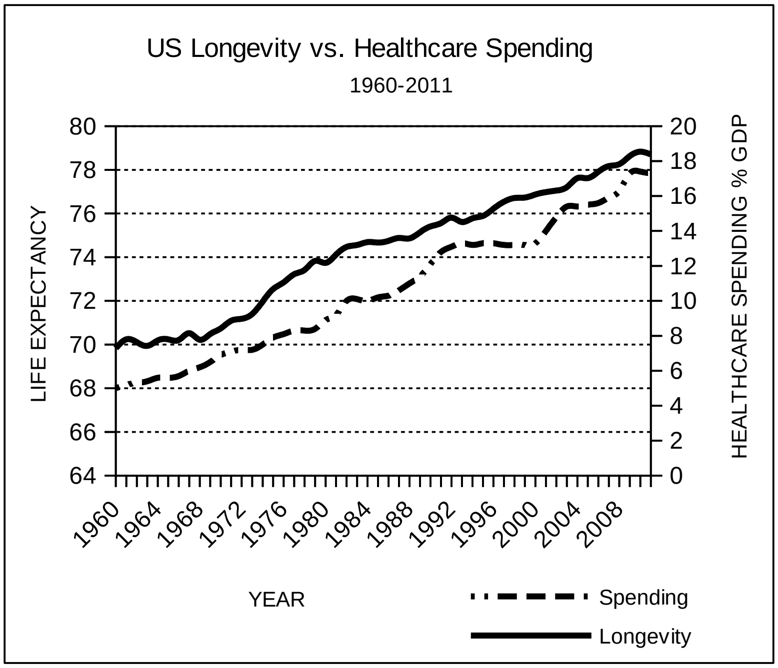

Figure 3: US Longevity vs. Healthcare Spending. While life expectancy increased 12% in the second half of the 20th Century, healthcare spending by GDP more than doubled. life expectancy data from Data from US Census Bureau and Clio Infra (IISH Dataverse). Pre-1960 spending figures from World Scientific Handbook of Global Health Economics and Public Policy, Table 5: Decennial employment and expenditures 1850-2010 (ed. Richard Scheffler, 2016).

In modern medicine, the germ theory's success explaining disease gave credence to the outlandish views of Ignaz Semmelweis, a nineteenth-century obstetrician who, after observing better outcomes among certain physicians at Vienna General Hospital, perversely advocated that doctors wash their hands. Thanks to various types of painkillers and anesthetics, few patients now die of neurogenic shock watching a limb get hacked off. The few tens of thousands of dollars spent developing penicillin in the 1930's has benefited every Westerner who has ever had surgery or chlamydia, or who has been bitten by a deer tick. Very few medical developments can claim so many beneficiaries for so few dollars.

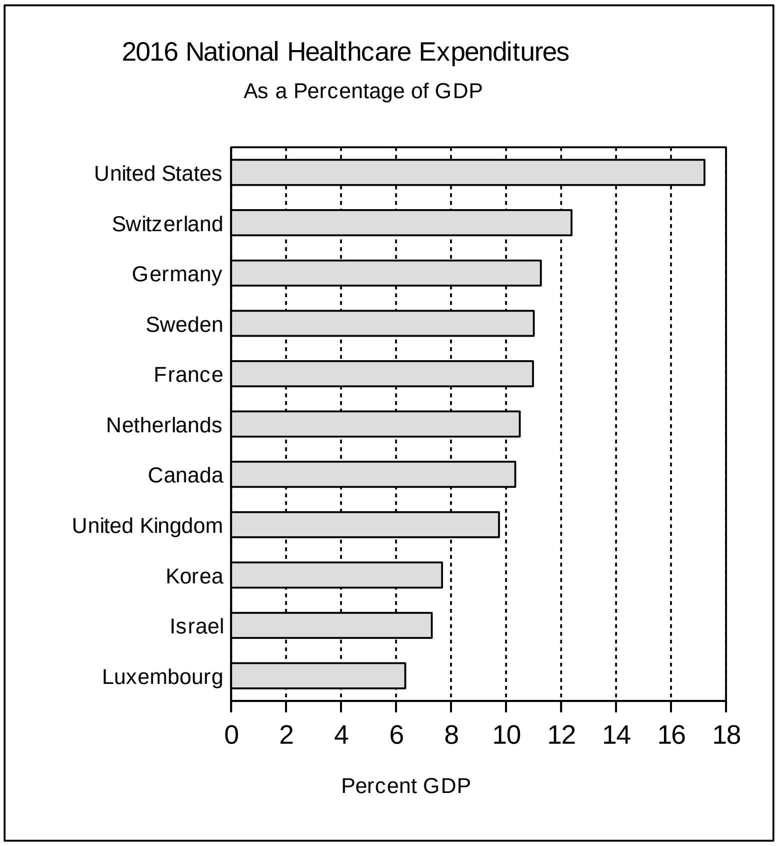

Figure 4: 2016 National Healthcare Expenditures as a Percentage of GDP. Source: Organization for Economic Cooperation and Development "Health expenditure and financing" data set.

Since immunization became common in the 1950's, modern medicine's focus has shifted increasingly to niche problems like X-linked hypophosphatemia and autosomal dominant polycystic kidney disease, and to addressing the adverse health impacts of industrial civilization itself on environmental toxicity, poor diet, sedentary lifestyle, and infectious disease among high population densities. By GDP, the United States spends 2-3 times more on healthcare than other developed nations (Figure 4), but, as diminishing returns predicts, American life expectancy is not proportionally greater than that of citizens of analogous European heritages in, say, Luxembourg or Germany (Figure 5). US life expectancy in the 20th Twentieth Century increased dramatically, from just under 50 to just over 75 by the year 2000. Modern longevity is not, however, unique to medical "progress." A detailed study that set out "to assess the mortality profiles of all extant hunter-gatherers for which sufficient high-quality demographic data exist"[36] found that "conditional upon surviving to age 15, for our composite categories of hunter-gatherers, forager-horticulturalists, and acculturated hunter-gatherers … the sample of premodern populations shows an average modal adult life span of about 72 years, with a range of 68–78 years." After 250 years of "progress," we in the West are for the most part just living for as long as our bodies evolved to survive (Figure 5).

20th Century Longevity Data Compared

Year	United States	France	Sweden	Luxembourg	Cuba	Argentina	Brazil
1905	49.3	48.3	54.5	46.2	34.2	39.7	
1910	51.8	51.3	57.8	49.7	36.0	44.2	31.0
1920	55.4	51.5	58.8	54.6	39.0	48.7	32.0
1930	59.6	56.8	63.2	56.8	42.0	52.6	34.0
1940	63.2	49.6	66.7	61.9	45.0	56.5	37.0
1950	68.1	66.4	71.1	66.0	59.4	62.5	51.0
1960	69.8	70.4	73.0	69.0	65.3	65.3	55.9
1970	70.7	72.1	74.7	69.6	71.0	67.2	59.8
1980	73.7	74.2	75.7	72.6	74.2	70.2	63.5
1990	75.4	76.8	77.6	75.4	74.8	72.1	67.5
2000	76.9	79.1	79.7	77.7	77.2	74.3	71.0

Figure 5: 20th Century Longevity Data Compared. Note Ignaz Semmelwiss advocated handwashing around 1850, and surgeons often operated without masks until the 1890's. Despite a trade embargo restricting available funds to invest in modern medicine, Cuba managed to increase longevity because most of modern medicine is derived from a very few basic innovations. Life expectancy data from Max Roser, "Our World in Data" (Oxford).

If life extension can be considered a frontier of medical science, there is a lesson here for those who dream of popping youth pills while snacking on potato chips and watching television. When Faust asked Mephistopheles to cure him of his age, the devil retorted that neither magic nor physicians were required: "Just go into the fields and see what fun it is to dig and hoe; live simply and keep all your thoughts on a few simple objects glued; restrict yourself and eat the plainest food ... that is the surest remedy: at eighty you would still be young."[37]

Modern medicine is largely devoted to solving problems caused by civilization, and many improvements during the late Twentieth Century may reasonably be attributed to simpler developments from the early Twentieth Century. Given that sanitation, anesthetics, antibiotics, and immunization can address many risks and complications of childbirth, infancy, and childhood at little cost, an evidence-based approach might argue that, from the perspective of longevity and overall health, "progress" in medical science largely ended in the mid-1950's.

VII. Diminishing Returns For Fun And Profit

Perhaps few modern industries are as wholly characterized by "progress" as the computer industry, which aggressively markets a constant stream of hardware and software upgrades at consumers to induce eager anticipation for new conveniences and sensory pleasures on screens of all sizes.

The upgrade model is a key source of revenue for the software industry, a source of constant change and a driver of diminishing returns. Many businesses invested in computer technology following the release of Windows 95 because the graphic user interface offered clear usability and productivity advantages over the command line interface used in the earlier DOS operating system. Later Windows releases like Vista were heavily criticized,[38] however, for the frustration and lost productivity due to bugs, incompatibilities, new hardware requirements, and unexpected changes to the user interface.[39] Commercial software upgrades like Vista offer computer users diminishing marginal utility for their existing computer investments.

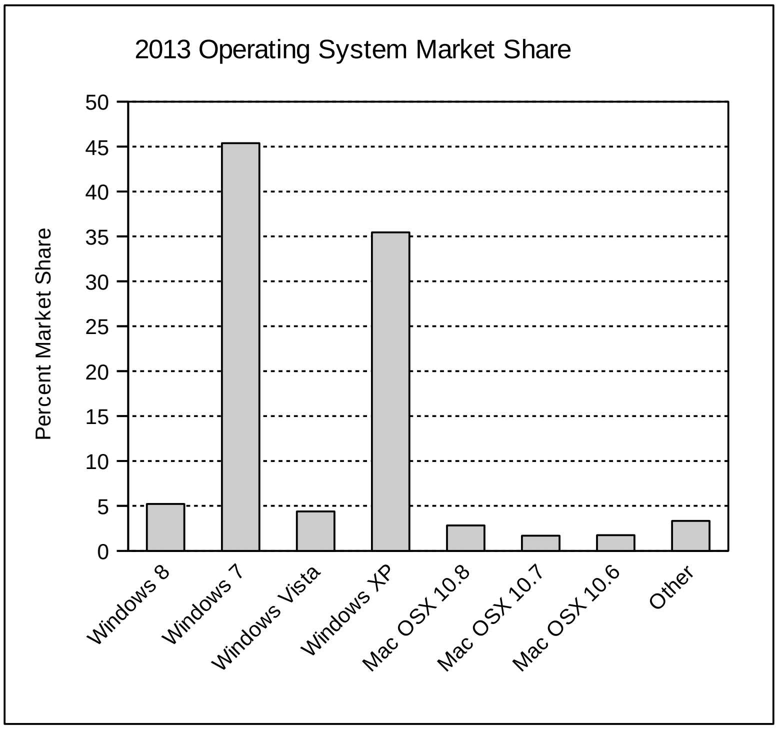

Figure 6: Operating system market share. Values are averaged across the year 2013, when Microsoft stopped issuing security updates to Windows XP, then a 12-year-old operating system. Data from Net Applications.

Roughly a third of all computer users online still ran Windows XP in 2013, just before Microsoft stopped issuing updates[40] (Figure 6). Many computer users do not care to upgrade because – perhaps even indirectly – they recognize the trend towards diminishing returns. While many users might prefer or require the stability of a familiar platform over some upgrade's new features, upgrades are routinely made compulsory.

The installed base of commercialized Linux code on web servers, browsers, mobile devices, embedded devices, point of sale systems, and video arcade equipment[41] provides evidence outside of sales figures that many users and developers want a familiar, stable computing platform. Non-proprietary and cost-free software play an important role in the modern software "ecosystem," and the growth dynamics of commercial software must be understood in terms of "the market" simultaneously failing to provide for this need.

Microsoft maintains monopoly power through a variety of anti-competitive business practices,[42] with European legal fines around $3.4 billion in one decade[43] just representing a routine expense on the road to market domination. One such technique for compelling upgrades, called "vendor lock-in," leverages proprietary file formats to keep customers attached to specific software packages, so that if the file format is changed, customers must upgrade to retain access to their data.

A patent in the Microsoft Office file format prompted the Commonwealth of Massachusetts to establish an open standards policy in 2004.[44] Speaking at the time, Secretary of Administration and Finance Eric Kriss observed: "It should be reasonably obvious for a lay person who looks at the concept of Public Documents that we've got to keep them independent and free forever, because it is an overriding imperative of the American democratic system that we cannot have our public documents locked up in some kind of proprietary format or locked up in a format that you need to get a proprietary system to use some time in the future." For Massachusetts, the advantages of electronic record-keeping were as evident as certain disadvantages to perpetual commercial upgrades, and Microsoft eventually capitulated, opening their file formats.[45]

Many car owners would consider it absurd if gasoline were re-formulated to require an entirely new engine every three years, though this is the routine cost of doing business in the computer world. Schools that train students for specialized industry-standard software get caught in the upgrade cycle along with students, and the compounded social impact of diminishing returns in software investments will only increase as more computing devices are put into use. In 2002, the US National Institute of Standards and Technology estimated that, shared between consumers and producers, the cost of bugs and incompatibilities stood around $59 billion,[46] even though total software sales only amounted to $180 billion.[47]

Many cost-free and open source software components exist, awaiting only organized labor to put them to use. As an alternative to subsidizing industry, some business owners might consider financing or developing custom software solutions built around open standards. University administrators with a tight budget and ongoing software needs might consider developing similar grant-funded open source solutions to provide practical coding and visual design experience for students.

Open source collaborations and casual "piracy" may both continue to be common ways of acquiring high quality software in virtue of an informal recognition that the cost of doing business in the computer world is not always worth it, and probably exploitative. Growth trends in the software industry may not accurately reflect the whole range of consumer preferences, however, due to the coercive business practices built around the upgrade cycle. Indirect costs like lost productivity and security holes subsidize a growth industry built around poorly-made products. In the words of Dan Geer, Chief Information Security Officer at the CIA's venture capital firm In-Q-Tel, "the only two products not covered by product liability today are religion and software, and software should not escape for much longer."[48]

VIII. Conclusion

As with agriculture in the 1920's, disaster may well loom on the horizon today, where computerization and artificial intelligence are poised to displace portions of the traditional white collar, much as mechanization and automation displaced blue collar workers in the Twentieth Century (Figure 7).

Figure 7: Employment vs. Productivity, US Manufacturing, 1939-2015. Gains in productivity due to automation and mechanization have translated directly into job losses. Data from St. Louis Federal Reserve, INDPRO and MANEMP/PAYNSA data series.

Large swaths of the world live with disaster daily, and if Westerners want to talk seriously about need in the Twenty-first Century, we need to talk about how problems like global hunger are the result of policy, not an opportunity for high-tech market-based solutions. It is for policy reasons that Americans burn excess grain production instead of feeding the hungry. The dynamics of diminishing returns make it unlikely that solving the social problems of the modern world require "fundamental scientific and engineering research, accompanied by the translation of that research into market-ready applications."

Historically and at present, the industrial system exists for the owners of capital, not for ordinary individuals. If industry existed for individuals and their needs, historic increases in productivity would have translated into employers asking employees if they would prefer more pay, a shorter workweek, or, perhaps, more say in management practices. Instead, major employers locked in the 40-hour workweek as a cultural norm, shed jobs, and enjoyed their increasingly financialized wealth.

The basic problems of production and public health were solved nearly a century ago. Effective solutions to the "daunting challenges" we will face on a planet of "more than 9 billion" will most likely need to be policy solutions, not technical solutions. Moral arguments in favor of market-based solutions to human need must address the implication that all need today is prima facie evidence of markets failing to solve these problems. As presently constituted, markets are unlikely to solve these problems in the future.

When one looks at how the dynamics of diminishing returns weave through different areas of industrial commerce, a systems approach to policy solutions begins to take shape. For example: global climate change conferences are elaborate, opulent, expensive, high-security affairs – and unlikely to accomplish much, especially if attendees insist on complex "market-based" approaches like "cap and trade" management of industrial carbon dioxide. An alternate approach might target energy use with an "industrial remediation tax" that would invest tax revenues in conservation measures known to be effective, returning wealth captured through misguided policies to those who produced the wealth both in the West and abroad.

If policy made energy more expensive, energy use would decrease. Decreased energy use would reduce carbon dioxide emissions without burning fossil fuels to make expensive wind turbines or solar panels. Because industrial meat production is so energy-intensive, the cost of meat would increase and consumers would consume less. Beyond the emissions and animal welfare issues that can be addressed by dramatically reducing meat consumption, changes in industrial meat production can also address ecological issues associated with agricultural runoff from fertilizer and manure.

Ruminant animals evolved while eating grasses; because industrial meat production typically feeds these animals a grain diet, their slow stomachs breed harmful bacteria like salmonella and e. coli.

Because livestock typically live in crowded, stressful, unhygenic conditions, as much as 80% of the antibiotics used in the United States are administered to livestock prophylacticly.[49]

If these bacteria develop immunity to antibiotics, medicine will become more expensive because an old problem will need a new and difficult solution. The mass production of cheap hamburgers in America is a threat to one of modern medicine's most crucial tools; this can and should be addressed through agricultural policy. Policies that have the result of encouraging healthier diets may also have beneficial effects on quality of life and longevity without requiring new technologies or increasing investments in medical science.

Yet, it's an odd symptom of our new world order that typical Americans may be able to do more about the weather through dieting than about policy through the ballot box.

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