

PERSPECTIVES

Fewer, Richer, Greener: The End of the Population Explosion and the Future for Investors

Laurence B. Siegel

The population explosion is almost over, with fertility below the replacement rate in many advanced countries and rapidly declining in most developing countries. In the next half century, economic growth will be robust, especially in developing countries, and will increase world wealth dramatically. These factors will make it easier, not harder, to preserve the natural environment and avoid resource shortages. Investors should focus on natural resources and other industries that will benefit from these trends.

The world has been going to hell in a handbasket for as long as anyone can remember, but it never quite seems to get there. In fact, according to just about any objective measure you choose, the health and wealth of the human race have been improving rapidly and almost continuously for at least the last 200 years.¹ There is every reason to expect this trend to continue, most dramatically in the developing world but also, more slowly, in the developed world. Contributing to this favorable economic outlook is the astonishing fact, too little appreciated, that the population explosion is almost over and, sometime in our children's or grandchildren's lifetimes, the world's population will peak between 10 billion and 11 billion and then either level off or begin to decline.

This world of fewer and richer people will also be greener.² Environmental quality is an economic good like any other. The only societies that can afford to pay for large helpings of environmental quality are rich ones. The whole point of getting rich is to buy things one wants. Nearly everyone wants a beautiful, clean, and safe natural environment, but people want other things too—to eat, for example. The human body demands three meals every day. When calories are scarce, future benefits are discounted at very high rates—all one cares about is the present. When calories

and other necessities are abundant, one can invest in the future, including in environmental quality. The tendency of societies to become environmentally cleaner as they pass a certain threshold of affluence is well documented and is referred to by economists as the “environmental Kuznets curve.” We will look at this phenomenon more closely later in the article. Along the way, we will also briefly examine the timely topic of economic inequality, the focus of Simon Kuznets's original curve (1955), which related economic growth first to increasing inequality as a society begins its economic development and then to greater equality as it becomes rich.

My thesis is at odds with most received opinion about the future. A large body of both popular and scientific literature suggests that natural-resource constraints, climate change, and other “limits to growth” will cause the future to be crowded, poor, and dirty. Ridley (2010) has noted that the tradition of pessimism among intellectuals of all stripes—literati, scientists, economists—runs very deep. (Maybe, as Joseph Schumpeter once said, “pessimistic visions about almost anything usually strike the public as more erudite than optimistic ones.”³ The archetype of the wise man or woman reciting a cautionary tale to a foolish optimist goes back at least as far as Aesop.) Economists have been among the least pessimistic of this bunch because they understand the concepts of substitution, incentives, and growth. Yet, many economists and market forecasters today see little in the future to look forward to. They are almost certainly wrong.

Laurence B. Siegel is the Gary P. Brinson Director of Research at the Research Foundation of CFA Institute, Charlottesville, Virginia, and senior adviser at Ouna-varra Capital LLC, New York City.

Economic growth and environmental remediation do not happen by magic. They involve hard work, ingenuity, and wisdom; and there will be setbacks, some of them on a large scale. But the incentives for wealth building are overwhelming. No one who has tasted wealth wants to return to poverty, and having seen others become rich, most people, if not all, will do what is necessary to have a chance at becoming rich themselves. It is human nature, which does not change very much over time.⁴

Fewer

As I write this, the world's population has just passed 7 billion, up from 6 billion only 13 years ago and 1.5 billion at the turn of the last century. The impression of out-of-control population growth is hard to avoid. The popular conception of historical world population growth looks like **Figure 1**.

Figure 1 is accurate, yet the arithmetic scale on which it is drawn conceals a vitally important fact: The population growth rate first accelerated, but more recently, it has begun to decelerate dramatically, and according to projections based on current fertility rates, the world's population will level off around 11 billion near the end of this century and then, possibly, begin to decline. **Figure 2** depicts the same data on a log scale, but starting in 1500 with projections to 2100.

Clearly, how you react to the information depends on how I draw it. An arithmetic scale says that each person counts the same as every other—an argument with which we can all be sympathetic. But if we want to portray the economic impact of change over time and if we want to make accurate forecasts, the log scale used in Figure 2 may be more useful. Figure 2 also paints a much more benign picture, not only because of the log scale but also because I have included projections for 2013–2100. We can see that population growth rates have been high for a long time, not just in the recent past. Because, as investors, we care only about the future, the dramatic deceleration at the end (only a hint of which is visible in Figure 1) is vitally important. In constructing Figure 2, I used the 2010 revision of the UN Population Division's medium-fertility projections, which do not envision a decline in world population, though some UN projections, including the previous (2002) rendition of its medium-fertility projections, do.⁵

Why has population growth slowed? A satisfactory answer depends on understanding why it was high in the first place. **Figure 3** is a stylized representation of the “demographic transition,” the pattern by which birth rates, death rates, and population change as a society industrializes. (In

addition to population, Figure 3 depicts the birth and death rates.) Pre-industrial societies (Stage 1) experience both high birth rates and high death rates, which tend to equilibrate such that population does not change much, because limits on the food supply and other resources constrain the size of the population that can be supported.

As an economy begins to develop (Stage 2), the death rate falls quickly because many deaths can be prevented through easily implemented public health measures and an improved food supply. The birth rate does not fall as quickly, however, because parents do not immediately become aware of the changing incentive structure they face. The decline in the birth rate is a result of the response to changing incentives. In pre-industrial societies, having a large number of children (with the hope that at least a few survive to adulthood) is insurance against penury in old age. Having children is cheap, and *not* having children is expensive (it is a hazardous strategy with a large opportunity cost). In an industrial or post-industrial society, however, having children is expensive—they cost a lot to educate, do not produce much for decades, and may or may not choose to support their aged parents. Meanwhile, not having children is a reasonable choice; the government and the financial markets provide an alternative means of securing retirement income. Therefore, when people respond to the incentives inherent in an advanced economy (Stages 3 and 4), they do so by having a very small number of children, say, one or two.

This transformation has taken place not only in developed countries but also in many emerging markets. **Table 1** shows the total fertility rate (the lifetime number of children per woman) in various countries for 1950–1955 and for 2005–2010 (the most recent period for which data are available). The most remarkable fact is the extent to which fertility rates have fallen *everywhere*.

Many readers are already aware that a number of European countries plus Japan and Russia have fertility rates below the replacement rate of 2.1—the rate at which a couple replaces itself, with the extra 0.1 representing children who do not live to reproductive age—although not everyone is aware how low the lowest fertility rates really are or how profound the resulting social changes will be. (A world with no Italians would not have much good cooking.) The effects of China's unevenly applied one-child policy are also well known. Benefiting from immigration and an economy that grew strongly for decades before the crash of 2008, the United States has a higher fertility rate than the countries just mentioned, although it is near the replacement rate.

Figure 1. Historical Population Growth on Arithmetic Scale, 1–2012

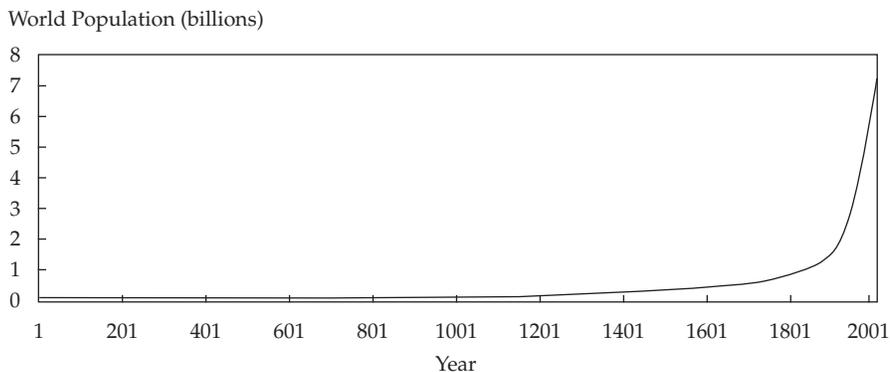


Figure 2. Historical and Forecast Population Growth on Logarithmic Scale, 1500–2100

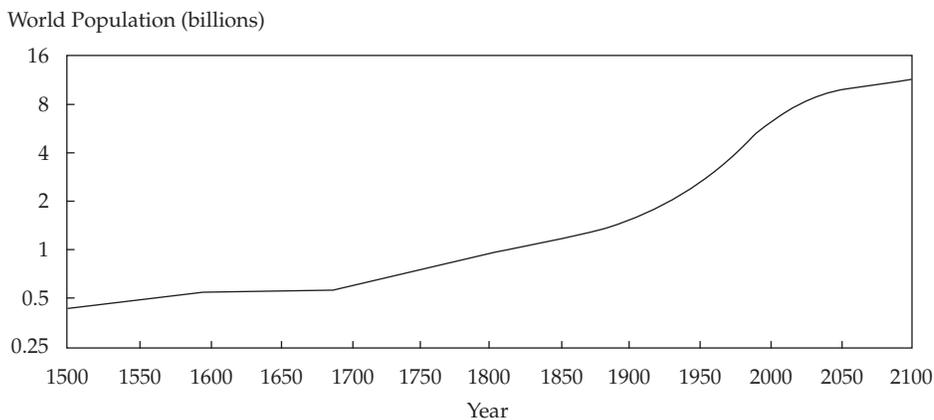


Figure 3. The Demographic Transition

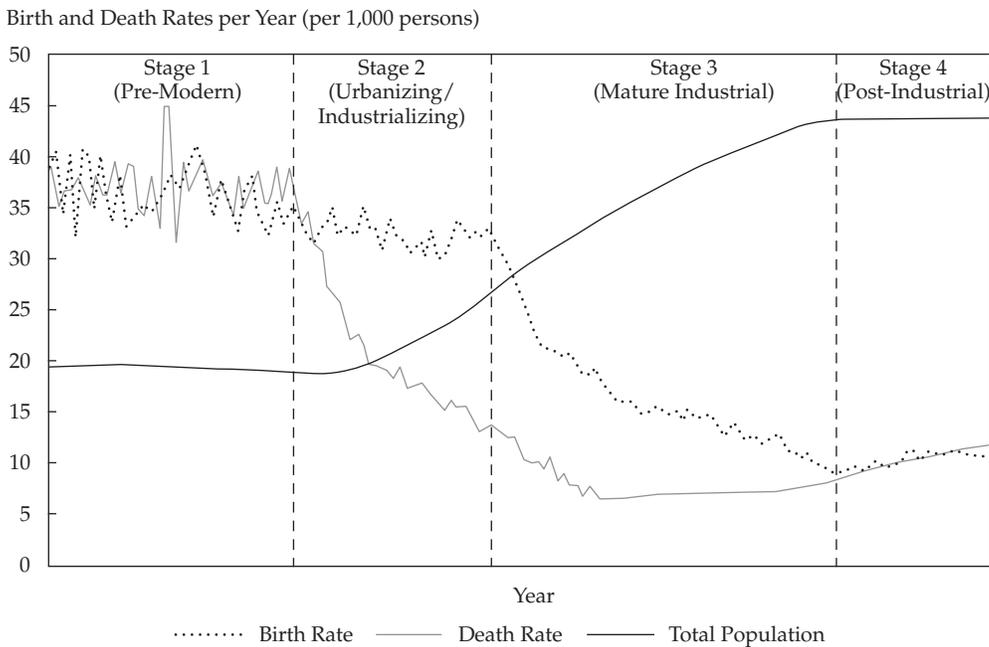


Table 1. Total Fertility Rates in Selected Countries and Regions, 1950–1955 and 2005–2010

Major Area, Region, or Country	Total Fertility (children per woman)		Major Area, Region, or Country	Total Fertility (children per woman)	
	1950–1955	2005–2010		1950–1955	2005–2010
<i>World</i>	4.95	2.52	<i>Europe and Russia</i>	2.65	1.53
More developed countries	2.81	1.66	France	2.76	1.97
Less developed, excluding least	6.01	2.41	Germany	2.16	1.36
Least developed countries	6.54	4.41	Italy	2.36	1.38
			Poland	3.62	1.32
<i>Africa</i>	6.60	4.64	Russian Federation	2.85	1.44
Egypt	6.37	2.85	Spain	2.53	1.41
South Africa	6.50	2.55	Sweden	2.21	1.90
Nigeria	6.35	5.61	Switzerland	2.31	1.46
			Ukraine	2.81	1.39
<i>Asia and Asia Minor</i>	5.58	2.28	United Kingdom	2.18	1.83
Bangladesh	6.62	2.38			
China	5.48	1.64	<i>Western Hemisphere</i>	5.86	2.30
Hong Kong	4.72	0.99	Argentina	3.15	2.25
India	5.90	2.73	Brazil	6.15	1.90
Indonesia	5.67	2.19	Canada	3.65	1.65
Iran	6.93	1.77	Chile	4.95	1.90
Israel	4.28	2.91	Colombia	6.76	2.45
Japan	2.16	1.32	Mexico	6.70	2.41
Malaysia	6.23	2.72	Peru	6.85	2.60
Pakistan	6.60	3.65	Puerto Rico	4.97	1.83
Philippines	7.27	3.27	United States	3.45	2.07
Saudi Arabia	7.18	3.03	Venezuela	6.46	2.55
Singapore	6.34	1.25			
South Korea	6.33	1.29	<i>Oceania</i>	3.81	2.49
Thailand	6.14	1.63	Australia	3.18	1.93
Turkey	6.30	2.15	New Zealand	3.69	2.14
Vietnam	6.76	1.89			

Source: UN Population Division (2010 revision): <http://esa.un.org/unpd/wpp/Excel-Data/fertility.htm>.

But the relatively low population growth rates in such countries as India, Indonesia, Thailand, Mexico, and Brazil are more surprising. Although India is still mostly very poor and the other countries on this list remain poor by First World standards, they have progressed enough to begin to offer advanced-country trade-offs to parents deciding how many children to have. The only large areas that still have high population growth rates are sub-Saharan Africa and the Middle East, and these growth rates will not persist forever. Owing to the boom in natural resources, Africa's economies are currently experiencing some of the fastest growth in the world, which will lead to population stabilization over time (but later than in other regions because Africa's population is so young).

In Figure 2, we can see that overall population growth rates have not fallen on a scale that we might expect given plummeting fertility rates. The reason is *population momentum*, which is a fancy way of saying that, once born, people tend to hang around for a long time (that's a good thing). Thus, the impact of a fertility change today on overall population is felt over the next generation or so, rather than immediately. The intuition behind this observation is that a population that has recently experienced a decline in the fertility rate—from, say, a rate above replacement to one below it—will continue to grow for a while because of the large number of young couples of childbearing age who were born before the fertility rate declined.⁶

Is Population Stabilization Desirable? Of course it is. A few thinkers regard “peak population” and a subsequent possible decline as bad news. Wattenberg (2004), for example, has written in melancholy tones about a world of old people pinning their hopes for the future on a few stressed-out children and has also been bearish on the economic prospects of an aging society.⁷ Arnott and Chaves (2012) have emphasized the empirical relation between an aging population (especially one with a high dependency ratio) and diminished productivity growth, leading to poor equity returns. Some of these concerns are legitimate,⁸ but I regard the prospect of a stable or even declining human population as wonderful news for the planet, making it much easier to solve environmental and resource problems and enabling greater per capita wealth and income to be achieved than would otherwise be possible.⁹

Population Stabilization and Investing. A world that is getting poorer would be very bad for any kind of risky investment (such as stocks), but one that is getting richer only on a per capita basis while the number of *capita* stays the same or

declines is entirely consistent with strong capital market returns. This idea can be illustrated with a simple thought experiment. Suppose that each U.S. national were endowed with one share of a comprehensive stock market index. As the population increases, new stock is issued to maintain the one-person, one-share endowment. The price of the stock is a constant multiple of corporate profits. The price return on this stock (ignoring dividends) is definitionally equal to the change in market capitalization divided by the change in population.

Assume that productivity, an inherently per capita concept, grows by 2% a year; GDP grows by approximately $(1 + \text{PROD})(1 + \text{POP})$ each year, where PROD and POP are the constant growth rates of productivity and population, respectively. Assume further that corporate profits are a constant share of GDP. Because we have already assumed that the stock market is priced at a constant multiple of corporate profits, stock market capitalization also grows at the same rate as GDP. Under such conditions, stock market capitalization, like GDP, grows by $(1 + \text{PROD})(1 + \text{POP})$ each year.

Now, what is the impact of population growth on the forecast for this “stock market”?

Faster population growth means faster GDP growth. However, the capitalization of the stock market is continually being split at POP to make new shares to be issued to new people. Thus, capitalization per capita grows at PROD, with no influence from the population growth rate. Because the price return to the investor (on a per share basis) is merely the change in the stock price—where the stock price has already been defined as capitalization divided by population, or capitalization per capita—return is unrelated to population growth. It is certainly unrelated in this highly stylized model, and I strongly suspect that it is unrelated in reality.

The literature connecting population growth, real GDP growth, and capital market returns is somewhat limited, but one brief paper confirms the crucial point that I have just made. William Bernstein (2002) set forth a clever method for separating the effects on the stock market of population growth and real per capita GDP growth. He did so by measuring the “leakage” between GDP growth and stock returns—that is, the extent to which stock market performance falls short of GDP growth. This leakage is greatest in countries for which high GDP growth is best explained by a rapid population increase (the R^2 is a very high 0.63). Bernstein concluded, “GDP rises are good for stock prices only when they come from increases in individual productivity, as measured by per capita GDP; they are bad when caused predominantly by population growth.”

It is just as well that rising markets do not require a population boom because we are not going to get one. What rising markets do require is a rising standard of living (income per capita). Let us now look at global trends in production and income.

Richer

In assessing the future of the global economy, we first look back at the monumental economic growth over the last two centuries and then attempt to ascertain the likeliest path of future economic growth. Along the way, we briefly examine the timely topic of economic inequality.

The Great Fact. One of the more distinctive passages in the history of economic thought comes from the great economic historian Deirdre McCloskey (2011), discussing the possible causes of what she calls the “Great Fact” of monumental economic growth over the last two centuries:

What I got with a jolt around age 65 was that economic growth since 1800, the Great Fact of an increase of real income per head by a factor of anything from a factor of 16 . . . to . . . a factor of 100, had very little to do with routine . . . adjustment of marginal cost to marginal benefit. (pp. 47–48)

That is, economic growth since 1800 had very little to do with improved “supply-and-demand efficiency,” which is one of the conventional explanations.

Nor, continues McCloskey, did it have to do with private property rights, an explanation favored by Hernando de Soto and many other illustrious scholars:

China . . . had secure property for millennia before failing to have an industrial revolution, and . . . ancient Rome had laws of contract and property, and ancient Greece had banks and wide trade, and Mesopotamia had detailed records of ownership without the slightest signs in the ancient world of a Great Fact.

Holland and England [in] 1600–1800, by contrast, . . . witnessed an obvious and historically unique improvement in the dignity and liberty of the bourgeoisie. (pp. 48–49)

Something of a surprise. McCloskey closes the loop:

None of the allocative, capital-accumulation explanations of economic growth since Adam Smith have worked scientifically. . . . None of them have the

quantitative force and the distinctiveness to the modern world and the West to explain the Great Fact. . . .

What works? Creativity. Innovation. Discovery. . . . And where did discovery come from? It came from the releasing of the West from ancient constraints on the dignity and liberty of the bourgeoisie, producing an intellectual and engineering explosion of ideas. As . . . Ridley has recently described it (2010 . . .), ideas started breeding, and having baby ideas, who bred further. (pp. 49–50)

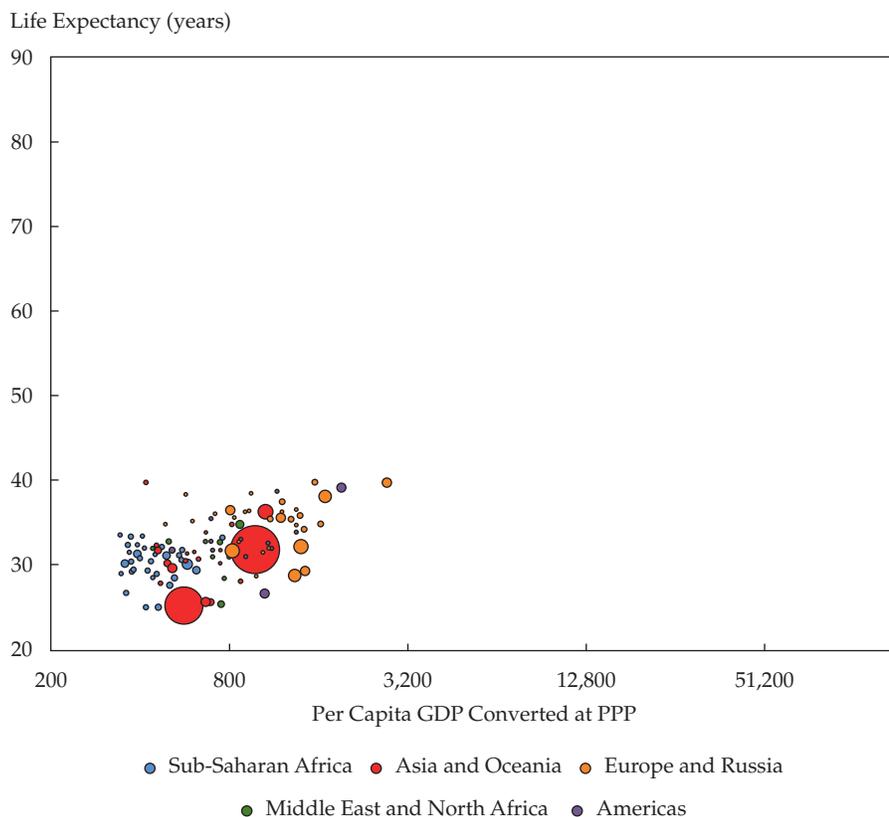
So, ideas having babies, not capital accumulation, are responsible for the most astounding increase in wealth and well-being in the history of humanity? Likely story. McCloskey is, of course, correct, and any analysis of the Great Fact should proceed from this starting point: The decision to save some of what one produces and invest it for the future is not nearly enough to explain economic growth that has been self-sustaining for more than two centuries; only an explosion of creativity and invention is.

(I began this section with a meditation on the history of economic thought because it would be a little foolish to begin it with, “Over the last 200 years, the world has gotten tremendously richer.” Everybody knows it. Yet, it is still possible to know this fact and simultaneously hold the view that conditions are getting persistently worse and long for days gone by.)¹⁰

The Great Fact can be summed up in one data point: The per capita GDP adjusted for purchasing power parity (PPP) for the *world* in 2010—\$11,200—was equal to the per capita GDP (in the same units) for the United States in 1929, when the United States had the highest standard of living in the world and was, by any reasonable accounting, very much a developed country.¹¹

Because we tend to take the world’s past economic development for granted, let us *briefly* review the history. Most pictures are worth a thousand words, but the ingenious data graphs of Swedish physician and statistician Hans Rosling are worth a multiple of that; so, let us look at the graphs, which are more or less self-explanatory (**Figure 4**, **Figure 5**, and **Figure 6**).

I have included a Rosling graph for the intermediate year of 1950 (Figure 5) because it corresponds roughly to “peak inequality.” While the developed world was well on its way to modern levels of health and wealth, parts of the less developed world had not moved much from early 19th-century levels and China was poorer than at any time since 1500. Ironically, some Americans who

Figure 4. The World in 1800: Income, Life Expectancy, and Population

Note: GDP is measured in current (2010) dollars. Each bubble represents a country, with the area of the bubble proportional to the country's population in 1800.

Source: Constructed using data obtained with permission from Hans Rosling's website, www.gapminder.org.

claim to be exercised about inequality consider the 1950s to be the "good old days."¹²

Economic development since 1800 can thus be divided into two subperiods: the Great Decompression of 1800 to roughly 1950, when the developed world achieved essentially a modern standard of living—leaving the rest of the world far behind—and the Great Convergence of roughly 1950 to the present, when the rest of the world started to catch up. The developed world continued to get richer, *but not in relative terms* (a source of great worry to some people!).

Forecasts of Future Wealth. The Great Fact is, of course, only an observation about the past and is not necessarily a forecast of the future. But developed-country growth rates have been remarkably stable over two centuries (as documented by Arnott and Chaves 2012), and developing-country growth rates have only accelerated.¹³ There is almost no hint in the data of a deceleration.¹⁴ Moreover, the forces that propelled economic growth between 1800 and the present have not changed. Most important,

creativity and invention have not stopped but, on the contrary, seem to be accelerating further.

Inequality. One of today's most heated discussion topics is whether economic inequality (among individuals in, say, a country) is increasing and if so, why it is increasing and what should be done about it. Conventional measures of inequality, such as the Gini coefficient, show a significant, though not huge, increase in inequality in the United States, the United Kingdom, and some other rich countries over the last half century. This trend is surprising in light of the celebrated observation by economist Simon Kuznets (1955) that inequality increases as a country moves off the floor of subsistence living into middle-income status and then decreases as it becomes rich. The logic of the Kuznets curve is that in the early stages of a country's development, opportunities for the educated and well placed become radically enhanced while wages for unskilled labor are kept low by the migration of desperately poor rural workers to the cities. In more advanced economies, education is wide-

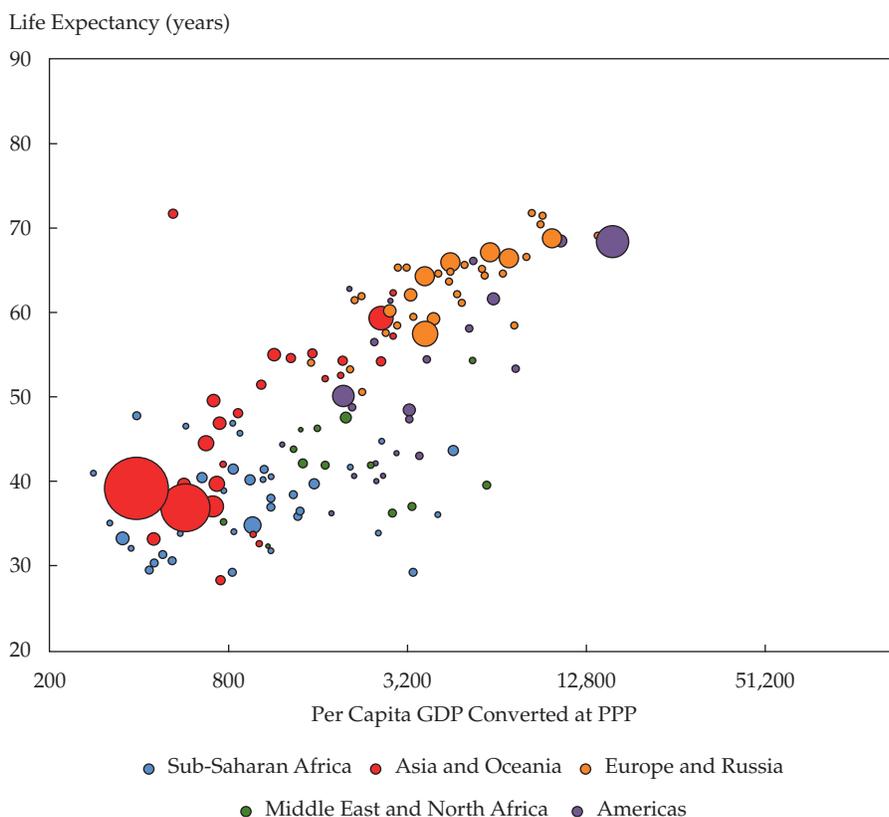
spread, most workers are skilled (and can thus earn relatively high industrial wages), and improvements in technology enable food to be grown by an ever-shrinking number of low-paid rural workers.

In general, the Kuznets curve hypothesis has been supported by data for countries at various stages of development. What Kuznets did not foresee, however, was the extent to which trade between rich and poor countries would affect outcomes for individuals. Today, unskilled laborers in the United States are competing with Chinese laborers, dragging the U.S. unskilled wage down. (The mirror image of that phenomenon, of course, is that the United States, as well as Chinese customers, is now bidding for the services of Chinese laborers, causing their wages to soar.) Although the price of highly skilled labor is subject to some of the same pressures, skilled workers are less fungible (you cannot easily go to a dentist located on another continent) and their wages have tended to remain high in high-income countries. Thus, the increase in inequality in rich countries is real—yet, it is part of a much larger trend toward equalization of both opportunity and outcomes, as well as

enrichment, across national borders. Surely, we do not want that latter trend to stop.

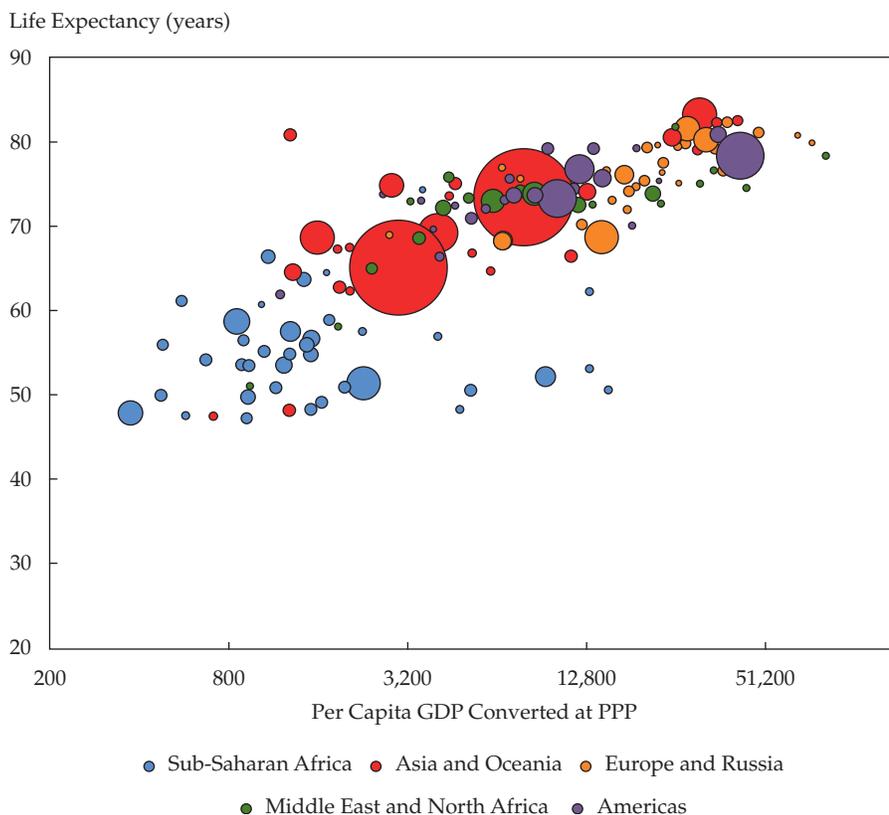
We can also draw a distinction between “good” and “bad” inequality. Inequality that arises from individuals’ differing levels of productivity can be defended as fair; it is also amenable to change if individuals have the opportunity to improve their productivity through education, training, and on-the-job experience. In contrast, inequality that arises from “rent seeking” cannot be defended on any sort of economic efficiency grounds. By rent seeking, I mean the use of political power to redistribute income or wealth, favor certain groups, or restrain trade and competition. There is, of course, a level of living below which no civilized society should allow its members to fall, and this level must necessarily be determined politically; but the cost of such a charitable effort must be transparent, with an open civic discussion of the trade-off between economic freedom—the right to keep all or most of the fruits of one’s labor—and protection of the least fortunate.

Figure 5. The World in 1950: Income, Life Expectancy, and Population



Note: GDP is measured in current (2010) dollars. Each bubble represents a country, with the area of the bubble proportional to the country’s population in 1950.

Source: Constructed using data obtained with permission from Hans Rosling’s website, www.gapminder.org.

Figure 6. The World in 2012: Income, Life Expectancy, and Population

Note: GDP is measured in current (2010) dollars. Each bubble represents a country, with the area of the bubble proportional to the country's population in 2012.

Source: Constructed using data obtained with permission from Hans Rosling's website, www.gapminder.org.

Economic Growth: The Past and the Future. The doomsayers tend to ascribe past growth to the exploitation of cheap energy, cheap labor, and cheap land. Although these factors have produced some economic growth, they were at work in the centuries before 1800 and sustained growth did not materialize. Moreover, energy was never more expensive, at least in terms of human effort (isn't that what counts?), than when all of it had to be produced by human muscle power—typically, slave power. Successively cheaper energy sources include animal muscle power, water and wind power, wood, coal, oil (first extracted from the blubber of whales!), nuclear energy, and sources yet to be discovered (or already discovered but not yet economical to exploit).

Each time energy production transitioned from one source to another, the transition occurred because the old source had become expensive (reflecting increasing scarcity), making the new source more economical. This process will continue—not just for energy but also for every resource that appears to constrain economic progress.

A compound rate of increase in consumption—of anything—in the face of fixed supply is, of course, unsustainable. It is tempting to see this fact as an insurmountable barrier, but economics asks, Even if the supply of the resource is fixed, is the supply of the *service provided by the resource* really fixed? If not—if substitutes can and will be found at some price—then economic progress is not constrained, although the higher cost of the service needs to be factored into growth forecasts.

I cannot forecast the future quantitatively, but there are those who try. In 2005–2006, Goldman Sachs prepared forecasts of per capita GDP by country, in then-current dollars (see Wilson and Stupnytska 2007). The forecasts are in **Table 2**, along with current (2010) GDP for comparison. Countries are listed in order of their expected per capita GDP in 2050.¹⁵

The forecasts are a little high because they were made before the Great Recession—which means only that if Goldman Sachs got the overall pattern of growth rates right, the numbers will be achieved in 2056 instead of 2050 for developed countries and

in 2051 or 2052 for emerging markets. Of course, there is a forecast error term, and so the realizations will be different from the forecasts, but it would be very surprising if the direction and general magnitude of the forecasts were wrong.

Mexicans, sporting an average income 30% higher than the current U.S. average, and Indians, with an average income equal to that of the United States in the 1960s, will be citizens of a world that is profoundly different—and *profoundly better*—than any past or present reality. There is every reason to expect this to happen; and it will happen more or less on schedule, within our children's or, at most, our grandchildren's lifetimes.

But all these rich people will consume a lot.¹⁶ What will this consumption do to the environment, to the planet?

Greener

It is almost an article of faith among educated readers that the world's past economic development has seriously degraded the natural environment

and that future economic development on the scale I'm describing will destroy the planet. Let us examine this proposition.

The U.S. national parks are among the world's most beautiful, healthful, and unspoiled places. How did they come into being?

Why is the northeastern United States more densely forested now than it was in 1850, 1900, or 1950?

Switzerland resembles one big national park.¹⁷ Its air and water are splendidly clean, and the country's natural beauty is preserved. With its relatively high population density—about 485 people per square mile, higher than that of China or Nigeria—how did this happen?

These paragons of environmental conservation have one common factor: They have been rich for a long time. Established in 1872, the U.S. national park system was developed into its modern form by President Theodore Roosevelt at the turn of the last century. In 1872, the United States was not yet the world's richest country, but it was in the top half dozen: Basic needs had been met to the extent that,

Table 2. Current (2010) and Forecast (2050) GDP per Capita by Country

Country	2010 PPP-Adjusted GDP per Capita (in U.S. dollars) ^a	2050 Projected GDP per Capita (in U.S. dollars) ^b
United States	47,200	91,683
South Korea	30,000	90,294
United Kingdom	34,600	79,234
Russia	15,900	78,435
Canada	39,400	76,002
France	33,100	75,253
Germany	35,700	68,253
Japan	34,000	66,846
Mexico	13,900	63,149
Italy	30,500	58,545
Brazil	10,800	49,759
China	7,600	49,650
Turkey	12,300	45,595
Vietnam	3,100	33,472
Iran	10,600	32,676
Indonesia	4,200	22,395
India	3,500	20,836
Egypt	6,200	20,500
Philippines	3,500	20,388
Nigeria	2,500	13,014
Pakistan	2,500	7,066
Bangladesh	1,700	5,235

^aCurrent (2010) dollars.

^bProjections as of 2005–2006 in 2006 U.S. dollars.

in a democracy, it was not inconceivable to divert a portion of tax revenues to environmental protection.¹⁸ By Roosevelt's day, the United States could afford to have conservation become a major government program. Switzerland and other countries at the top of the income scale tell a similar tale. (I'll get to the northeastern U.S. forests later.) Effective environmental protection cannot be achieved through private action alone; much of it requires the kind of mass cooperation that can be enforced only by government. But in a free society, taxpayers must consent to their taxes being used in this way or else the environmental protection will not take place.

Why this emphasis on government? Private agents always externalize, or get other people to pay part of their costs, as best they can (and competition forces them to do so even if they would rather not). Many, though not all, environmental effects are externalities—they consist of harm to the "commons" (property held in common by the people). Examples of such externalities are pollution (air, water, noise, etc.), overgrazing, and overfishing. Such harm is suffered by individuals who do not benefit from the transaction causing the harm, which can be alleviated only through government regulation or direct government action.

Free-market environmentalists have noted that if there were no commons—if private property rights could be established in everything, including air, water, forests, fisheries, and so on—the environment could be protected by the owners of these goods acting in their own interest. However, it is unrealistic to think that private property rights could be established that broadly, although there has been some progress in that direction (see the discussion of Iceland's fisheries later in the article).

The Environmental Kuznets Curve. Recalling my earlier observation that rich countries tend to be green, one might hypothesize that a society is as green as it can afford to be. But this principle does not hold up at all income levels. In the early stages of a country's economic development, the environment becomes degraded pretty quickly. Why? As an economy begins its rise out of poverty, progress must be made on the cheap (that is what it means to be poor). Low incomes are also often associated with high rates of population growth.

Thus, we have the following time progression: Land unsettled by humans is pristine. Subsistence living, with its very high discount rates, is the most environmentally destructive lifestyle ever known, but the population may be too small for the damage to be immediately obvious. Rapid industrialization causes profound environmental problems. After reaching a tipping point at which environmental protection becomes a desirable and afford-

able expense, however, a society becomes greener. Fewer, richer, greener.

Recall that, in 1955, Simon Kuznets observed an inverse U-shaped relation between economic development and income inequality. As an economy first develops, incomes become more unequal as a few successful people take advantage of newfound opportunity. At a later stage of development, incomes become more *equal* as education becomes more widespread and capital becomes sufficiently abundant to make even unskilled labor more productive. We saw a version of this phenomenon earlier in the article when I made comparisons across (not within) countries, noting that peak inequality had occurred around 1950.

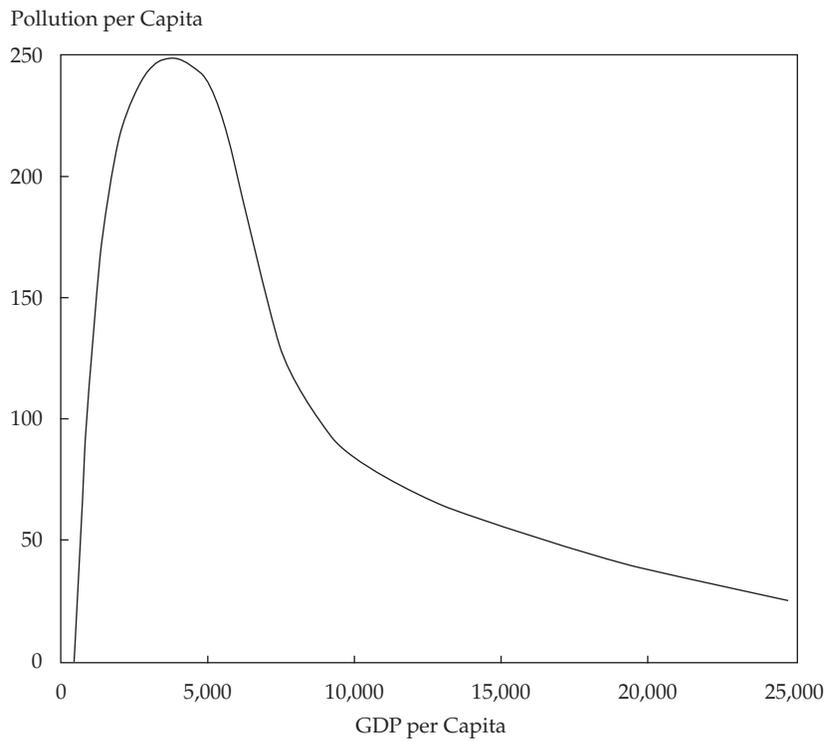
Beginning with Grossman and Krueger (1995), researchers inspired by Kuznets have fitted the pattern of worse and then better environmental conditions as an economy grows to the curve that Kuznets developed for a different purpose. These researchers call the resulting relation the environmental Kuznets curve (EKC), the general pattern of which is shown in **Figure 7**.¹⁹ John Tierney (2009b), a science reporter for the *New York Times*, summarized EKC theory by saying, "The richer everyone gets, the greener the planet will be in the long run." Tierney's work was welcomed warmly in some circles and greeted with derision and outrage in others, and the EKC has become one of the most widely discussed and debated topics in environmental policy, spawning more than 100 scholarly papers by 2004.

Research on specific environmental variables tends to confirm the EKC, but unevenly: The theory "works" better for some resources than for others. Industrial pollutants follow the hypothetical EKC very closely; **Figure 8** plots the empirically estimated curve for sulfur dioxide.

Forests. The EKC also works well for forestation. Although some developing countries are still cutting down forests to obtain arable land, the United States has experienced dramatic reforestation, especially in the Northeast. This reforestation began when the settlement of the Midwest, in the early to mid-19th century, made previously valuable northeastern farmland marginal and has continued to the present day. As the market environmentalist Jonathan Adler (1993) noted,

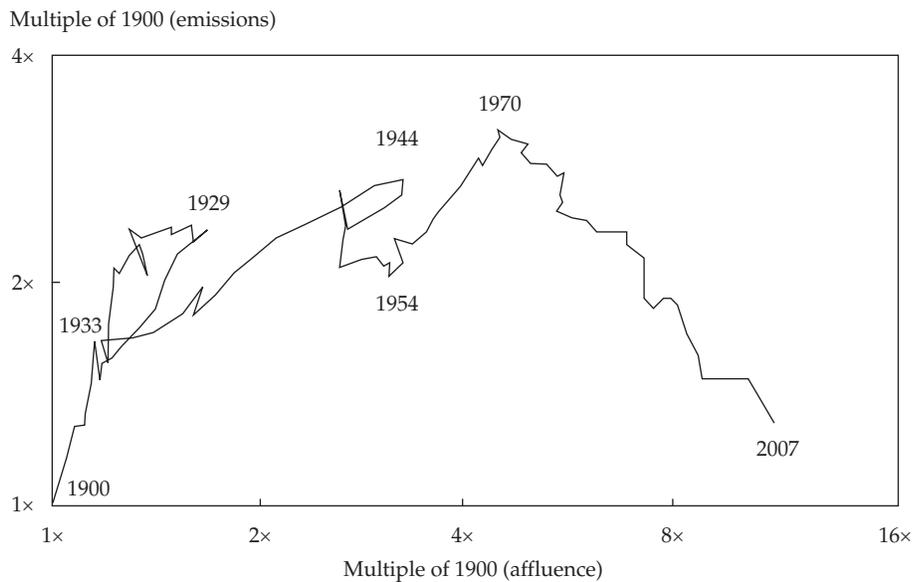
In the past 40 years, timberland east of the Mississippi has expanded by 3.8 million acres, in addition to the nearly three million acres in the eastern United States that have been declared wilderness in the past two decades. By 1980, New England contained more forested acres than in the mid-19th

Figure 7. Hypothetical Environmental Kuznets Curve for a Generic Pollutant



Note: GDP is measured in dollars.
Source: Gallagher (2009).

Figure 8. Environmental Kuznets Curve for U.S. Sulfur Dioxide Emissions



Source: Ausubel and Waggoner (2009), cited in Tierney (2009a).

century; Vermont is now twice as forested as then. Fifty-nine percent of the northeastern United States is covered by forest. (p. 84)

This is not simply a matter of land returning to its natural state. Forests are a positive good, and people are willing to pay to live in or near one or to visit one. Ellen Stroud, a Bryn Mawr College environmentalist and urbanologist, has written, "It is no coincidence that the most heavily urbanized part of the country has experienced the most dramatic return of woodlands. . . . The desires and physical needs of city people encouraged and required the return of the forest."²⁰

The EKC seems to break down, however, for biodiversity and for goods that are usually held in common, such as fisheries. Biodiversity cannot obey a conventional EKC because extinction is a one-way street. A species that is made extinct cannot be brought back; so, biodiversity, as measured, can only go down. (New species are evolving all the time, but we are unable to observe that process directly.) The best we can hope for is to reduce the rate of species extinction to near zero.

Fishing. Natural fisheries are currently under great strain and, like other resources held in common, have generally failed to conform to the EKC model.²¹ Although a fishing ground is self-renewing in the long run, the incentive for overfishing is seldom balanced by any countervailing force other than diminishing returns to effort, with the result that fisheries typically degrade over time. A system of enforceable property rights would probably eliminate this problem, but it is hard to establish property rights in fish (they tend to swim away). However, it is not impossible. Michael Lewis (2011) described an ingenious system, used in Iceland, which has had the effect of conserving fisheries there:

They privatized the fish. Each fisherman was assigned a quota, based roughly on his historical catches . . . [entitling him] to, say, 1 percent of the total catch allowed to be pulled from Iceland's waters that season. Before each season . . . scientists . . . would determine the total number of cod or haddock that could be caught without damaging the fish population; from year to year, the numbers of fish you could catch changed. But your percentage of the annual haul was fixed . . . in perpetuity [and], even better, if you didn't want to fish you could sell your quota to someone who did. The quotas thus drifted into the hands of . . . the best fishermen, who could extract the fish from the sea with maximum efficiency. (p. 29)

Creative thinking along these lines will be required if the potential environmental benefits of greater wealth are to be realized.

Climate Change. Although some thoughtful observers question it, we appear to be in a global warming phase, at least similar in scale to the Roman and medieval warmings. (The medieval one reached an astonishingly high peak in the North Atlantic, making southern Greenland arable and enabling Newfoundland to be called Vinland or Vineland.) Any large-scale climate change, be it warming or cooling, is problematic because human settlement and agriculture are already optimized around the current climate. It is less clear, although certainly possible, that the modern warming is related to increased atmospheric carbon dioxide concentrations caused by human activity.

If the most widely accepted warming projections are correct, what happens to my forecasts? According to the Natural Resources Defense Council, a global warming "hawk," the all-in cost of global warming is projected to be 3.6% of GDP on an ongoing basis.²² At the historical per capita GDP growth rate of 1.8%, this scenario calls for GDP projections to be realized two years later than otherwise. At the 1% growth rate that is a likelier outcome for the most highly developed economies, GDP projections would be realized three and a half years later than otherwise. This result would be unfortunate but far from catastrophic, delaying GDP attainment by about as much as the 2007–09 recession did.²³

Running Out of and Into Oil. Julian Simon (1996, p. 162) called energy the "master resource" because it "enables us to convert one material to another," thus allowing us to create any other resource that we need. We would do well to be concerned about its continued supply and cost. In fact, some observers are more concerned about the limits to economic growth caused by resource scarcity than they are about environmental degradation. If the growth cannot occur because we do not have the raw materials for it, why worry about the consequences of growth that will not happen? We should worry about poverty and resource exhaustion instead.

In a fascinating Q Group presentation, David Greene (2004) of Oak Ridge National Laboratory projected the supply and demand for oil and other energy resources through 2050. The title of his presentation, "Running Out of and Into Oil," reflects the fact that we have been running into oil—discovering it—at about the speed we are using it or even a little faster. As a result, if, as of a given date, we have 30 years' reserves, 30 years later we

may have 40 years' reserves. It is all very counter-intuitive. The trick is that "reserves" indicates the amount of oil that can be profitably extracted from known sources at the current price. Reserves based on known sources are larger at higher prices, and more effort is expended in discovering new sources at high prices. However, the amount of oil is not infinite, and this fact needs to be taken into account in any analysis.

One of the more optimistic scenarios studied by Greene (2004) is a demand-driven (not supply-driven) peak in oil production around 2040. In a demand-driven peak, both the price mechanism and conservation are at work. As oil becomes more scarce and more costly to extract, the price rises to the point where non-oil sources of energy are more attractive; at the same time, demand eases owing to conservation or energy efficiency (relative to the massive growth in consumption that would otherwise occur).

Other scenarios that Greene studied are less favorable; in 2009, he commented that the current rate of oil consumption, relative to the total amount of oil that will ever be extracted, was "alarming" (Greene 2009, slide 7). Overall forecasts of economic growth should consider both high oil prices—which Greene did not foresee in 2004, despite his detailed analysis—and the potential difficulty in developing other sources of energy.

The same logic applies to other resources. Nothing is in infinite supply, but new discoveries and new ways of using existing resources more efficiently can cause the supply curves for most or all resources to move profoundly over time.

Investment Advice

I wish I knew how to turn these futuristic thoughts into highly specific investment recommendations. If I did, I would start a hedge fund and make the world greener with my riches.

I can, however, offer some general observations and suggestions. The immense amount of consumption implied in these forecasts—both at the end-user level and at various intermediate production stages—means that the following will be in great demand:

- *Food* and its "ingredients"—farmland, fertilizer, agri-technology (even a stable or declining population will want to eat higher-quality food with more protein)
- *Water* and delivery systems for clean water
- *Energy*, both traditional and alternative (we are going to need it all)
- *Minerals and other basic materials*

- *Forestry*
- *Infrastructure*, desperately needed, with demand expressed through both the public sector and the private sector
- *Environmental quality*, a "luxury" the world can finally afford

The investment vehicles for most of these items are straightforward: equities, commodities, private securities. Investing in environmental quality is a little more difficult and mostly involves selecting companies (public or private equities) that will benefit from spending on the environment.

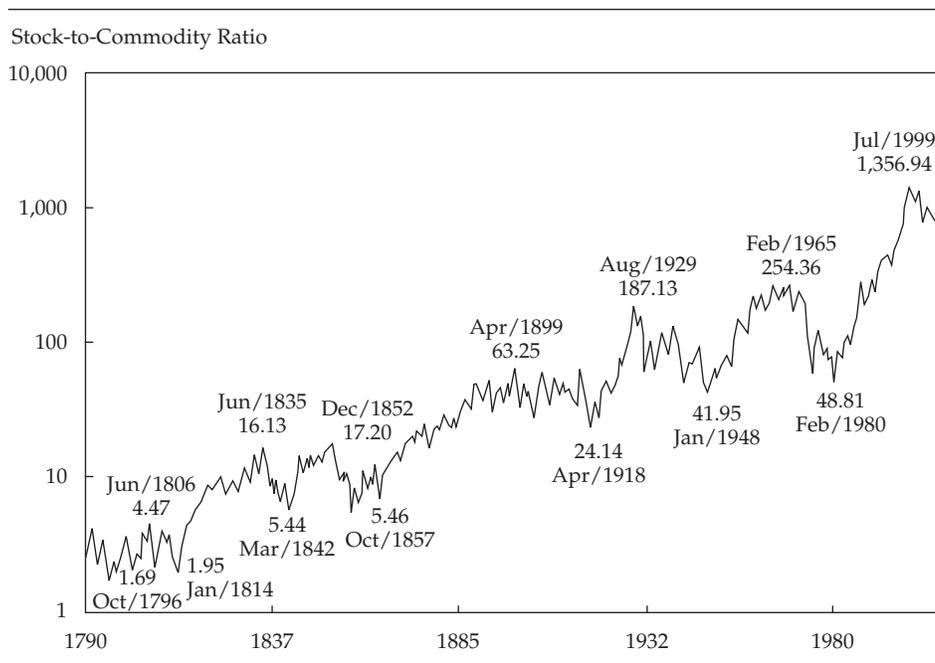
Asset Allocation. The expectation of massive future growth favors equities over bonds: If we are really going to be much richer, fixed-claim holders will get their fixed claims and variable-claim holders will get much more. Table 2 suggests that the increased riches will be strongly tilted in favor of emerging and frontier markets; by all means, hold them, but also buy stocks of developed-market companies that make a substantial share of their profits in these markets. Alternative investments are probably the best medium for making focused commitments to such asset classes as mining, farmland, and forestry, which are hard to obtain in the stock market. Finally, one should not overlook debt instruments: In any given situation, they may offer a better risk–return trade-off than equity in the same asset or deal, or the debt instrument may be the only security available.

Commodities. After hearing the story I have told, many investors would respond by increasing their allocation to commodities. Although this reaction is reasonable, commodities are already very high priced, and the going-in price for any investment is a primary determinant of subsequent return. **Figure 9** shows the relative return on equities and commodities (a cumulative index of the stock market divided by a cumulative commodity index) from 1790 to 2011.²⁴

The stock-to-commodity ratio has moved in long waves—that is, the series has a high serial correlation. The current move in favor of commodities and against stocks is becoming significant by historical standards; commodities have become expensive and stocks are (somewhat) cheap. **Figure 9** also shows that stocks have outperformed commodities, on average, over time, though with a great deal of variability.

In general, buying stocks of the companies that own or produce the commodities is a better idea than investing directly in commodity futures. One reason is that returns on commodity futures are

Figure 9. Relative Price of Stocks and Commodities (Cumulative Index), 1790–2011



Source: Gann Global Financial (2011).

strongly influenced by backwardation and contango, which are fancy words for the term structure of futures prices. (You cannot buy “spot,” or physical, commodities unless you have a place to store them.) The term-structure effects can overwhelm the underlying commodity return. A more fundamental reason to buy the company rather than the commodity is that the price of the company’s stock includes a real option—the option to produce less (or none) of the commodity when it is not profitable but keep it in reserve and ramp up production when it is profitable. The presence of this option reduces risk.

However, because stocks and commodities have been negatively correlated in the past (though not recently), this negative correlation could reappear; thus, investors may wish to invest directly in commodity futures as a hedge.

Human Capital. Finally, investors should seek out ways to invest in human capital (the present value of future labor income). The riches of the future will accrue primarily to labor in the form of rising standards of living rather than to capital. Portfolio investment in human capital is difficult almost by definition: You can’t buy shares of individual people. However, there may be equities, debt securities, currencies, or commodities that correlate highly with human capital. Identifying these correlations involves security analysis that is well beyond the scope of this article.

One approach might be to invest in intellectual property, either directly (as some hedge funds do) or by buying stocks of companies that own or produce a lot of intellectual property. Hirshleifer, Hsu, and Li (2011) noted that some companies are efficient at turning R&D funds into intellectual property whereas others seem to spend a lot on R&D but get little for it. They found a strong relation between this “innovative efficiency” and subsequent stock returns. Thus, investors pursuing a human capital theme might consider buying stocks of innovatively efficient companies.

Conclusion

All right, I’m done. I’m tired of people whining about the miserable future and scaring their children. The future will be much like the present, only better in many ways and worse in a few. At any rate, it hasn’t happened yet, so you can do something about it. Wealth accumulation may be inevitable, but it isn’t easy. Get to work.

This research was conducted with the support of Aronson Johnson Ortiz (AJO, Philadelphia), for which I am deeply grateful. I thank Timothy Aurthur, Paul Kaplan, Stephen Sexauer, Barton Waring, and many others for their help and constructive comments.

This article qualifies for 0.5 CE credit.

Notes

1. The economist's traditional view is that "takeoff" into self-sustaining development occurred around 1820 in what is now the developed world (Rostow 1956). Angus Maddison (2007, 2009), whose recent work on historical GDP by country over the last 2,000 years is considered authoritative, portrays a gentler discontinuity but supports the general idea of a significant increase in growth rates around 1800.
2. By "fewer," I mean either fewer than the peak population in the sense of an absolute decline in the world's population or fewer than most people are expecting. In the title of this article, *fewer* is a reference to Wattenberg (2004), who made the case for an absolute decline, which was in the medium-fertility UN Population Division forecast available at the time.
3. Cited in Bernstein (2008, p. 1).
4. That said, civilizations do collapse, and ours could too. But capitalism and economic development have become globalized to an extent that makes it seem unlikely that the entire world will lapse into long-term economic decline. Any given region or subset of the world economy could, of course, experience such a decline.
5. Before the 2010 upward revision of the UN Population Division's projections, the medium-fertility forecast projected a decline in the world's population later in this century; with the 2010 revision, the low-fertility forecast still does (the high-fertility forecast projects a world population of 15 billion in 2100). Wattenberg (2004) cited demographers who forecasted depopulation on a massive scale, with the world's population falling to 3 billion by 2300. Although I think 300-year forecasts are ridiculous, the fact that population stabilization is widely agreed upon—and that the magnitude of subsequent decline, if any, is a source of contention—shows the extent to which the population explosion can be considered to be nearing its end.
6. Today's low developed-country fertility rates could, of course, rise. There is some evidence of an uptick in fertility as a population becomes very affluent. If children are a luxury good in an advanced economy, fertility may rise as more and more people can afford the luxury. See Myrskylä, Kohler, and Billari (2009).
7. With enough depopulation, one runs into real problems. Skills and knowledge are lost. Ridley (2010) wondered aloud whether a modern village of 200 people, blessed with such technologies as double-entry bookkeeping and wireless telephony, could sustain these technologies if the village became isolated. The American Indian depopulation in Columbian times was associated with a devastating loss of cultural capital. However, no one is seriously suggesting that *overall* depopulation on such a scale is about to take place.
8. But not insoluble! A high dependency ratio can be alleviated by people working longer, not just toward the end of life but also toward the beginning (because so much of young people's energy is wasted through inefficient schooling).
9. The late Julian Simon would almost certainly have objected to this statement, on the ground that population growth and wealth building have been closely allied throughout human history. He might argue that all the problems we face would be even easier to tackle with more brains and hands at work (and that these factors would more than offset the cost of having more mouths to feed). The evidence he accumulated and the accuracy of his forecasts are reasons to give his views considerable respect (Simon 1981, 1996). I would point out, however, that we have only one sample of the past and that both population and wealth have grown tremendously, giving the appearance of a causal relation even if there is none and making it difficult to find counterexamples without studying collapsed civilizations that have little in common with our own.
10. For a much fuller discussion of nostalgia as a persistent cognitive error, see Ridley (2010).
11. The 2010 number is from the U.S. Central Intelligence Agency's *World Factbook* (2010). The 1929 number reflects Maddison's (2009) estimate of \$6,899 in 1990 Geary-Khamis dollars, which inflates to \$11,942 in 2011 dollars (according to the U.S. Bureau of Labor Statistics inflation calculator at <http://data.bls.gov/cgi-bin/cpicalc.pl>, which uses Consumer Price Index for All Urban Consumers inflation rates). Note that U.S. per capita GDP fell sharply after 1929 and then recovered, surpassing the 1929 high by 1940 and never again falling below that level. Although world average per capita GDP is not available for 1929, it was \$3,389 (in 2011 dollars) in 1940—again, drawing on Maddison (2009) and inflating to the present.
12. The 1950s are the good old days if you care only about people in the United States, if you ignore racial minorities, and if equality, not absolute prosperity, is the relevant welfare measure.
13. In a personal communication from Robert D. Arnott (graphed as Exhibit 6 in Grinold, Kroner, and Siegel 2011), Arnott documented a per capita real GDP growth rate of 1.8% in the United States over 1789–2008. The rate is remarkably constant across subperiods.
14. Controversially, and I think wrongly, Tyler Cowen (2011) has detected a hint of deceleration in the United States but believes that the nation, having gotten sick, will (eventually) feel better. My critique of Cowen's analysis is that the transition that he describes, from "eating low-hanging fruit" to making difficult and costly improvements, just barely shows up in the data: Overall growth in the 1980s and 1990s was almost as rapid as in the 1950s and 1960s; there was stagnation in median but not mean incomes.
15. The current incomes are PPP adjusted, but the forecasts are not. Although this approach might seem a little unfair, I think it advisable to use the best data available for each period. Clearly, for comparing standards of living, PPP-adjusted data are much better than unadjusted data, and so I used the former for the current time frame. The Goldman Sachs analysis seems to assume that purchasing-power differences among currencies will disappear between now and 2050. "Nominal" GDP per capita, converted at the market exchange rate, measures the amount of goods and services that a year's per capita income in a given country would buy if that income were consumed in the United States (at U.S. prices). PPP GDP per capita, in contrast, measures the amount of goods and services that a year's per capita income in a given country would buy if that income were consumed in the country where it was earned (e.g., a U.S. dollar goes further in China than it does in the United States, and so China's PPP GDP per capita is higher than its "nominal," or market rate, GDP per capita). As noted in De Rosa (2009, p. 2), "PPP exchange rates are preferred for comparing living standards among countries."
16. My use of the word *rich* is an economist's use and may not comport exactly with the popular conception. The rich United States has many poor people, and a somewhat richer Mexico in the 2050s will too; needless to say, so will India in the 2050s, with a per capita income one-third as large as Mexico's is expected to be. But billions of people around the world will have been lifted out of poverty, and hundreds of millions more will have been lifted from middle-income status to what an American, European, or Japanese reader would regard as true affluence.
17. Amazingly, Switzerland, with an area of 15,940 square miles, is smaller than the largest U.S. national park (Wrangell-St. Elias National Park in Alaska, with an area of 20,625 square miles).

18. In non-democracies, kings and other despots have often preserved natural resources for their own use (often as parks), whether or not the people's basic survival needs were being met.
19. An earlier, unpublished paper by Grossman and Krueger (1991) contains the original reference to an EKC. An excellent primer on the EKC is in Yandle, Vijayaraghavan, and Bhattarai (2002).
20. U.S. Environmental Protection Agency, "The Return of the Forest: Urbanization and Reforestation in the Northeastern United States," grant description (<http://cfpub.epa.gov/ncer/abstracts/INDEX.cfm/fuseaction/display.abstractDetail/abstract/2221>); see also Stroud (2012).
21. See Diamandis and Kotler (2012, p. 257, Exhibit 22 ["Evidence of Overfishing"], citing <http://simondonner.blogspot.com/2008/11/farming-oceans.html>).
22. I do not know how this estimate was arrived at, but a comprehensive estimate of the economic impact of global climate change would include migration away from overheated or desertified areas, resettlement of near-sea-level populations, conversion of marginal land (marginal because its climate is now too cold) to agricultural uses, and other adjustments.
23. The relation between wealth and environmental quality is not "tight," nor should one expect it to be. Some countries have started to become environmentally cleaner at lower income levels than others. The specifics depend on governance, the wishes of voters, the geography of the country, and many other factors. An especially difficult problem arises in relating income levels to environmental remediation efforts that are effective only if undertaken worldwide. Controlling carbon dioxide emissions is an example. A country such as Nauru, which stands to lose its physical territory (to flooding) if oceans rise substantially, can be expected to be on the leading edge of efforts to ameliorate global warming—especially because the sacrifices required are mostly of others. A country such as China, which is much less susceptible to damage from warming but which would have to pay a substantial portion of the price, can be expected to be on the trailing edge. A comparison of costs and benefits of a given policy, along these lines, may be helpful in predicting which environmental causes are likely to be taken up by which countries at a given stage of development.
24. Stock market data before 1871 are of unknown quality.

References

- Adler, Jonathan H. 1993. "Poplar Front: The Rebirth of America's Forests." *Policy Review* (Spring):84–87.
- Arnott, Robert D., and Denis B. Chaves. 2012. "Demographic Changes, Financial Markets, and the Economy." *Financial Analysts Journal*, vol. 68, no. 1 (January/February):23–46.
- Ausubel, Jesse H., and Paul E. Waggoner. 2009. "The Jack Rabbit of Depression, or Do Economic Slumps Benefit Environment?" Rockefeller University (18 April): <http://phe.rockefeller.edu/news/wp-content/uploads/2009/04/jackrabbitofdepressionfinal.pdf>.
- Bernstein, Peter L. 2008. "Of Schumpeter, Erudition, and Regression to the Mean." *Journal of Portfolio Management*, vol. 34, no. 4 (Summer):11.
- Bernstein, William J. 2002. "Of Markets, Economies, and Populations" (www.efficientfrontier.com/ef/402/mep.htm).
- Central Intelligence Agency. 2010. *The World Factbook 2010*. Washington, DC: Central Intelligence Agency.
- Cowen, Tyler. 2011. *The Great Stagnation*. New York: Dutton.
- De Rosa, David F. 2009. *Central Banking and Monetary Policy in Emerging-Markets Nations*. Charlottesville, VA: Research Foundation of CFA Institute.
- Diamandis, Peter, and Steven Kotler. 2012. *Abundance: The Future Is Better Than You Think*. New York: Free Press.
- Gallagher, Kevin P. 2009. "Economic Globalization and the Environment." *Annual Review of Environment and Resources*, vol. 34, (November):279–304.
- Gann Global Financial. 2011. "Will Stock and Commodity Prices Finally Decouple?" (3 August): www.gannglobal.com/stock-commodity-prices-decouple/.
- Greene, David L. 2004. "Running Out of and Into Oil." Presentation at the Q Group, Key Largo, FL (4 April). Based on an unpublished paper by David L. Greene, Janet L. Hopson, and Jia Li.
- . 2009. "Why Future Oil Prices Are So Uncertain." Presentation (10 February): www.energy.ca.gov/2009_energypolicy/documents/2009-02-10_workshop/presentations/David_Greene_Why_Future_Oil_Prices_Are_So_Uncertain.PDF.
- Grinold, Richard C., Kenneth F. Kroner, and Laurence B. Siegel. 2011. "A Supply Model of the Equity Premium." In *Rethinking the Equity Risk Premium*. Edited by P. Brett Hammond, Jr., Martin L. Leibowitz, and Laurence B. Siegel. Charlottesville, VA: Research Foundation of CFA Institute.
- Grossman, Gene M., and Alan B. Krueger. 1991. "Environmental Impact of a North American Free Trade Agreement." NBER Working Paper 3914 (November).
- . 1995. "Economic Growth and the Environment." *Quarterly Journal of Economics*, vol. 110, no. 2 (May):353–377.
- Hirshleifer, David A., Po-Hsuan Hsu, and Dongmei Li. 2011. "Innovative Efficiency and Stock Returns." American Finance Association 2012 Chicago Meetings Paper (April).
- Kuznets, Simon. 1955. "Economic Growth and Income Inequality." *American Economic Review*, vol. 45, no. 1 (March):1–28.
- Lewis, Michael. 2011. *Boomerang: Travels in the New Third World*. New York: W.W. Norton.
- Maddison, Angus. 2007. *Contours of the World Economy, 1–2030 AD: Essays in Macro-Economic History*. Oxford, U.K.: Oxford University Press.
- . 2009. "Statistics on World Population, GDP and Per Capita GDP, 1–2008 AD." Microsoft Excel data file (www.ggdc.net/MADDISON/oriindex.htm).
- McCloskey, Deirdre N. 2011. "A Kirznerian Economic History of the Modern World." *Annual Proceedings of the Wealth and Well-Being of Nations*, vol. 3, no. 2010–2011:45–64.
- Myrskylä, M., H. Kohler, and F.C. Billari. 2009. "Advances in Development Reverse Fertility Rate." *Nature*, vol. 460, no. 7256 (6 August):741–743.
- Ridley, Matt. 2010. *The Rational Optimist: How Prosperity Evolves*. New York: HarperCollins.
- Rostow, Walt W. 1956. "The Take-Off into Self-Sustained Growth." *Economic Journal*, vol. 66, no. 261 (March):25–48.
- Simon, Julian L. 1981. *The Ultimate Resource*. Princeton, NJ: Princeton University Press.

———. 1996. *The Ultimate Resource 2*. Princeton, NJ: Princeton University Press.

Stroud, Ellen. 2012. *Nature Next Door: Cities and the Rebirth of Northeastern Forests*. Seattle: University of Washington Press.

Tierney, John. 2009a. "The Richer-Is-Greener Curve" (20 April): <http://tierneylab.blogs.nytimes.com/2009/04/20/the-richer-is-greener-curve/>.

———. 2009b. "Use Energy, Get Rich and Save the Planet." *New York Times* (21 April):D1.

Wattenberg, Ben J. 2004. *Fewer: How the New Demography of Depopulation Will Shape Our Future*. Chicago: Ivan R. Dee.

Wilson, Dominic, and Anna Stupnytska. 2007. "The N-11: More than an Acronym." Goldman Sachs Global Economics Paper 153 (28 March).

Yandle, Bruce, Maya Vijayaraghavan, and Madhusudan Bhattacharai. 2002. "The Environmental Kuznets Curve: A Primer." PERC Research Study 02-1 (May).