INNOVATIVE DYNAMISM IMPROVES THE ENVIRONMENT

ARTHUR M. DIAMOND, JR.*

1. Introduction

"INNOVATIVE DYNAMISM" is the economic system that has brought us the new goods and process innovations that over the last 250 years have spectacularly improved life (McCloskey 2010, pp. 2 and 48; see also Diamond 2019a). The system has previously been called "entrepreneurial capitalism," but that name is misleading because capital is not the system's salient feature and because "capitalism" is also sometimes used to name the very different system in which entrenched cronies reward and protect each other. Joseph Schumpeter suggested that the phrase "creative destruction" is a better label for what is most important in "capitalism" (1950, p. 83). Schumpeter's label is better than "capitalism" because it emphasizes how goods that are new and better add to, and partly replace, old goods. But Amar Bhidé and others have noted that the "destruction" in "creative destruction" misleadingly exaggerates the costs of innovation (Bhidé 2008, pp. 341–55; 2009, p. 17).

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* Arthur M. Diamond, Jr. is Professor of Economics at the University of Nebraska Omaha. Some of the issues in this paper are discussed, though more briefly, in his book *Openness to Creative Destruction: Sustaining Innovative Dynamism* (expected in 2019). In a few places, the discussion overlaps. The author is grateful to Mark Wohar for discussing, and providing a reference on, the robustness of his and McMillan's results on the effect of carbon dioxide on temperature. I also appreciate thoughtful and constructive comments from the editor and from two anonymous referees.

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Innovations often add to our choices rather than replace our earlier choices. Even buggy whips are still made, sold, and used. When innovative new goods replace older goods, the replacement is rarely total, is often gradual, and usually occurs with significant warning that allows those who are alert some time to adapt. A better phrase to describe "capitalism" or "creative destruction" is "innovative dynamism." "Dynamism" suggests change broad enough to include change that adds to, as well as change that replaces, what has come before. "Innovative" suggests that the change is not merely directionless churn but positive change that improves life.

Some of us want the new goods and processes but fear that they come at too high a cost in terms of damage to the environment. Here I take the fear seriously and respond. Those who fear the environmental effects of innovative dynamism are most afraid that some new goods and process innovations may greatly harm humanity by increasing global warming. I will devote much of the discussion of the environment to addressing that issue. But because a full accounting should include the often beneficial effects of innovative dynamism on other aspects of the environment, I start there.

Although this is a long paper, it still does not answer all questions a scholar might ask related to the environment. For instance, it treads lightly, or not at all, on some important theoretical issues as to how a system of innovative dynamism can and should affect the environment. There have been many useful theoretical papers on issues such as how property rights should affect policies on the environment, and how a market economy is intergenerationally sustainable in the sense of leaving a better environment to future generations. Some of the papers that at least in part discuss how property rights should affect policies on the environment include Rothbard (1982), Cordato (2004), Pennington (2005), Dawson (2009), McCaffrey (2012), Carden (2013), Hebert (2013), Block (2014), and Dolan (2014). Other papers have, in whole or part, addressed other important topics, such as how a market economy is intergenerationally sustainable (Diamond 1987; Dawson 2008) and how public choice theory can help us to understand the rise of environmentalism (Yandle 2013).

In contrast to the papers just mentioned, my paper focuses mainly on empirical issues. I empirically defend the claim that the system of innovative dynamism has been friendly to the environment in the past and will continue to be friendly to the environment in the future. Theoretical issues of political philosophy, institutions, and policies are important and are worthy of considerable discussion, but my approach also tells us something important.

The contribution of this paper is not to gather new data or to develop new techniques for analyzing old data. Rather the contribution is synthetic: to compile and organize a wide array of previously isolated evidence, examples, and arguments that together present a more optimistic view of the past, present, and potential effects of innovative dynamism on the environment.

Some readers may mostly share my optimistic view but believe that some of the claims of environmentalists may be true or partly true. These readers may then conclude that we should agree to environmentalist policies either for the sake of social harmony or as putative insurance against a worst-case environmental scenario.

Before buying the environmentalists' putative insurance, these readers should consider the price of insurance actually offered in the market. Part of Warren Buffett's company Berkshire Hathaway sells "super-cat" reinsurance, which insures other insurance companies against the occurrence of very large (i.e., super) catastrophes ("cat"), including those that some worry will result from global warming. When the price of such insurance is high, that implies market participants with a lot to gain or lose judge the probability of global warming catastrophes to be correspondingly high. But in actual fact the price of super-cat insurance is low and falling. This implies that the market assigns a low and falling probability to global warming catastrophes. Warren Buffett, in an annual shareholder letter, concludes: "When you are thinking only as a shareholder of a major insurer, climate change should not be on your list of worries" (Buffett 2016, p. A9).

While real global warming insurance may be a bargain, the faux insurance consisting of environmentalist government policies is not. Money, time, and effort spent to implement environmentalist policies have opportunity costs in terms of forgone economic growth that could feed the poor or cure the sick. Those who are regulated or taxed to pay for the insurance have fewer funds, and have less freedom of action, for pursuit of their own projects and dreams. As Bastiat taught us (1995, pp. 1–50) and Hazlitt reminded us (1952, pp. 17–21), we see the windmills and solar panels from environmental policies but do not see the projects and dreams that would have been made real if individuals had been left more of their own funds and the freedom of how to spend those funds.

Some of the direct costs can easily be measured. We can measure the over $8 billion budget of the Environmental Protection Agency.[1] We can measure how subsidies for renewable energy in Germany increased the cost for a German middle class family to heat its home in winter (Reed 2017, pp. B1-B2). We can measure the roughly 15,000 British poor who lost their lives

[1] See the EPA's website: http://www.epa.gov/planandbudget/budget.

in the winter of 2014–15 because of higher fuel costs from environmental policies such as renewable-energy mandates (Lomborg 2018, p. A15). It is much harder to measure the cost of entrepreneurial dreams forgone.

But the costs of anti–fossil fuel environmental policies are even higher than that. If fossil fuels were banned, as many environmentalists demand, we would not just stagnate, we would regress (Broughton 2014, p. A15; Epstein 2014, p. 87). We still might choose regress if it was necessary to fend off some worse threat to humanity or even to life on earth. But what if we could have progress and our dreams and still have a better environment, with life on earth flourishing? The evidence and argument of this paper is that progress, our dreams, the environment, and life on earth can indeed all flourish together.

2. How Innovative Dynamism Improves the Environment

Innovations have changed the environment, more often for the better than for the worse. One of our great innovations is the car, which has often been accused of being a cause of increased pollution. But cars put an end to the pollution from huge quantities of horse manure in city streets, which was not only unpleasant to walk in and smell, but was also unhealthy. Cars can produce noise, but clanking horse hooves were not quiet (Preston 1991, p. 51). Replacing horses with cars reduced horse manure in cities, just as replacing gas lighting with electric lighting reduced soot in homes.

Cancer has sometimes been attributed to aspects of modern life that result from innovations. But archeological discoveries show that cancer has been part of human life at least since the age of the Egyptian pharaohs, and probably much earlier (Mukherjee 2010, pp. 40–43 see also Zimmer 2018, p. A9; Krause-Kyora et al. 2018; Mühlemann et al. 2018). Increases in cancer in modern times are probably largely due to practices having nothing to do with innovation, such as smoking, and due to increasing longevity, which has allowed more people to reach an age at which they are at greater risk of cancer. If you doubt that preindustrial cooking and heating methods exposed humans to more cancer-causing toxins than the cooking and heating methods resulting from modern innovations, then you should "try cooking over an open fire burning half-rotten wood, or sitting in a cave warming yourself with a peat or dung fire, and you will know what pollution really is" (Selinske 2011, p. D4). Hunter-gatherers had dubious environmental credentials in other respects too. Kevin Kelly has pointed out that hunter-gatherers had the ultimate disposable culture, in which every tool and shelter was temporary (Kelly 2010, p. 30).

The innovation of creating fertilizer from nitrogen in the air increased food production per acre, allowing more of our land to be left in an uncultivated, green state (Ridley 2013, p. C4; see also Hager 2008). Lush vegetation worldwide is also promoted by increasing temperatures and higher levels of carbon dioxide (Ridley 2013, p. C4).

The many computer and communication innovations of recent decades have allowed us to produce goods digitally that previously required material versions. Books, videos, music, and mail are increasingly digital rather than material (Kelly 2010, p. 67). This dematerialization allows us to produce more goods, while at the same time making use of fewer resources and less energy (Ridley 2012, p. C4; see also Diamandis and Kotler 2012).

One cause of air pollution has been city drivers who must drive in circles to find free parking spaces. Innovations in information technology and communications now allow variable pricing in parking meters, so that the price will increase when most parking spaces are occupied, reducing the quantity demanded and ensuring that spaces will always be available without the circling (Cooper and McGinty 2012, p. A1).

3. Population, Resources, and Organic Farming

One of the first prophets of environmentalism was Robert Malthus in the late 1700s and early 1800s. In his account, humans were doomed to live at the margin of starvation because population increases faster than food supplies. Malthus was wrong (Fox 2014; Mayhew 2014). Partly through new technologies, population increased more slowly and food production increased more quickly, allowing humans, especially in the West, to enjoy huge improvements in the length and quality of life. Fertility rates have actually declined throughout the world and are expected to continue to modestly decline.

In the 1960s and 1970s, neo-Malthusians worried about a "population bomb," but they were just as wrong as their mentor (Ehrlich 1968). The United Nations (UN) provides a range of estimates, which it occasionally tweaks, but its rough expectation is that the rate of growth of world population will continue to fall until world population reaches a peak sometime before the end of this century (Ridley 2011, p. C4; see also Wattenberg 2004; Adamy 2016, p. A2; Soble 2016, p. A12). One respected analyst believes that the UN is overestimating fertility and that world population will peak as early as 2055 (Norris 2013, p. B3).

Part of the neo-Malthusian position is that as population increases, natural resources will become scarcer and more expensive. Economist Julian

Simon understood that with the advances from innovative dynamism, we learn how to find more resources and we find new ways to use materials that were previously considered useless (Simon 1996; see also Diamandis and Kotler 2012, p. 4; Ridley 2014b). In 1980, Julian Simon bet that the sum of the prices of five commodities would actually decline in the following ten years; Paul Ehrlich bet that the sum would increase (Last 2013, p. C6; Sabin 2013). In 1990, Paul Ehrlich paid Julian Simon.

The exhaustion of oil and gas has long been predicted, and with increasing urgency (Zuckerman 2013, p. 257). But as prices rose, many were surprised (Julian Simon would not have been among them, if he had lived long enough) by how innovations in the fracking process are allowing us to cheaply recover oil and gas that were thought to be beyond our reach (Burrough 2013, p. 7; Zuckerman 2013), and to do so without harm to drinking water (Gold and Harder 2015, p. A5).

With innovation, old resources lose value and new resources gain value. Whale oil was growing scarce until the little-used gunk percolating up through the oil seeps of Pennsylvania could efficiently be turned into kerosene by innovators such as John D. Rockefeller (Applebome 2008, p. 20; Dolin 2007). More recently there have been fears about limited supplies of rare earth metals, and about China monopolizing the known supplies. As prices rose, mine investors located new sources of supply, and some users of rare earth metals found substitute materials to use in place of them (Taylor 2015, pp. 265–266; Gholz 2014; Jakab 2017, p. B14; see also Norton 2017, p. B6; Fountain 2016a, p. A8).

The organic-food movement suggests that food grown without chemicals or genetic modification is more nutritious, healthier, and avoids spreading toxins to the environment. But actually in most cases organic and nonorganic food have similar levels of nutrition, and in some cases the nonorganic varieties have substantially higher levels of nutrition (Brody 2013, p. D7; Schwarcz 2012). A nonorganic, genetically modified tomato, for instance, "contains nearly 80 times the antioxidants of conventional tomatoes" (Brody 2013, p. D7). In a metastudy of the literature, Stanford scientists found that organic fruits and vegetables generally had no greater nutrition, but were much more expensive, than nonorganic fruits and vegetables (Chang 2012, p. A20; Smith-Spangler et al. 2012, pp. 348 and 357). The metastudy did find that organic foods on average had less pesticide residue and smaller quantities of antibiotic-resistant bacteria (Smith-Spangler et al. 2012, p. 358). However, a later study found that neither organic nor kosher chicken had fewer antibiotic-resistant bacteria than standard, nonorganic chicken (Strom 2013, p. D3; Millman et al. 2013). Organic foods are increasingly being recalled because of bacterial contamination, including "salmonella, listeria and hepatitis A" (Strom 2015, p. B3; see also Stewart 2016, p. B1).

So the benefits of organic food are more limited than is often believed. At the same time, the costs are larger than is often believed. The lower yields of organic farming imply that more labor, land, and water must be used to produce the same amount of food, hardly a prescription for greening the planet or feeding the hungry (Cowen 2013, p. 6). And a metastudy from Britain concluded that "ammonia emissions, nitrogen leaching and nitrous oxide emissions per product unit were higher from organic systems" (as quoted in Miller 2014, p. A13; see also Tuomisto et al. 2012).

I have nothing to say about the relative taste of organic and nonorganic food except to report that after partaking of the vegan organic food at his friend Steve Jobs's house, Rupert Murdoch was alleged to have commented, "Eating dinner at Steve's is a great experience, as long as you get out before the local restaurants close" (Murdoch's alleged comment as quoted in Isaacson 2011, p. 509).

4. Extinction and Resilience

Some environmentalists hold the view that we must preserve the earth in some particular state. But which state? In appearance, composition, and climate, the earth has always been in flux (Botkin 2012). Since life began, species have arisen, thrived (or not), and gone extinct. The vast majority of these extinctions occurred before humans existed. For instance, Stephen Jay Gould described an intriguing array of long-gone Burgess Shale creatures in his *Wonderful Life* (1989).

Often, we overestimate the negative effects of human activities on aspects of the environment. Many clusters of events for which humans are assigned blame are random (David Hand as quoted in Chozick 2014, p. 12; see also Hand 2014). Humans were initially blamed for bee-colony-collapse disorder; now the collapse is over, and we must admit that we do not understand why it came or why it left (Wilson-Rich 2014, p. A27). Where humans have intervened in major ways, life often has proven surprisingly resilient.

Birds have adapted to radiation from Chernobyl by producing more antioxidants that protect them from genetic damage (Fountain 2014a, p. D2; Galván et al. 2014). Animal life is thriving close to the Chernobyl site, and no long-term increase in human cancer has been demonstrated in the Chernobyl region (Hale 2011, p. C6; Moynihan 2012, p. C11; Blackwell 2012). In Montana, an abandoned copper mine has filled with water, creating a small, extremely toxic lake. Yet some hardy micro-organisms have evolved that can survive in the lake. Initially through self-funding, a pair of entrepreneurs with lowly academic positions have found unique chemicals produced by a couple of these micro-organisms that show promise in fighting cancer (Maag 2007, p. A21). We are beginning to understand that part of the reason for the greater resilience of life may be the "variable gene expression" that allows our genes to respond more flexibly to changes in our environment (Dobbs 2014, p. 11; Moalem 2014).

Our knowledge of the extent and resilience of life remains imperfect. Mark Twain, upon hearing of his obituary, once said that rumors of his death were premature. If they could speak, the same would be said by the oblong rocksnail and the Santa Marta sabrewing, both of which had long been considered extinct, only to be observed alive many years later (Bhanoo 2012b, p. D3; Whelan, Johnson, and Harris 2012; Fountain 2010b, p. D3). The rediscovery of the latter led a vice president of the American Bird Conservancy to conclude that "the ecosystem is more intact than you might have feared" (Michael Parr as quoted in Fountain 2010b, p. D3). Not only are species once thought extinct being rediscovered, but a large number of new species are identified for the first time each year. Often these new species are small, but sometimes they are large, as with the discovery by scientists in 2010 of the six-foot-long *Varanus bitatawa* lizard species (Fountain 2010a, p. D3; Welton et al. 2010).

Since the extinction of old species and the efflorescence of new species are part of the ebb and flow of the natural order (or maybe it should be called "natural disorder"), it is not clear how morally culpable humans are for extinctions that may be partly caused by human activity (Thomas 2017). And it is important to remember that humans are not necessarily responsible for every extinction that has occurred on our watch. For instance, the extinction of woolly mammoths roughly ten thousand years ago has been blamed on overhunting, but recent evidence suggests it may have been more due to the disappearance of a flower source of protein called "forbs" (*New York Times* 2014, p. D2; Willerslev et al. 2014) or to inbreeding and related difficulties during pregnancy (Bhanoo 2014, p. D2; Reumer, Broek, and Galis 2014).

More recent human activity is often blamed for the decline of Australia's Great Barrier Reef, but roughly half of the decline is due to a poorly understood increase in predation of the coral by starfish (Kwai 2018, p. A9; De'ath et al. 2012). Coral elsewhere have been found to be resilient to warmer water temperatures (Weintraub 2016, pp. D1 & D6), and scientists have successfully bred coral to be even more resilient (Cave and Gillis 2017, p. A6). Although the overall harm to coral from global warming is not yet known, we should note that any harm may partially be compensated by global warming's benefits to the thriving cuttlefish, squid, and intelligent octopus (St. Fleur 2016, p. A7; Doubleday et al. 2016).

Some extinctions have indeed been caused by humans, for instance the passenger pigeon. But is the world necessarily much worse off as a result? I remember that as a child, my great-grandmother told me how she, as a child, had seen the Indiana skies filled with passenger pigeons, and that passenger pigeon pie was delicious (Diamond 1987, p. 271). But passenger pigeons were viewed by farmers as a menace, descending and devouring their crops in enormous flocks (Greenberg 2014, pp. 74–78). Stanford scholar Henry Greely notes that the flocks of passenger pigeons were so large that they could take three days to cross a city, leaving the city "covered in an inch of guano" (Greely as quoted in Kolata 2013, p. A16). And are passenger pigeons anyone's idea of a Rawlsian primary good (Rawls 1971), required as a nonsubstitutable building block of the good life?

If we decide that humans treated the mammoths or the passenger pigeons unjustly, or if we decide the benefits of their presence are greater than the costs, then it appears increasingly likely that continued innovations in biology and chemistry will allow us to bring the mammoths, the passenger pigeons, and some other species back from extinction (Kolata 2013; Wade 2010, p. D3; Campbell et al. 2010; Shapiro 2015).

Stephen Jay Gould long ago noted that all of our genomes contain currently inactive sequences that code for traits of our ancestors that we no longer possess. Sometimes mutations accidentally activate these strands, resulting in horses with toes and hens with teeth (Gould 1983). If we could control these accidental activations, we would have another pathway to increased diversity of creatures, and perhaps of bringing back some of the traits (if not the species itself) of species that are now extinct. Inexpensive technology to recombine pieces of DNA is already within the reach of breeders and inventors, suggesting to Princeton physicist and futurist Freeman Dyson that we will enjoy "an explosion of diversity of new living creatures" (Dyson as quoted by Gorman 2012, p. D4).

Evidence of the diversity and resilience of nature can be found in many directions. In 2013, scientists were concerned about record-low water levels in the Great Lakes; in 2014, the scientists were "startled" to observe that the lakes were a foot higher, and rising (Bosman 2014, p. 16). Large stretches of the American West remain as wild and rugged as they were before Europeans arrived on the continent (Stark 2014, pp. 311–12). Most of us would be shocked to learn how quickly the planet would "return to its pre-human condition" if humans were to suddenly disappear (Shermer 2013, p. C10; see also Weisman 2007).

5. Does Government Intervention Help or Hurt?

Those who allege that the innovative entrepreneur often harms the environment usually propose government actions that constrain the innovative entrepreneur, either through regulations or through government programs funded by taxes that reduce the funds available for entrepreneurial innovation. So it is useful to consider the benefits and costs of such government programs.

As we have already seen, since the environment is constantly changing, with or without human actions, it is not immediately clear what static snapshot of earth should be preserved by those who want the government to save the environment. But apart from that key issue, government actions may not always have the effects desired by those who want to protect the environment. A startling example occurred in 1964, when the United States Forest Service chopped down the oldest tree in existence, a 4,900-year-old flourishing, dignified, defenseless bristlecone pine known to its friends as "Prometheus" (Robbins 2017, p. D9).

For an earlier historical example, in the early decades of the twentieth century, the Department of Agriculture encouraged farmers to settle in the Great Plains, in spite of the evidence that the region was subject to recurring severe droughts, and Congress doubled down by subsidizing banks that agreed to offer generous loans to those who credulously followed the department's advice (Egan 2006, pp. 50 and 126). In recent decades, government mandates for ethanol have raised prices for food and increased the amount of land under cultivation, reducing land left as natural habitat for native species (Martin 2008, p. 5). Surprisingly, the mandates also actually *add* carbon dioxide to the atmosphere since plowing additional land to grow corn for ethanol releases carbon dioxide from the soil (Matthews 2016, p. A9).

Another current example is the government-subsidized crop insurance for farmers that reduces the incentive farmers would otherwise have to adapt their farming practices to global warming and so increases the costs of global warming (Annan and Schlenker 2015, p. 266). Another unintended consequence arises when local governments limit the use of plastic bags at stores on the grounds that manufacturing the bags hurts the environment: reused plastic or cotton bags have been found to be contaminated with bacteria (Gruen 2014, p. A13; Klick and Wright 2012; Williams et al. 2011). Advocates of bag banning suggest that bags only be reused after they are washed. But is that consistent with conserving water and energy, not to mention human time?

Innovation in the construction and architecture professions could result in using land in ways that provide housing and services to a wider part of the population, but instead "environmental" regulations often freeze neighborhoods in a way that serves the preferences and interests of the incumbent long-term residents of the neighborhood (Dewan 2014; see also Glaeser 2011).

Or consider the Amish, who prefer to use simpler machines on their farms. If their corn stalks are broken by the corn borer pest, then their simple machines cannot pick up the stalks, and they must pick them up by hand, which is hard, tiring work (Kelly 2010, p. 222). So they prefer corn seed that is genetically modified to repel the corn borer. The Amish do not want government regulations against genetically modified seed innovations, because the innovations allow them to preserve other forms of stasis on their farms that they prefer.

6. Global Warming

What humans can achieve depends crucially on being able to use energy beyond our own muscles. Gasoline-powered cars and electricity-powered machines have extended our reach. The question here is whether those innovations have harmed the environment and, if so, how much. The main concern is that the production of energy increases global warming. I will consider that concern shortly. But before considering the possible costs, we should remember the benefits. The Amish, and some environmentalists, try to avoid electricity, both to encourage a simpler life for humans and to protect the environment. But it turns out that the only way to totally avoid electricity is to die: electricity flows in crucial biological processes and is literally "the spark of life" (Bynum 2012, p. C9; Ashcroft 2012).

Whatever our life plans, many of us increasingly want to guard against lapses in our electricity. We are buying home generators to protect us against lapses in electric-utility service that would deprive us of the safety and productivity of our lights, the freshness of our refrigerated food, the comfort of our air conditioning, and the knowledge and human connections of our computers and smart phones (Belson 2013, p. F8; Quindlen 2013, p. M14).

a. Are We Getting Warm? Data and Models

The alleged certainty of a scientific consensus on the causes, magnitude, and dire effects of global warming is based on the implications of some formal econometric models. Models of this kind are often called "integrated assessment models," or "IAMs" for short. MIT environmental economist Robert Pindyck summarizes what such models can tell us about the social cost of carbon ("SCC" for short) as a guide for policy choice:

IAMs are of little or no value for evaluating alternative climate change policies and estimating the SCC. On the contrary, an IAM-based analysis suggests a level of knowledge and precision that is nonexistent, and allows the modeler to obtain almost any desired result because key inputs can be chosen arbitrarily (Pindyck 2013, p. 870; see also Pindyck 2015).

In an eye-opening account, former Environmental Protection Agency (EPA) modeler Robert Caprara describes how he was pressured to tweak his model until it produced the result his boss desired. He was assigned to model the environmental benefits of an EPA program to subsidize sewage-treatment plants. When he presented his results to the EPA, they were rejected and he was told to revise the model. So he "reviewed assumptions, tweaked coefficients and recalibrated data" (Caprara 2014, p. A13). But the final estimate of total benefits for the EPA program did not change much, and the EPA continued to reject his analysis. In talking with the EPA administrator, he writes,

> [A]fter three iterations I finally blurted out, 'What number are you looking for?' He didn't miss a beat: He told me that he needed to show $2 billion of benefits to get the program renewed. I finally turned enough knobs to get the answer he wanted, and everyone was happy" (Caprara 2014, p. A13; see also Cragg and Caprara 1991).

Caprara's account is fully consistent with the public choice literature that suggests that administrators in government bureaucracies can be understood to be maximizing their power, as partly proxied by their budgets. (Niskanen 1971).

Steven Koonin, former professor of theoretical physics at Caltech and undersecretary of science in Barack Obama's Energy Department, has concluded that "we often hear that there is a 'scientific consensus' about climate change. But as far as the computer models go, there isn't a useful consensus at the level of detail relevant to assessing human influences" (Koonin 2014, p. C2). Even heavily tweaked models must eventually confront the evidence, if they are to have any claim to scientific credibility. So far, the evidence has not been fully consistent with the models' predictions.

The most prominent climate models predict increasing temperatures at a steady or increasing rate. But from about 2000 until about 2015, the rate of increase substantially decreased (Ridley 2014a, p. A13; see also McKitrick 2014). This slowdown in global warming was variously called a "pause," a "lull," and a "plateau" (Ridley 2014a, p. A13; Gillis 2013c, p. D3). As a result, some climate modelers lowered their "high end" and "best guess" estimates of how high temperatures will rise in the future (Gillis 2013b, p. D6; Revkin

2013). *New York Times* environmentalist reporter and blogger Andrew Revkin, with wistful chagrin, noted that the new estimates were trending toward those supported in the past by some libertarians, but he suggests that evidence be respected, writing that "nonetheless, the science is what the science is" (Revkin 2013).

The lull posed a practical setback for those who counted on the models, such as Shell Oil and the federal government. Shell shelled out several billion dollars for drilling rights from the federal government, and for equipment to drill in the Arctic, but has been stymied because the ice has not melted as quickly, or for as long, as they expected (Fowler 2012, p. B1; see also Gillis 2013a, p. A8). Also consistent with the general lull was the very cold winter of 2014 in the United States (Gillis 2014, p. D3). Global warming advocates increasingly relabeled "global warming" as "climate change" in order to distract attention away from the lukewarm empirical support that the lull provided for their models.

Nate Silver, who is famous for his success at statistical forecasting, believes that the lull is consistent with a long-term increase in global temperatures due to human actions (Scheiber 2012, p. 12; see also Silver 2012). But he also believes the lull demonstrates how hard it is to accurately forecast temperatures decades into the future. As a result, he suggests that global warming advocates and activists are unjustified in expressing their views with so much certainty. Where there is uncertainty, scientific progress might be best served by global warming advocates engaging, rather than dismissing, global warming skeptics (Garud, Gehman, and Karunakaran 2014, p. 62; see also Pearce 2011, p. 237; Hulme 2012, p. 224).

The reaction of some climate scientists to the lull was to double down on defense of the models by vilifying those who criticized the models (Wines 2014b, p. A14). The vilification took place partly through calling the critics pejorative names such as "denier" to try implicitly to associate the global warming "deniers" with Holocaust deniers. The vilification also took place through blacklisting climate skeptics from receiving research grants and from having their articles published in leading journals. But some scientists resist vilification.

Freeman Dyson is often viewed as one of the most important physicists of the second half of the twentieth century and has been on the faculty of the School of Natural Sciences at the Institute for Advanced Study in Princeton, New Jersey. Dyson has a lot of experience with mathematical models and believes that climate scientists exaggerate the precision of their models' forecasts, saying that "they come to believe models are real and forget they are only models" (Dyson as quoted in Dawidoff 2009, p. 36).

According to Dyson, increases in carbon dioxide mainly improve the environment by encouraging the growth of forests and crops. Any increases in temperatures will be modest, localized, and mainly benign. He observes that, for many, climate science has become a religion in which "belief is strong, even when scientific evidence is weak" (Dyson as quoted in *New York Times* 2015, p. 8).

"Science" is not the body of doctrine endorsed by a majority of those who are credentialed as scientists. Science is a process of open-minded, skeptical inquiry. Science is the activity of looking through Galileo's telescope, even when a majority of credentialed scientists refuse to look. When science is operating progressively, consensus is reached by the continuous accumulation and evaluation of evidence. But the evidence is rarely completely definitive, which is why the scientific attitude is one of tolerance toward those who hold different views. Not only does the evidence accumulate, but the methods of analyzing and weighing it differ and evolve.

The predictive accuracy of climate models on issues of practical importance remains tenuous, even for short-run predictions, let alone for predictions extending several decades. For example, climate-science models have been spectacularly wrong in predicting the following year's number of Chesapeake blue crabs (Suri 2015, p. 4). Harvard cognitive-bias expert Daniel Gilbert explains that conscientious scientists have major disagreements on how to collect, verify, and analyze data, which explains "why scientists disagree about the dangers of global warming" (Gilbert 2006, p. 162).

b. Humans and Nonhumans Adapt

More deaths are caused by cold days than by hot days, so global warming, which reduces the number of cold days and similarly increases the number of hot days, should result in an overall reduction in deaths (Gasparrini et al. 2015, p. 369). As a result of a highly variable climate during human evolution, natural selection gave a survival advantage to those of our ancestors who were more adaptable to quick and large climate change (Switek 2017, p. A15; Ungar 2017). Pre-industrial Icelanders, who had fewer modes of adaptation, substantially reduced their population growth rates in response to global *cooling* (Turner et al. 2012, pp. 254–55). Today humanity can survive and thrive if the global climate warms by a few degrees, so long as we do not abandon the policies and institutions that permit entrepreneurial innovation and adaptation. Economic historians who have studied past adaptability of United States agriculture to climate changes are generally optimistic about the ability of the US economy to adapt to global warming (Swoboda 2012, p. 222; see also Libecap and Steckel 2011). Consider an illustrative example. The maple-syrup tapping season consists of the range of days when nights are freezing and daytime temperatures are higher than 40 degrees Fahrenheit. In Vermont, the average tapping season is about five days shorter than it was fifty years ago, possibly partly because of global warming. In response, syrup producers have developed tubing technologies to more efficiently pull sap from the trees, with the result that, even with a shorter tapping season, they can now pull in roughly twice as much sap as they could fifty years ago (Scott 2013, p. 11).

Optimism for the future of cities can be defended by adaptations that will occur within cities, but also by migration to cities such as Minneapolis and Detroit that will become more appealing as the climate warms (Kotchen 2011, pp. 777–78; see also Kahn 2010). Major cities, such as Rotterdam, Tokyo, and St. Petersburg, have designed defenses against encroaching water, and such defenses could also be deployed in cities such as New York if the threat increases (Hotz 2012b, p. C3). In terms of individual comfort and productivity, individuals in the United States have increasingly protected themselves against the costs of hot weather, for example through the adoption of air conditioning, which has reduced heat-related mortality (Barreca et al. 2015, p. 251; see also Diamond 2017). More generally, John Christy, a University of Alabama distinguished professor of atmospheric science, believes that the modest temperature increases that are likely can be readily handled by adaptation strategies (Wines 2014b, p. A14).

In some areas of the earth, partly through human adaptation, warming brings some substantial benefits. For example, it would reduce the costs of shipping (Kramer and Revkin 2009; Goldman 2017, p. 12), communicating in (Joling 2010) and retrieving oil and minerals from (Kramer and Krauss 2011; Revkin 2008; Mouawad 2008; Krauss et al. 2005) the Arctic. It would increase agriculture and animal husbandry in Greenland (Faris 2008; Etter 2006); increase the opportunities for golf in Alaska (Dean 2009, p. A1) and sparkling-wine cultivation in England (Naik 2010, pp. A1 and A18); make Chicago winters milder (Kramer 2013, p. B1; Shteir 2013, p. 20); and make colorful fall foliage last longer (Smith 2016, p. A20). Roughly 80 percent of Americans live in counties where the weather has become more pleasant than it was forty years ago, back when global warming started to become an issue of debate (Egan and Mullin 2016a, p. 9; Egan and Mullin 2016b; see also Popovich and Migliozzi 2018, p. A11). The greatest benefit from global warming, however, may be in the very long run.

Palaeoclimatologist William Ruddiman believes an ice age that would have occurred about eight thousand years ago was prevented by global warming caused by carbon dioxide released from the soil when humans switched to agriculture (Kelly 2010, p. 38; Ruddiman 2005, p. 12). In the prestigious journal *Science*, earth scientist Shaun Marcott and his colleagues have reconstructed temperatures for the past 11,300 years and forecast that in the next several thousand years the North American continent would freeze over if past patterns continued (Gillis 2013d, p. A15; see also Marcott et al. 2013). This massive and disastrous freeze would be prevented by global warming (Gillis 2013d, p. A15).

It may be natural for us to care more about the adaptability of human beings to potential global warming than we care about the adaptability of other species. But many of us have some level of goodwill toward other species as well, and so we may also wonder whether they will have any ability to adapt to global warming. Fortunately, there is evidence that many of them can and will. For example, some scientists investigated how tropical flies would fare if their environment changed from very high humidity to a humidity of just 35 percent. For one of the species they investigated, after only five generations, the fifth generation was able to survive 23 percent longer than had the first generation (Zimmer 2014, p. D7; see also van Heerwaarden and Sgrò 2014). In England, as the climate has warmed somewhat, the brown argus butterfly has extended its range by fifty miles toward the North over a period of twenty years (Bhanoo 2012a, p. D3; Chen et al. 2011). As the annual temperature lows increase, Florida mangrove swamps have been found to greatly expand their range, which is good not only for the mangroves, but for the many fish and other organisms that spawn and thrive in the mangrove habitat (Gillis 2013e, p. A14; see also Cavanaugh et al. 2014).

Toward the poles, the Stony Brook ecologist Heather Lynch and her colleagues were "surprised" to find "a 53% increase in abundance globally" of the Antarctic's Adélie penguin population (Lynch as quoted in Hotz 2014, p. A3; see also Lynch and Schwaller 2014). The Adélie penguin, whose population is in the millions and is growing, is "considered a bellwether of climate change" (Hotz 2014, p. A3). Scientists recently discovered an additional 1.5 million Adélie penguins they had previously missed (Weintraub 2018, p. D2). Lest it be objected that this was a fluke, it is consistent with the latest count of 595,000 Antarctic emperor penguins, which was a substantial increase from the previous high-end estimate of 350,000 (Hotz 2012a, p. A2; Fretwell, LaRue et al. 2012; see also Fretwell 2012; Fretwell et al. 2014). Adaptability is not limited to penguins in the Antarctic. Toward the opposite pole, in the Arctic, as some ice has melted, perhaps because of global warming, polar bears are spending more time on land and less on ice, and so have switched their diets somewhat away from seal pups and toward caribou and snow-goose eggs (Bhanoo 2014, p. D2; see also Gormezano and Rockwell 2013a, 2013b; Iles et al. 2013).

c. Causes of Warming

Global warming is usually blamed on increases in carbon dioxide due to human activities. Among those activities are the production of many of the new goods that are among the benefits of innovative dynamism, such as air conditioning and the car, since these innovations use energy that emits carbon dioxide. Other results of innovative dynamism reduce carbon dioxide in the atmosphere, such as the process innovations that make manufacturing more efficient and that allow more food to be grown on less land. We do not yet know whether, on balance, innovative dynamism increases or reduces carbon dioxide in the atmosphere. If it turns out that on balance innovative dynamism increases carbon dioxide in the atmosphere, then those of us making a case for innovative dynamism would want to learn the extent to which carbon dioxide causes global warming.

However, William Happer, Princeton University physics professor and former director of the Office of Energy Research at the Department of Energy, coauthored a commentary in which he points out that the effects of carbon dioxide on temperature are ambiguous and that the main effect of increased carbon dioxide is the benefit of increased agricultural productivity, concluding that,

> [W]e know that carbon dioxide has been a much larger fraction of the earth's atmosphere than it is today, and the geological record shows that life flourished on land and in the oceans during those times. The incredible list of supposed horrors that increasing carbon dioxide will bring the world is pure belief disguised as science (Schmitt and Happer 2013, p. A19).

The benefits of carbon dioxide for plant life have been widely confirmed. For example, researchers at Columbia University found that oak trees in high–carbon dioxide Central Park weighed eight times as much as equally old oak trees in low–carbon dioxide rural areas (Gugliotta 2012, p. D3; see also Ziska et al. 2012; Searle et al. 2011). Other, more general empirical research also has confirmed the ambiguous effect of carbon dioxide on temperature. For example, a sophisticated econometric analysis using a very long time-series dataset on carbon dioxide and temperature found that carbon dioxide has little, if any, effect on temperature (McMillan and Wohar 2013). A different study using other econometric techniques and shorter time-series datasets finds a stronger positive relationship, but also finds that the previously discussed lull in global warming is genuine, not a statistical artifact, and is largely due to human actions reducing greenhouse emissions (Estrada and Perron 2017).

One feature of some climate models is that they include a tipping-point effect in which beyond some threshold, climate change accelerates. The potential costs implied by climate catastrophes in such models can be large and sudden. One geohistorical illustration sometimes given of the effects of passing a tipping point is the desertification of the Sahara. But evidence from geological and archeological research indicates that both the change in climate and the related human migrations occurred "over millennia, not just in a few desperate decades" (Naik 2014, p. C3; see also Francus et al. 2013).

Journalists and the public often assume that every destructive weather event is at root caused by global warming. But some phenomena often attributed to global warming may be due to periodic and hard-to-predict natural variations (Bhanoo 2009; Hansen 2009). One example is the warming of the American Northwest. Recent research suggests that the warming is almost entirely due to the effect of winds on the waters of the Pacific, winds little affected by human activity (Wines 2014a, p. A19; see also Johnstone and Mantua 2014).

d. What We Should Do

The main relevance of global warming to the case for innovative dynamism is that if global warming justifies restricting the production of carbon dioxide, then it will be much harder to reap the benefits of many of the innovations that otherwise make life better. James Payne has written a clear and persuasive article arguing that each of six claims must be true to justify carbon dioxide–limiting policies (Payne 2014, p. 265). These six claims are as follows:

> 1. Global temperature over the past century has risen.
>
> 2. Temperature will continue to rise over the next century and impact climate.
>
> 3. The main cause of this continuing temperature rise is the emission of carbon dioxide due to consumption of fossil fuels.
>
> 4. The future rise in global temperature will have extremely high human costs (the great-net-harm proposition).
>
> 5. The cost of governmental programs for restricting the use of fossil fuels will be significantly less than the net harm of carbon-dioxide-induced global warming (the benefit-cost proposition).
>
> 6. Governments are effective and responsible problem-solving machines and can therefore implement a robust, consistent, and worldwide policy of restricting the use of fossil fuels (the government-efficacy proposition).

To these six claims, I add a seventh:

> 7. Geoengineering, either by government or done privately, cannot effectively and efficiently mitigate a large increase in temperatures.

Of these I judge that claim 1 is true; claim 2 is likely true, though a recent lull raised doubts; claim 3 is likely true, though some recent econometric analysis is ambiguous; claim 4 is likely false, based mainly on humanity's proven ability to adapt through entrepreneurial technological innovations and other means; claim 5 is likely false, based on the sort of evidence presented by Ridley (2010) and Lomborg (2007). On claim 5, among the important costs of government programs are their opportunity costs. Other problems, including poverty, disease, and war, exceed in severity any problems caused by global warming (Lomborg 2009a, 2009b; 2009c, 2009d; Henderson and Cochrane 2017, p. A17).

Claim 6 is almost certainly false, based partly on the theory and evidence of the public choice literature. Bjørn Lomborg calculates that the $11 billion spent by Spain to produce more energy without releasing carbon dioxide, has "delayed the impact of global warming by roughly 61 hours, according to the estimates of Yale University's well-regarded Dynamic Integrated Climate-Economy model" (Lomborg 2013, p. A17). That $11 billion is roughly 1 percent of Spain's GDP and is more than the country spends on higher education. Such a large expenditure, with such high opportunity costs and small reduction in global warming, is not evidence of government effectiveness or efficiency. Another example is government mandates on the use of biofuels, such as the US mandate on ethanol use. Farmers switching land from food crops to biofuel increases the price of food crops, which leads farmers in countries such as Brazil to cut down carbon dioxide–absorbing rainforests to grow the now-higher-priced crops (Power 2008, p. A13; see also Fargione et al. 2008; Searchinger et al. 2008).

Claim 7 is likely false, based mainly on humanity's proven ability to develop technological innovations. A variety of geoengineering solutions are in various stages of development (Wagner and Weitzman 2015a, 2015b). One of the best-known solutions is from physicist, information technologist, inventor, and entrepreneur Nathan Myhrvold, who proposes to benignly simulate the earth-cooling effects of past major volcanic eruptions (Stephens 2009, p. A19; Levitt and Dubner 2010, pp. 180–203; see also Porter 2017a, pp. B1 & B4; Fountain 2018b, p. D3).

Another approach being applied in a variety of forms is to sequester carbon dioxide, meaning to take it from the air and store it as part of some liquid or, usually, solid mixture or compound. Dr. Olaf Schuiling, a retired geochemist, is exploring the use of the mineral olivine, which naturally absorbs carbon dioxide from the environment (Fountain 2014b, p. A1). Ants naturally break down minerals into olivine through a process that may be emulated by humans (Akst 2014, p. C4; see also Dorn 2014). Algae are being developed that absorb carbon dioxide and produce oil (Catsoulis 2010, p. C8). Carbon dioxide is being drawn from the air to sequester in forms of carbonate in Iceland (Fountain 2016b, p. A6; Matter et al. 2016) and Oman (Fountain 2018a, p. A10). Carbon dioxide can be sequestered in forests (Gillis 2016, p. D6; Chazdon et al. 2016) and in the soil (Leslie 2017, p. 7; Hansen et al. 2017). Finally, the FuelCell Energy firm is developing a new fuel cell that may efficiently both sequester carbon dioxide and produce energy (Schwartz 2016a, p. B2).

Of the seven claims then, one is almost certainly true, two are likely true, three are likely false, and one is almost certainly false. Since all the claims must be true to justify government policies restricting carbon dioxide, such policies are not justified.

Humans have a long history of successful adaptation to climate change. (For example, on the adaptability of Paleolithic humans to major climate change, see Rothstein (2010).) In modern times under a system of innovative dynamism, creative inventors find ways to reduce global warming (*Economist* 2010; Stephens 2009; Hotz 2007), and innovative entrepreneurs find ways to adapt to it (Ouroussoff 2010; Sengupta 2009; Dell, Jones, and Olken 2009, p. 203) or make use of it (Revkin 2009).

But what if I am wrong, and all seven claims are true? Would that justify having the government subsidize or mandate greater use of renewable-energy technologies such as solar and wind? Even more ominously for the flourishing of innovative dynamism, would that justify restricting development and use of energy-consuming innovations such as cars, air conditioning, and computers? First, consider alternative energy technologies.

These technologies are not free of problems. For example, wind power is land intensive: it takes three hundred square miles of windmills to generate sufficient electricity to power a city of seven hundred thousand, and that is assuming enough wind for the turbines to generate electricity 100 percent of the time, instead of the roughly 30 percent of the time that they actually do (Lehr 2013, p. A17; see also Porter 2017b, pp. B1-B2; Sweet 2015, p. B1). And whether wind turbines are friendly to the environment depends on which aspects of the environment you focus on. They are noisy, not everyone enjoys seeing them in their landscape, and they kill birds in large numbers: in 2013, Duke Energy agreed to pay $1 million for killing golden eagles and other birds at two of its Wyoming wind farms (Bryce 2013, p. A17; see also Schwartz 2016b, p. D2; Lintott et al. 2016).

If renewable-energy technologies are not promising, then are we left with no choice but to restrict the development and use of energy-consuming innovations that produce carbon dioxide? I argue that even then, there would be better ways of limiting carbon dioxide. I highlight one of the most obvious: nuclear power. Nuclear power generates minimal carbon dioxide, allows us to continue to benefit from technological innovations, and has risks that are lower than often thought and can readily be reduced even further. The worst nuclear-power accident to date occurred at Chernobyl. I have already cited evidence that the effects of this accident on both human and nonhuman life have been less than was expected and is commonly believed. The Yucca Mountain storage facility for spent nuclear fuel has multiple barriers to ensure that radioactive materials will be isolated for the long term (Wald 2014a, p. A20). If an alternative to Yucca Mountain is desired, the deep, thick salt beds near Carlsbad, in New Mexico, would provide a self-sealing repository expected to encapsulate the waste for millions of years (Wald 2014b, p. A9). New designs for smaller nuclear reactors would greatly increase the efficiency and safety of reactors, especially in comparison to the one in Chernobyl, but also in comparison to those operating in countries such as the United States and Japan (Wald 2013, p. B6).

7. Conclusion: Three Shades of Green

The goals of environmental activists vary: some seek to protect the vitality and beauty of nature, others seek to appear noble, and still others seek to end innovative dynamism. In short, there are three shades of green: Scout green, sanctimonious green, and watermelon green.

Many of us enjoy spending time in nature, hiking or camping or driving through scenic vistas. We are Boy Scouts at heart (I once was a Scout, and am not embarrassed to admit it). We do not litter, and we vote with our dollars for parks or organizations that take the adventure, wonder, and beauty of nature seriously. These would include Disney's Epcot, Omaha's Henry Doorly Zoo, and the Nature Conservancy. We are Scout green.

Sanctimonious green was embodied by Henry David Thoreau, a hero to many. Yet he carelessly, and unrepentantly, started a fire in a dry forest near Concord that destroyed over three hundred acres of the forest (Glaeser 2011, pp. 199–200). Also, Thoreau apparently was only comfortable in the tame, civilized forests such as those near Concord, since he became "near hysterical" with stress when he once encountered a true wilderness forest (Bryson 1999, p. 45). Thoreau was not the only one whose practice was not aligned with his preaching. Thomas Edison went on famous camping trips with Henry Ford as a "feeble protest against civilization," but he installed electric lights in his tent (Freeberg 2013, pp. 296).

Many modern environmentalists are proud to recycle and to use fluorescent or LED bulbs, but stop short of unplugging their refrigerators or washing machines (Kurutz 2009, p. D4; Rosling 2010). Greenpeace activists unfurled a banner extolling renewable energy, and in the process damaged an ancient etching of a hummingbird in the Peruvian desert (Neuman 2014, p. A17). On the other hand, there is Mexican ecologist Jesús Manuel García-Yánez, who grew up living a "sustainable" life only because his family was too poor to do anything else. He worked hard and got an education in order to "get out of that life" (García-Yánez as quoted in Tortorello 2012, p. D6).

Green is traditionally the color of environmentalists, and red is traditionally the color of communists and the left. Watermelons are green on the outside and red on the inside (Delingpole 2012). Watermelon environmentalists support environmentalism mainly as a tactic in their deeper goal of destroying innovative dynamism (Klein 2014; Porter 2015, p. B9; Roberts 2018). While the vast majority of environmentalists are not adopting environmentalism as a strategy to undermine innovative dynamism, the watermelon environmentalists make up in shrewdness what they lack in numbers. They understand that by increasing regulations and costs, they can undermine entrepreneurial innovations, reducing the benefits of innovative dynamism and thereby undermining the system they seek to destroy.

A perceptive analysis of watermelon greens was penned by Deirdre McCloskey, in part quoting from Joseph Schumpeter's *Capitalism, Socialism and Democracy* (McCloskey 2007; Schumpeter 1950, p. 144). Those who benefit from stagnation or cronyism have over time strategically alleged a variety of harms from innovative dynamism. They alleged that innovative dynamism impoverishes workers. When that claim was refuted, they shifted to alleging that innovative dynamism colonized the underdeveloped countries. When this was refuted, they began alleging that innovative dynamism will destroy the environment. When that is refuted, they will shift to alleging some other harm; there is already talk of a robot apocalypse (Diamond 2019b).

Schumpeter and McCloskey's insightful analysis might discourage us from investing the time and effort to show how innovative dynamism improves the environment. But that would be a mistake. Unless the evidence is shown and the case is made, many conscientious citizens will support policies that will shackle innovative dynamism, stopping the flow of new goods and processes that would otherwise make their lives longer and better. Unjustified environmental policies are not insurance bought; they are opportunities lost.

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