The Singularity Is Near

Chapter 2: The Singularity As Economic Imperative

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The Singularity as Economic Imperative

> The reasonable man adapts himself to the world; the unreasonable one persists in trying to adapt the world to himself. Therefore all progress depends on the unreasonable man.
>
> —GEORGE BERNARD SHAW, "MAXIMS FOR REVOLUTIONISTS," *MAN AND SUPERMAN*, 1903

> All progress is based upon a universal innate desire on the part of every organism to live beyond its income.
>
> —SAMUEL BUTLER, *NOTEBOOKS*, 1912

> If I were just setting out today to make that drive to the West Coast to start a new business, I would be looking at biotechnology and nanotechnology.
>
> —JEFF BEZOS, FOUNDER AND CEO OF AMAZON.COM

Get Eighty Trillion Dollars—Limited Time Only

You will get eighty trillion dollars just by reading this section and understanding what it says. For complete details, see below. (It's true that an author will do just about anything to keep your attention, but I'm serious about this statement. Until I return to a further explanation, however, do read the first sentence of this paragraph carefully.)

The law of accelerating returns is fundamentally an economic theory. Contemporary economic theory and policy are based on outdated models that emphasize energy costs, commodity prices, and capital investment in plant and equipment as key driving factors, while largely overlooking computational capacity, memory, bandwidth, the size of technology, intellectual property, knowledge, and other increasingly vital (and increasingly increasing) constituents that are driving the economy.

It's the economic imperative of a competitive marketplace that is the primary force driving technology forward and fueling the law of accelerating returns. In turn, the law of accelerating returns is transforming economic relationships. Economic imperative is the equivalent of survival in biological evolution. We are moving toward more intelligent and smaller machines as the result of myriad small advances, each with its own particular economic justification. Machines that can more precisely carry out their missions have increased value, which explains why they are being built. There are tens of thousands of projects

that are advancing the various aspects of the law of accelerating returns in diverse incremental ways.

Regardless of near-term business cycles, support for "high tech" in the business community, and in particular for software development, has grown enormously. When I started my optical character recognition (OCR) and speech-synthesis company (Kurzweil Computer Products) in 1974, high-tech venture deals in the United States totaled less than thirty million dollars (in 1974 dollars). Even during the recent high-tech recession (2000–2003), the figure was almost one hundred times greater.[79] We would have to repeal capitalism and every vestige of economic competition to stop this progression.

It is important to point out that we are progressing toward the "new" knowledge-based economy exponentially but nonetheless gradually.[80] When the so-called new economy did not transform business models overnight, many observers were quick to dismiss the idea as inherently flawed. It will be another couple of decades before knowledge dominates the economy, but it will represent a profound transformation when it happens.

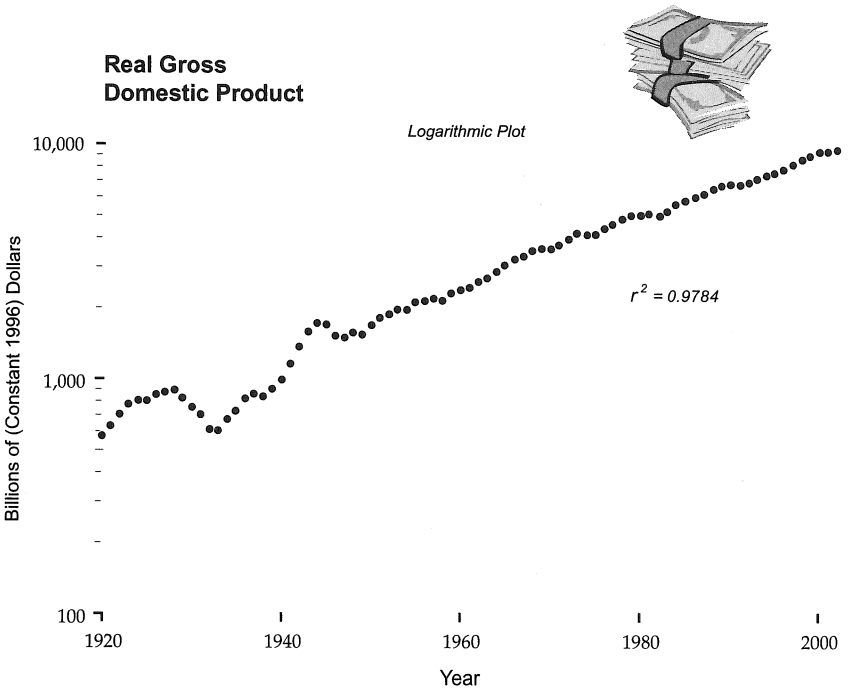
We saw the same phenomenon in the Internet and telecommunications boom-and-bust cycles. The booms were fueled by the valid insight that the Internet and distributed electronic communication represented fundamental transformations. But when these transformations did not occur in what were unrealistic time frames, more than two trillion dollars of market capitalization vanished. As I point out below, the actual adoption of these technologies progressed smoothly with no indication of boom or bust.

Virtually all of the economic models taught in economics classes and used by the Federal Reserve Board to set monetary policy, by government agencies to set economic policy, and by economic forecasters of all kinds are fundamentally flawed in their view of long-term trends. That's because they are based on the "intuitive linear" view of history (the assumption that the pace of change will continue at the current rate) rather than the historically based exponential view. The reason that these linear models appear to work for a while is the same reason most people adopt the intuitive linear view in the first place: exponential trends appear to be linear when viewed and experienced for a brief period of time, particularly in the early stages of an exponential trend, when not much is happening. But once the "knee of the curve" is achieved and the exponential growth explodes, the linear models break down.

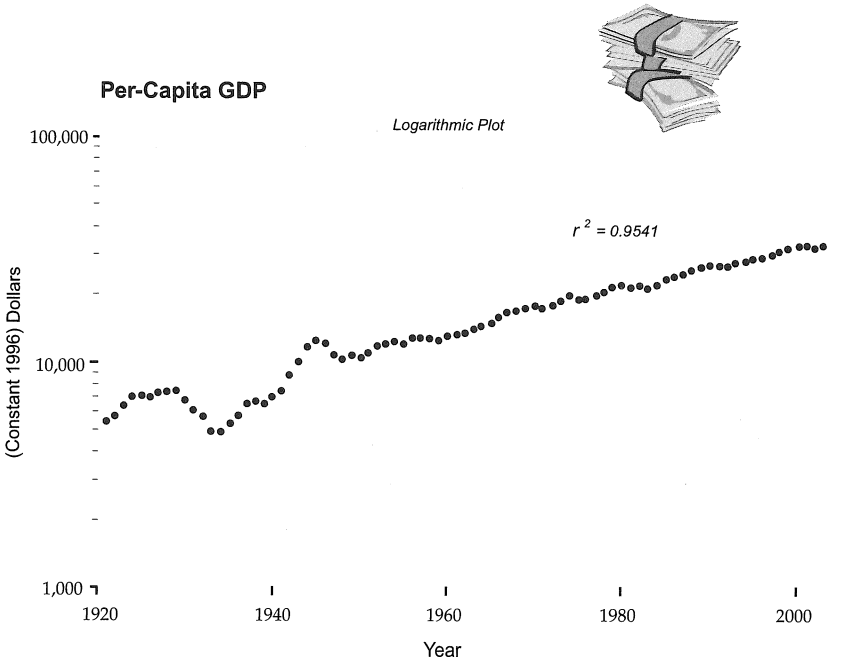
As this book is being written, the country is debating changing the Social Security program based on projections that go out to 2042, approximately the time frame I've estimated for the Singularity (see the next chapter). This economic policy review is unusual in the very long time frames involved. The pre-

dictions are based on linear models of longevity increases and economic growth that are highly unrealistic. On the one hand, longevity increases will vastly outstrip the government's modest expectations. On the other hand, people won't be seeking to retire at sixty-five when they have the bodies and brains of thirty-year-olds. Most important, the economic growth from the "GNR" technologies (see chapter 5) will greatly outstrip the 1.7 percent per year estimates being used (which understate by half even our experience over the past fifteen years).

The exponential trends underlying productivity growth are just beginning this explosive phase. The U.S. real gross domestic product has grown exponentially, fostered by improving productivity from technology, as seen in the figure below.[81]



Some critics credit population growth with the exponential growth in GDP, but we see the same trend on a per-capita basis (see the figure below).[82]



Note that the underlying exponential growth in the economy is a far more powerful force than periodic recessions. Most important, recessions, including depressions, represent only temporary deviations from the underlying curve. Even the Great Depression represents only a minor blip in the context of the underlying pattern of growth. In each case, the economy ends up exactly where it would have been had the recession/depression never occurred.

The world economy is continuing to accelerate. The World Bank released a report in late 2004 indicating that the past year had been more prosperous than any year in history with worldwide economic growth of 4 percent.[83] Moreover, the highest rates were in the developing countries: more than 6 percent. Even omitting China and India, the rate was over 5 percent. In the East Asian and Pacific region, the number of people living in extreme poverty went from 470 million in 1990 to 270 million in 2001, and is projected by the World Bank to be under 20 million by 2015. Other regions are showing similar, although somewhat less dramatic, economic growth.

Productivity (economic output per worker) has also been growing exponentially. These statistics are in fact greatly understated because they do not

fully reflect significant improvements in the quality and features of products and services. It is not the case that "a car is a car"; there have been major upgrades in safety, reliability, and features. Certainly, one thousand dollars of computation today is far more powerful than one thousand dollars of computation ten years ago (by a factor of more than one thousand). There are many other such examples. Pharmaceutical drugs are increasingly effective because they are now being designed to precisely carry out modifications to the exact metabolic pathways underlying disease and aging processes with minimal side effects (note that the vast majority of drugs on the market today still reflect the old paradigm; see chapter 5). Products ordered in five minutes on the Web and delivered to your door are worth more than products that you have to fetch yourself. Clothes custom-manufactured for your unique body are worth more than clothes you happen to find on a store rack. These sorts of improvements are taking place in most product categories, and none of them is reflected in the productivity statistics.

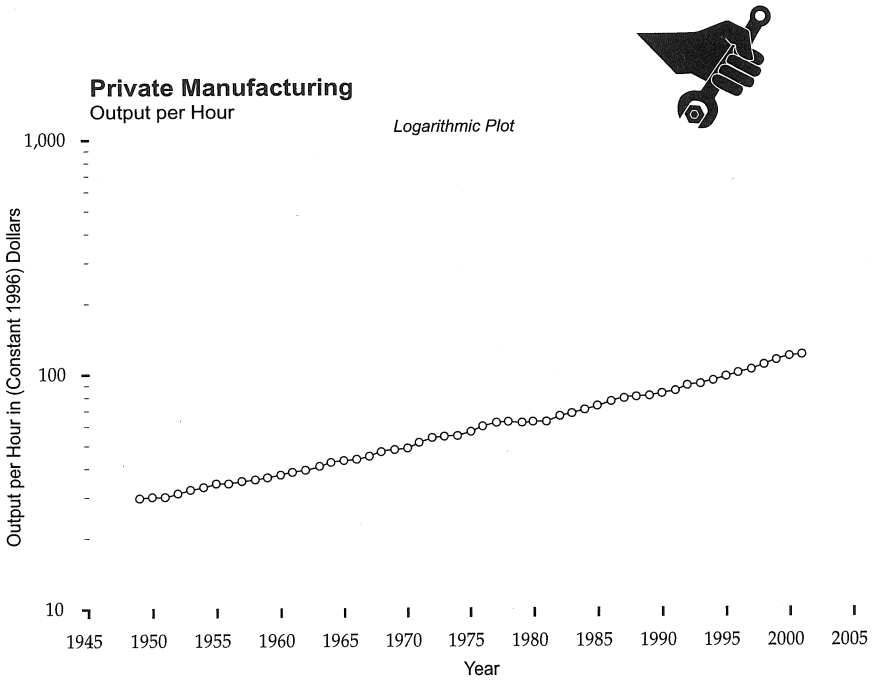
The statistical methods underlying productivity measurements tend to factor out gains by essentially concluding that we still get only one dollar of products and services for a dollar, despite the fact that we get much more for that dollar. (Computers are an extreme example of this phenomenon, but it is pervasive.) University of Chicago professor Pete Klenow and University of Rochester professor Mark Bils estimate that the value in constant dollars of existing goods has been increasing at 1.5 percent per year for the past twenty years because of qualitative improvements.[84] This still does not account for the introduction of entirely new products and product categories (for example, cell phones, pagers, pocket computers, downloaded songs, and software programs). It does not consider the burgeoning value of the Web itself. How do we value the availability of free resources such as online encyclopedias and search engines that increasingly provide effective gateways to human knowledge?

The Bureau of Labor Statistics, which is responsible for the inflation statistics, uses a model that incorporates an estimate of quality growth of only 0.5 percent per year.[85] If we use Klenow and Bils's conservative estimate, this reflects a systematic underestimate of quality improvement and a resulting overestimate of inflation by at least 1 percent per year. And that still does not account for new product categories.

Despite these weaknesses in the productivity statistical methods, gains in productivity are now actually reaching the steep part of the exponential curve. Labor productivity grew at 1.6 percent per year until 1994, then rose at 2.4 percent per year, and is now growing even more rapidly. Manufacturing productivity in output per hour grew at 4.4 percent annually from 1995 to 1999,

durables manufacturing at 6.5 percent per year. In the first quarter of 2004, the seasonally adjusted annual rate of productivity change was 4.6 percent in the business sector and 5.9 percent in durable goods manufacturing.[86]

We see smooth exponential growth in the value produced by an hour of labor over the last half century (see the figure below). Again, this trend does not take into account the vastly greater value of a dollar's power in purchasing information technologies (which has been doubling about once a year in overall price-performance).[87]



Deflation . . . a Bad Thing?

> In 1846 we believe there was not a single garment in our country sewed by machinery; in that year the first American patent of a sewing machine was issued. At the present moment thousands are wearing clothes which have been stitched by iron fingers, with a delicacy rivaling that of a Cashmere maiden.
>
> —*SCIENTIFIC AMERICAN*, 1853

As this book is being written, a worry of many mainstream economists on both the political right and the left is deflation. On the face of it, having your money

go further would appear to be a good thing. The economists' concern is that if consumers can buy what they need and want with fewer dollars, the economy will shrink (as measured in dollars). This ignores, however, the inherently insatiable needs and desires of human consumers. The revenues of the semiconductor industry, which "suffers" 40 to 50 percent deflation per year, have nonetheless grown by 17 percent each year over the past half century.[88] Since the economy is in fact expanding, this theoretical implication of deflation should not cause concern.

The 1990s and early 2000s have seen the most powerful deflationary forces in history, which explains why we are not seeing significant rates of inflation. Yes, it's true that historically low unemployment, high asset values, economic growth, and other such factors are inflationary, but these factors are offset by the exponential trends in the price-performance of all information-based technologies: computation, memory, communications, biotechnology, miniaturization, and even the overall rate of technical progress. These technologies deeply affect all industries. We are also undergoing massive disintermediation in the channels of distribution through the Web and other new communication technologies, as well as escalating efficiencies in operations and administration.

Since the information industry is becoming increasingly influential in all sectors of the economy, we are seeing the increasing impact of the IT industry's extraordinary deflation rates. Deflation during the Great Depression in the 1930s was due to a collapse of consumer confidence and a collapse of the money supply. Today's deflation is a completely different phenomenon, caused by rapidly increasing productivity and the increasing pervasiveness of information in all its forms.

All of the technology trend charts in this chapter represent massive deflation. There are many examples of the impact of these escalating efficiencies. BP Amoco's cost for finding oil in 2000 was less than one dollar per barrel, down from nearly ten dollars in 1991. Processing an Internet transaction costs a bank one penny, compared to more than one dollar using a teller.

It is important to point out that a key implication of nanotechnology is that it will bring the economics of software to hardware—that is, to physical products. Software prices are deflating even more quickly than those of hardware (see the figure below).

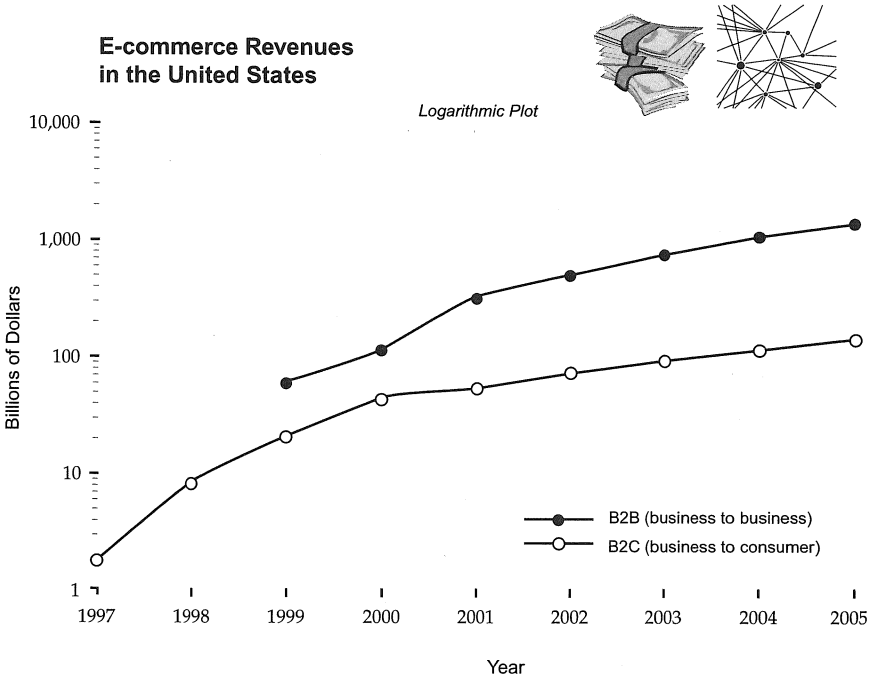
Exponential Software Price-Performance Improvement[89]

Example: Automatic Speech-Recognition Software

	1985	1995	2000
Price	$5,000	$500	$50
Vocabulary Size (number of words)	1,000	10,000	100,000
Continuous Speech?	No	No	Yes
User Training Required (minutes)	180	60	5
Accuracy	Poor	Fair	Good

The impact of distributed and intelligent communications has been felt perhaps most intensely in the world of business. Despite dramatic mood swings on Wall Street, the extraordinary values ascribed to so-called e-companies during the 1990s boom era reflected a valid perception: the business models that have sustained businesses for decades are in the early phases of a radical transformation. New models based on direct personalized communication with the customer will transform every industry, resulting in massive disintermediation of the middle layers that have traditionally separated the customer from the ultimate source of products and services. There is, however, a pace to all revolutions, and the investments and stock market valuations in this area expanded way beyond the early phases of this economic S-curve.

The boom-and-bust cycle in these information technologies was strictly a capital-markets (stock-value) phenomenon. Neither boom nor bust is apparent in the actual business-to-consumer (B2C) and business-to-business (B2B) data (see the figure on the next page). Actual B2C revenues grew smoothly from $1.8 billion in 1997 to $70 billion in 2002. B2B had similarly smooth growth from $56 billion in 1999 to $482 billion in 2002.[90] In 2004 it is approaching $1 trillion. We certainly do not see any evidence of business cycles in the actual price-performance of the underlying technologies, as I discussed extensively above.



Expanding access to knowledge is also changing power relationships. Patients increasingly approach visits to their physician armed with a sophisticated understanding of their medical condition and their options. Consumers of virtually everything from toasters, cars, and homes to banking and insurance are now using automated software agents to quickly identify the right choices with the optimal features and prices. Web services such as eBay are rapidly connecting buyers and sellers in unprecedented ways.

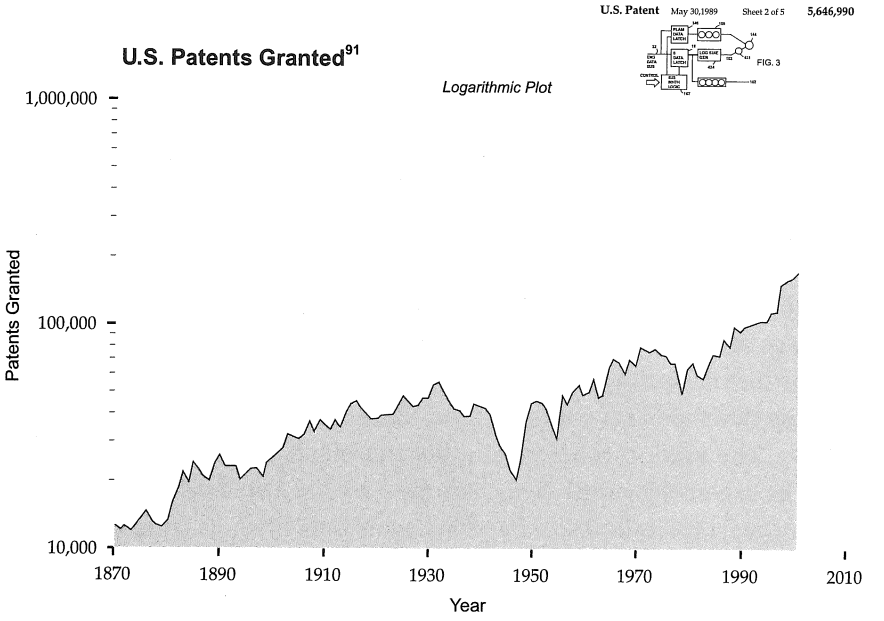
The wishes and desires of customers, often unknown even to themselves, are rapidly becoming the driving force in business relationships. Well-connected clothes shoppers, for example, are not going to be satisfied for much longer with settling for whatever items happen to be left hanging on the rack of their local store. Instead, they will select just the right materials and styles by viewing how many possible combinations look on a three-dimensional image of their own body (based on a detailed body scan), and then having the choices custom-manufactured.

The current disadvantages of Web-based commerce (for example, limitations in the ability to directly interact with products and the frequent frustrations of interacting with inflexible menus and forms instead of human personnel) will gradually dissolve as the trends move robustly in favor of the electronic world.

By the end of this decade, computers will disappear as distinct physical objects, with displays built in our eyeglasses, and electronics woven in our clothing, providing full-immersion visual virtual reality. Thus, "going to a Web site" will mean entering a virtual-reality environment—at least for the visual and auditory senses—where we can directly interact with products and people, both real and simulated. Although the simulated people will not be up to human standards—at least not by 2009—they will be quite satisfactory as sales agents, reservation clerks, and research assistants. Haptic (tactile) interfaces will enable us to touch products and people. It is difficult to identify any lasting advantage of the old brick-and-mortar world that will not ultimately be overcome by the rich interactive interfaces that are soon to come.

These developments will have significant implications for the real-estate industry. The need to congregate workers in offices will gradually diminish. From the experience of my own companies, we are already able to effectively organize geographically disparate teams, something that was far more difficult a decade ago. The full-immersion visual-auditory virtual-reality environments, which will be ubiquitous during the second decade of this century, will hasten the trend toward people living and working wherever they wish. Once we have full-immersion virtual-reality environments incorporating all of the senses, which will be feasible by the late 2020s, there will be no reason to utilize real offices. Real estate will become virtual.

As Sun Tzu pointed out, "knowledge is power," and another ramification of the law of accelerating returns is the exponential growth of human knowledge, including intellectual property.



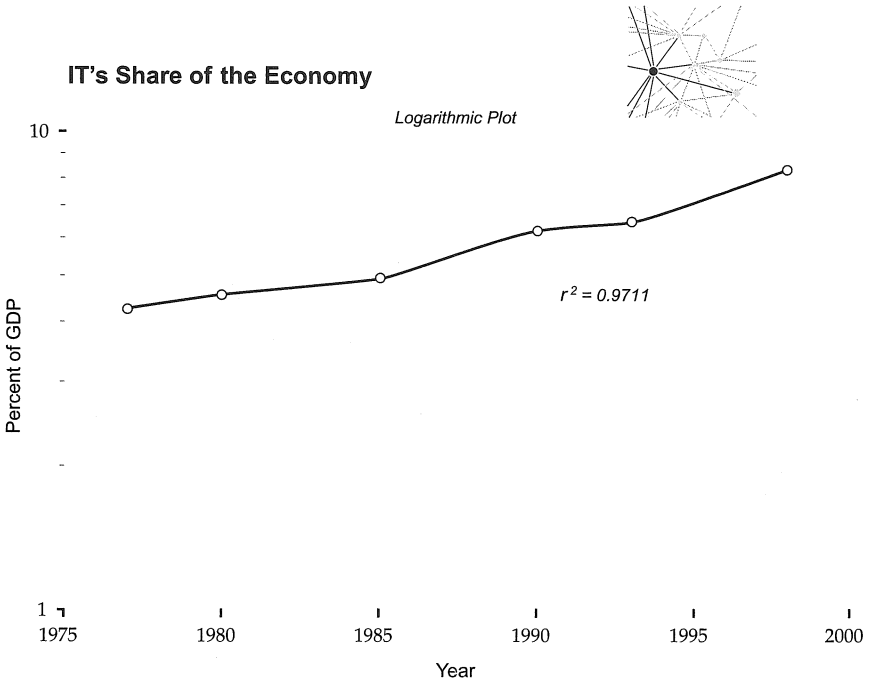
None of this means that cycles of recession will disappear immediately. Recently, the country experienced an economic slowdown and technology-sector recession and then a gradual recovery. The economy is still burdened with some of the underlying dynamics that historically have caused cycles of recession: excessive commitments such as overinvestment in capital-intensive projects and the overstocking of inventories. However, because the rapid dissemination of information, sophisticated forms of online procurement, and increasingly transparent markets in all industries have diminished the impact of this cycle, "recessions" are likely to have less direct impact on our standard of living. That appears to have been the case in the minirecession that we experienced in 1991–1993 and was even more evident in the most recent recession in the early 2000s. The underlying long-term growth rate will continue at an exponential rate.

Moreover, innovation and the rate of paradigm shift are not noticeably affected by the minor deviations caused by economic cycles. All of the technologies exhibiting exponential growth shown in the above charts are continuing without losing a beat through recent economic slowdowns. Market acceptance also shows no evidence of boom and bust.

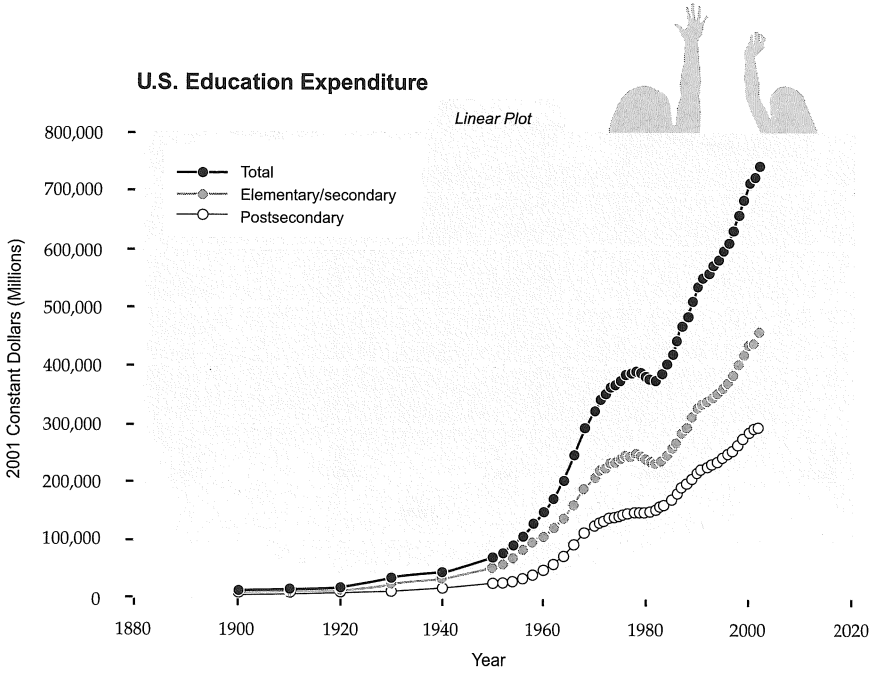
The overall growth of the economy reflects completely new forms and layers of wealth and value that did not previously exist, or at least that did not previously constitute a significant portion of the economy, such as new forms of

nanoparticle-based materials, genetic information, intellectual property, communication portals, Web sites, bandwidth, software, databases, and many other new technology-based categories.

The overall information-technology sector is rapidly increasing its share of the economy and is increasingly influential on all other sectors, as noted in the figure below.[92]



Another implication of the law of accelerating returns is exponential growth in education and learning. Over the past 120 years, we have increased our investment in K–12 education (per student and in constant dollars) by a factor of ten. There has been a hundredfold increase in the number of college students. Automation started by amplifying the power of our muscles and in recent times has been amplifying the power of our minds. So for the past two centuries, automation has been eliminating jobs at the bottom of the skill ladder while creating new (and better-paying) jobs at the top of the skill ladder. The ladder has been moving up, and thus we have been exponentially increasing investments in education at all levels (see the figure below).[93]



Oh, and about that "offer" at the beginning of this précis, consider that present stock values are based on future expectations. Given that the (literally) shortsighted linear intuitive view represents the ubiquitous outlook, the common wisdom in economic expectations is dramatically understated. Since stock prices reflect the consensus of a buyer-seller market, the prices reflect the underlying linear assumption that most people share regarding future economic growth. But the law of accelerating returns clearly implies that the growth rate will continue to grow exponentially, because the rate of progress will continue to accelerate.

Molly 2004: *But wait a second, you said that I would get eighty trillion dollars if I read and understood this section of the chapter.*

Ray: *That's right. According to my models, if we replace the linear outlook with the more appropriate exponential outlook, current stock prices should triple.*[94] *Since there's (conservatively) forty trillion dollars in the equity markets, that's eighty trillion in additional wealth.*

Molly 2004: *But you said I would get that money.*

Ray: *No, I said "you" would get the money, and that's why I suggested reading the sentence carefully. The English word "you" can be singular or plural. I meant it in the sense of "all of you."*

Molly 2004: *Hmm, that's annoying. You mean all of us as in the whole world? But not everyone will read this book.*

Ray: *Well, but everyone could. So if all of you read this book and understand it, then economic expectations would be based on the historical exponential model, and thus stock values would increase.*

Molly 2004: *You mean if everyone understands it and agrees with it. I mean the market is based on expectations, right?*

Ray: *Okay, I suppose I was assuming that.*

Molly 2004: *So is that what you expect to happen?*

Ray: *Well, actually, no. Putting on my futurist hat again, my prediction is that indeed these views on exponential growth will ultimately prevail but only over time, as more and more evidence of the exponential nature of technology and its impact on the economy becomes apparent. This will happen gradually over the next decade, which will represent a strong long-term updraft for the market.*

George 2048: *I don't know, Ray. You were right that the price-performance of information technology in all of its forms kept growing at an exponential rate, and with continued growth also in the exponent. And indeed, the economy kept growing exponentially, thereby more than overcoming a very high deflation rate. And it also turned out that the general public did catch on to all of these trends. But this realization didn't have the positive impact on the stock market that you're describing. The stock market did increase along with the economy, but the realization of a higher growth rate did little to increase stock prices.*

Ray: *Why do you suppose it turned out that way?*

George 2048: *Because you left one thing out of your equation. Although people realized that stock values would increase rapidly, that same realization also increased the discount rate (the rate at which we need to discount values in the future when considering their present value). Think about it. If we know*

that stocks are going to increase significantly in a future period, then we'd like to have the stocks now so that we can realize those future gains. So the perception of increased future equity values also increases the discount rate. And that cancels out the expectation of higher future values.

MOLLY 2104: *Uh, George, that was not quite right either. What you say makes logical sense, but the psychological reality is that the heightened perception of increased future values did have a greater positive impact on stock prices than increases in the discount rate had a negative effect. So the general acceptance of exponential growth in both the price-performance of technology and the rate of economic activity did provide an upward draft for the equities market, but not the tripling that you spoke about, Ray, due to the effect that George was describing.*

MOLLY 2004: *Okay, I'm sorry I asked. I think I'll just hold on to the few shares I've got and not worry about it.*

RAY: *What have you invested in?*

MOLLY 2004: *Let's see, there's this new natural language–based search-engine company that hopes to take on Google. And I've also invested in a fuel-cell company. Also, a company building sensors that can travel in the bloodstream.*

RAY: *Sounds like a pretty high-risk, high-tech portfolio.*

MOLLY 2004: *I wouldn't call it a portfolio. I'm just dabbling with the technologies you're talking about.*

RAY: *Okay, but keep in mind that while the trends predicted by the law of accelerating returns are remarkably smooth, that doesn't mean we can readily predict which competitors will prevail.*

MOLLY 2004: *Right, that's why I'm spreading my bets.*