Federal Reserve Bank of Dallas
1996 Annual Report

The Economy at Light Speed

Technology and Growth in the Information Age—And Beyond

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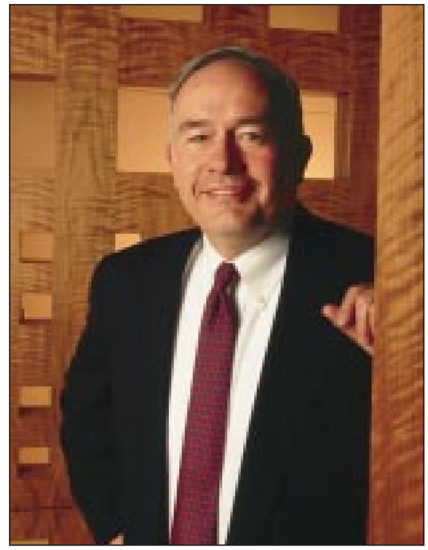


The Federal Reserve Bank of Dallas has projected optimism in our recent annual report essays—optimism that the creative destruction of jobs renews and reinvigorates our economy ("The Churn: The Paradox of Progress," 1992); optimism that our living standards are continuing to rise, as shown by the way we live our lives ("These Are the Good Old Days," 1993); optimism that our evolution toward a service economy is not a bad thing ("The Service Sector: Give It Some Respect," 1994); and optimism that our dynamic economy still offers plenty of opportunity for individuals to move up ("By Our Own Bootstraps," 1995). In short, we have chosen to see the glass half full rather than half empty. We have confidence in the power of our free enterprise economy to produce rising living standards.

This year, we may be going too far, projecting our optimism well into the future. As a former economist, I've learned that forecasting is not too hazardous, as long as it isn't about the future. I've also learned that optimists have a better track record than pessimists. Besides, by 2020, I'll be retired and so, probably, will the authors of this and the other essays cited above, Mike Cox and Richard Alm.

Their hook in this essay, and the reason you may want to take it more seriously than a science fiction comic book, is that their high-tech world of 2020 is based on applications and refinements of technology that exists today. Our rationale for exploring the possibilities here is to counter the pessimism generated by current growth and productivity statistics, which seem increasingly inadequate for our third-wave service and information economy.

1996 was a good year for the Federal Reserve Bank of Dallas. Our banking system remained sound, our regional economy continued to outpace the national average, and we fully recovered the cost of the services we provided to our customers. Productivity improved as we continued to provide more services with fewer employees. Our public programs and educational activities were well received by larger audiences. We expect more of the same in 1997.

At the end of 1996, Cece Smith completed three years as chairman of the Board of Directors of the Federal Reserve Bank of Dallas and turned the chairmanship over to Roger Hemminghaus, who had been serving as deputy chairman. During 1997, Cece will serve the last of her six years on the Board as deputy chairman. I appreciate the valuable contribution Cece has made as chairman. She's a great boss.

1996 also saw the retirement of Dallas Fed Director J. B. Cooper, after six years of service on the Board and after previously serving on our Advisory Council on Small Business and Agriculture. J. B. will always remain for me the prototypical gentleman Texas farmer. Peyton Yates left the Dallas Board in April 1996 and was replaced by Bob McNair, who had been serving on our Houston Board. We will miss J. B. and Peyton. We will also miss Erich Wendl, who retired from our San Antonio Board; Walter Johnson, who retired from our Houston Board; and Veronica Callaghan and Ben Haines, who retired from our El Paso Board. All have made valuable contributions.

Internally, the most significant management changes in 1996 were the retirement of Tony Salvaggio on April 1 after almost 40 years of distinguished service, and the appointment of Helen Holcomb as our new first vice president.

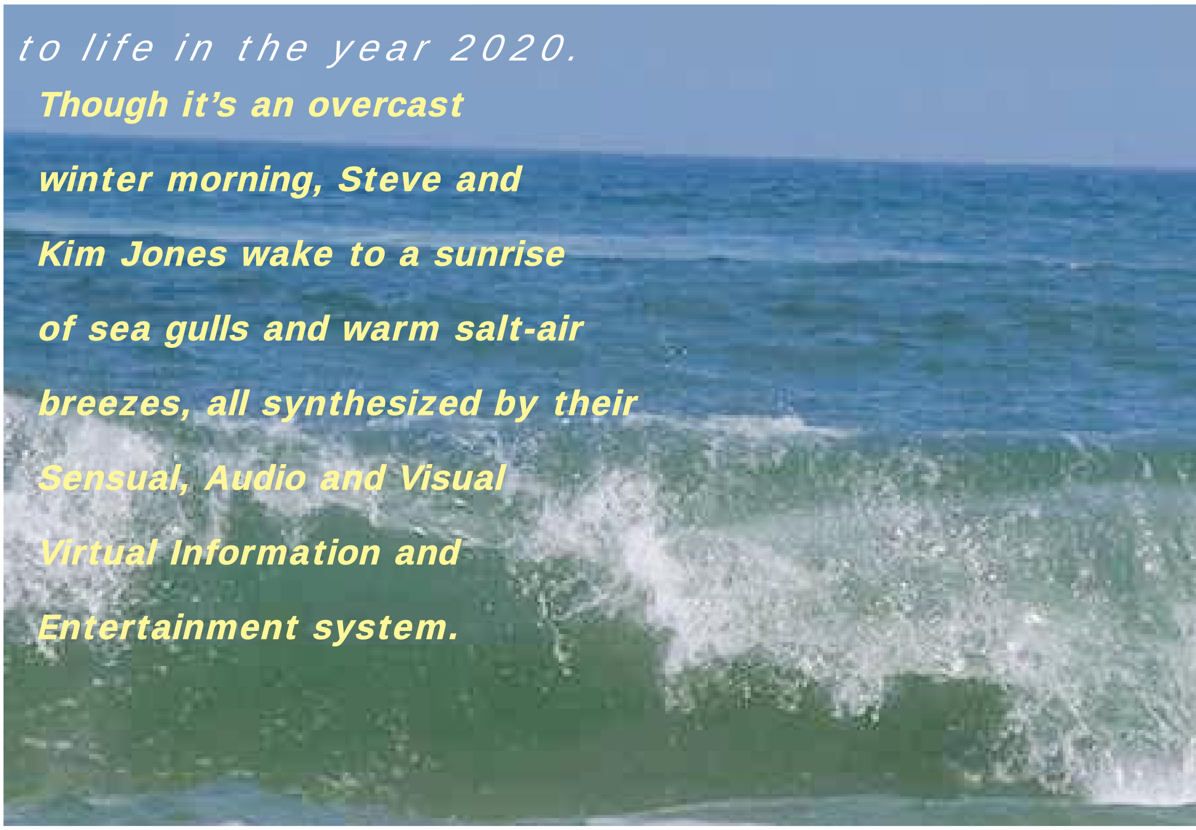
Innovation and change are inherent components of our free enterprise economy and, I believe, of our great strength. Therefore, our optimism continues both for our world and for our economy.

Bob McTeer

Robert D. McTeer, Jr.
President and Chief Executive Officer

The Economy at Light Speed

Technology and Growth in the Information Age—And Beyond



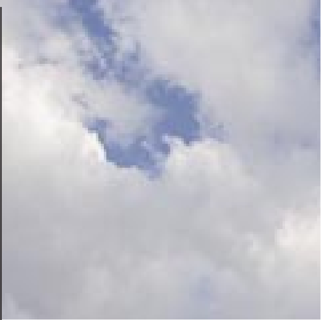
Fast-forward to life in the year 2020.

Though it's an overcast winter morning, Steve and Kim Jones wake to a sunrise of sea gulls and warm salt-air breezes, all synthesized by their Sensual, Audio and Visual Virtual Information and Entertainment system.

by W. MICHAEL COX and RICHARD ALM

IMAGE BANK

Imagination is more important than knowledge.
—Albert Einstein



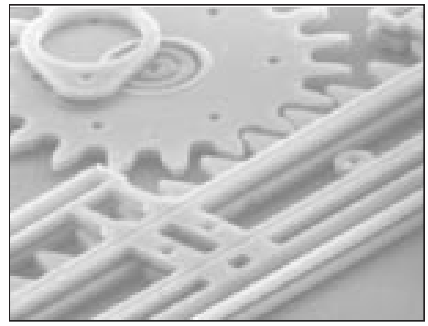
A fixture in most middle-class homes, SAVVIE regulates the indoor environment and operates 50-odd computer-controlled appliances, among them the Joneses' bed. All night it reads body shapes, weight, temperature and positions, adjusting to ensure the couple's complete comfort. The bed gathers data on each snoozer's heart rate, oxygen intake, bone density, neurological activities and other vital signs, all of it logged into a memory bank that compiles a daily health report.

After showering and dressing, Steve says, "Breakfast, Max." He's speaking to the family's intelligent agent, Maxwell, a book-sized computer that commands the SAVVIE appliances, maintains the home's environment and handles the family's shopping via the Internet. Max comes with its own personality. On hearing its name, Max activates the floor-to-ceiling video wall in any room and answers in the charming Scottish accent chosen by the Joneses, "Good morning, sir. What would you be having for breakfast today?"

Steve orders bacon and eggs without a twinge of guilt. In 2020, most foods have been genetically engineered to maintain taste and texture but provide optimal nutrition with less fat and cholesterol. As Steve and Kim eat, they ask Max for the morning newscast, personalized to reflect their interests. After a report on China's efforts to clean up the environment, Kim wants an update on the Chinese and American Mars colony. Steve requests an interview with Cowboys head coach Troy Aikman, preparing for Super Bowl LIV. Business news starts with the latest on around-the-clock stock trading, showing the Dow Jones industrial average surging past 31,000.[1]

Tiny robots scrub the dishes and run a whisper-quiet vacuum cleaner as Steve remarks to Kim, "TGIT"—Thank God it's Thursday. Like most Americans in 2020, Steve works from 9 a.m. to 4 p.m., Mondays through Thursdays. Steve has Max make reservations at the local sports cybercade, a virtual reality club that simulates hang-gliding, skiing and other outdoor adventures. Having fallen three times, Steve is resolved to complete his conquest of Mount McKinley. After reviewing Steve's daily health report, Max says, "Along with your usual vitamins, I'm recommending a wee extra bit of molybdenum to build stamina for tomorrow's climb."

Steve works for International Microtools Inc., a consortium that makes machines small enough to maneuver inside the human heart. He designs them on a three-dimensional computer screen, tailoring each tool to the customer's exact specifications. With a single keystroke, he sends his designs to factories, where durable-product generators fabricate the tiny machines from molec-

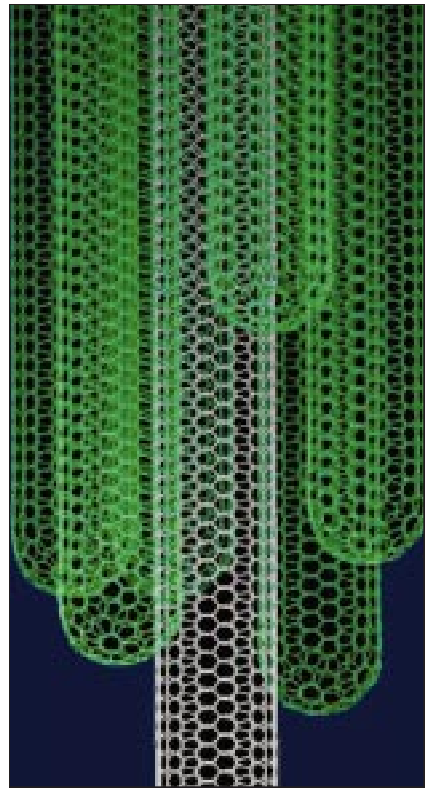


With gears the width of a human hair, this micromachine component includes a linear rack, rack guides, a drive gear and drive linkage to convert rotational motion into linear motion. Photo copyright Sandia National Laboratories.

ularly engineered composites that are stronger than steel, lighter than plastic and cheaper than either. Most days, Steve works from home or his vacation cabin, when necessary using his teleconferencing port to hold virtual meetings. Sensors follow Steve's eyes, changing the image on the video wall to match his slightest shift in focus. With a word to Max, Steve can consult with colleagues in Thailand and Argentina while working with a customer in Egypt. Language processors translate Steve's English into Thai, Spanish and Arabic.

After kissing Steve good-bye, Kim, a doctor, leaves for work in her nonpolluting vehicle powered by superconductive batteries that require recharging just once a month. There's no need for a key: the car identifies her by voice and smell. Kim speaks only a simple command, "Max, the office, please," and

1 This number is not pulled from thin air. The Dow ended 1996 at 6,448, and matching the long-term growth of 7 percent a year would put the index above 31,000 in 2020.



Nanotechnology researchers are growing carbon nanotubes from which they someday hope to build ultrathin metallic electrical conductors. By polymerizing carbon into a continuous, perfect graphene tube with metal atoms sealed inside, researchers make nanowires that have the potential to be as conductive as copper and 100 times stronger than steel. Photo copyright Rice University Center for Nanoscale Science and Technology.

the car responds. Steering, acceleration and braking are self-controlled, with continuous feedback from the Coordinated Travel Network linked to navigational satellites that pinpoint a car's position anywhere on the planet. Computers and sensors in cars and roadbeds prevent collisions. As she travels to the office without fear of accident or breakdown, Kim catches up on her work by accessing the American Medical Association's Internet site on the vehicle's video display.

The emphasis of medicine in 2020 is on preventing disease and managing the aging process. With new vaccines and treatments, cavities, baldness, arthritis, hearing loss and the common cold rarely afflict Kim's patients. She analyzes patients' DNA to assess the risk of illnesses before they occur. Where necessary, DNA therapy allows her to implant healthy genes for those producing Alzheimer's disease, multiple sclerosis and heart ailments. Kim prescribes drugs that have slowed aging and stopped cancers, and she can order cloned blood, skin, bones, organs and the latest biotech breakthrough.

The Jones children—Jane, a teenager, and Ben, age 10—attend neighborhood schools, where teleconferencing and virtual reality provide indelible learning experiences—the sights, sounds and feel of rocketing through Saturn's rings, a touch-of-a-button tour of the Louvre. After school, Jane designs a new outfit, using 3-D scanners to perfect the fit and laser-guided machines to sew it. Ben and his pals play baseball on a holographic field that offers the realism of the Texas Rangers' ballpark.

That evening, Steve and Kim meet the Mings and the Huxtables at the Eclectic Rouge, a restaurant that offers a choice of ambiance as well as entree. It's Kim's birthday, so she chooses a Parisian sidewalk cafe for appetizers and the main course, then fireside at a Colorado ski resort for coffee and dessert. After dinner, the three couples head to the Jones home, where satellite linkups and fiber optic cables deliver a world of entertainment—everything from Las Vegas shows to symphony concerts and action movies. Thanks to the latest holographic device, viewers can walk inside the film and even talk with the characters. After a final champagne toast, the Joneses' guests hop into their self-driving cars for a safe trip home, and Steve and Kim retire for the evening, bidding Max to put out the dog, lock up and turn off the lights.

This vision of 2020 may sound far-fetched—a pipe dream, worlds away from today. After all, the rapid progress implied by the Joneses' lifestyle runs counter to well-publicized reports of an American economy whose growth rate has slipped. Pessimists, citing statistics on weakening productivity and gross domestic product growth, contend that the economy isn't strong enough to keep hoisting Americans upward. They offer a dour view: the generation coming of age today will be the first in American history not to live better than its parents.

One simple fact, however, suggests that this view will be proven wrong—and spectacularly so: *nothing conjured up in this vision of 2020 requires any new technologies.* Every device in the Joneses' lives uses 1997 science and technology, honed by a competitive economy into the next generation of




With a little help from the Jason V Primary Interactive Network and live satellite broadcasts, schoolchildren in Massachusetts explore coral reefs off the coast of Belize by guiding underwater cameras mounted on a remotely operated vehicle. Research scientists answer students' questions, demonstrate on-site research techniques and even quiz students on their observations.

goods and services.[2] With a mother lode of technologies ready to shape the next quarter century, there's reason to believe that progress will be faster than ever—a stunning display of capitalism's ability to lift living standards.

Ironically, though, our economic statistics may miss the show. The usual measures of progress—output and productivity—lose touch in an age of rapid technological advances. As the economy evolves, it delivers not only more production but also new goods and services, improved products, greater variety, more time off, better working conditions, more enjoyable jobs and other benefits. All of these raise our living standards but by their nature aren't easily measured. Most aren't even counted in GDP.

What the next quarter century of capitalism likely promises, then, is a *silent boom*—a rapid economic advance that will improve everyday life but elude the regular readings of the economy's vital signs.[3] Statistical tools simply can't keep up with an economy moving at light speed.

2 Americans will doubtlessly enjoy the fruits of even further advances in technology over the next 25 years. To suppose otherwise would be to exhibit the shortsightedness of Charles H. Duell, commissioner, U.S. Office of Patents, who in 1899 said, "Everything that can be invented has been invented."

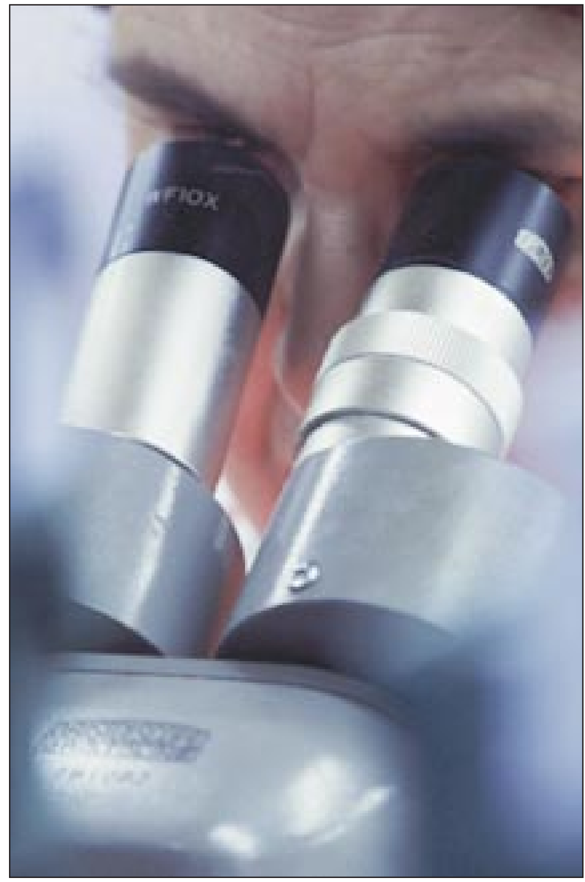
3 The discrepancy applies to the past quarter century as well as to the future. The Dallas Fed's 1993 annual report essay, "These Are the Good Old Days," presented overwhelming evidence that the average American has a lot more than ever before. Yet the national accounts report only slow growth over the previous two decades. In their article "1974," Greenwood and Yorukoglu (forthcoming) explain how the measured productivity slowdown over the past two decades may have been related to the rapid technological advances associated with the computer.

Technology and Capitalism— Partners in Progress

Few Americans would deny today's technology explosion. Even in this era of supercomputers, space travel and cloning, though, technology isn't always seen as a boon. Amid the modern world's hustle and bustle, nostalgia for the simpler ways of times past is not uncommon. Technophobes cringe at programming the VCR or installing new peripherals on the PC. Apocalyptic literature, science fiction movies and neo-Luddite rhetoric portray technology as a dark, dehumanizing force.

That is the technology of *myth*. The technology of *reality* is a vital part of what spurs economic progress and raises living standards. Stone Age "high-tech" was knowing how to strike flint on rock to produce a spark and ignite a fire. But even at that basic level, technology improved the lives of those who used it. They kept warmer at night, ate hot food and slept more soundly, worrying less about attacks by saber-toothed tigers and marauding tribes. Fast-forward through the millennia, and it's the same story. Today's technology is much more complex, but it still makes those who use it bet-

Blending electronics with biology, neuroscience researchers have achieved long-term functional viability of cells treated with ions and implanted these cells into study animals. In the not-too-distant future, researchers hope to use the technology to treat neurodegenerative diseases such as Parkinson's disease.



ter off. We are warmed by gas and electric furnaces, nourished by food heated in microwave ovens, and protected by locks, alarm systems and 911 operators. Technology leads to new products and services that improve our everyday lives. It must. After all, every innovation must pass the test of the marketplace: if people don't want it, they won't buy it.[4]

But technological know-how doesn't just happen. Ideas are sterile until an entrepreneur or a company transforms them into new goods and services or better production methods. The process involves discerning consumer tastes, researching, designing prototypes, obtaining financing, manufacturing, marketing and, often, starting all over again. Blood, sweat and tears. Why go through it?

Profit. Capitalism gives incentives to innovate by bestowing profit on those who bring successful products to market. Just as important, it readily shifts money, people and other resources from producing yesterday's goods and services to what consumers will buy today and tomorrow. Capitalism's ability to unleash innovation and invention lies at the very heart of the great legacy of the American experience—*economic progress.*

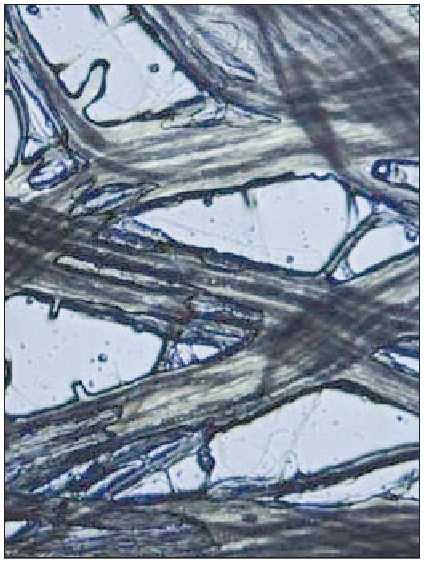
Successive generations of transportation show how new products come along to compete with existing ones. Suppose bankers in New York and San Francisco want to enter into a merger. In California's gold rush era, meeting might have meant a boat trip around the tip of South America. As time went by, the bankers would have found the train faster, then the airplane faster still. With the advent of teleconferencing, they can now convene in a matter of seconds, skipping the hassle and expense of transcontinental flight. Sometime beyond 2020, virtual meetings and all modes of shipping may be made obsolete by a *Star Trek*-like "transporter" that zaps people and products from one place to another.

In a free enterprise system, there's always competition from inventions and innovations that meet consumers' needs in a different way or make it cheaper and easier to manufacture existing products. Most of us overlook this "minor" feature of a market-based economy. When we catch a bargain on airfare, see our long-distance phone rates plummet, get a good deal on a car and so on, we welcome the low prices that result as today's companies compete for market share. But the *existence* of airplanes, telephones, automobiles and our other amenities we owe to another kind of rivalry that capitalism promotes. It's the competition from the next generation of goods and services, made possible by the relentless impulse in human beings to make themselves better off by improving life for everyone else.

By its very nature, capitalism seeks progress. Understanding this fact helps us see what speeds it up or slows it down.

Because technology in large part drives growth, stepping up the pace of invention and innovation increases the speed of economic progress. As with most economic activities, putting technology to work has a lot to do with incentives. An economy will produce technological change faster when the costs of doing so go down or the benefits go up. Several factors influence the speed of the process: the breadth and depth of a society's existing endowment of technology, the introduction of inventions with wide-ranging uses,

4 The list of patented inventions that didn't quite make it illustrates the point. There wasn't much of a market for the boomerang bullet, eyeglasses for chickens, coffins with escape hatches or fire escape suspenders.



the time it takes for products to spread throughout society, and overall market size. In assessing the possibilities of the future, it's more useful to look at these forces—the dynamics of how technology soaks into society—than statistics that say more about where we've been than where we're going. What's already in place offers to quicken economic progress.

Our inventory of technology is large and growing. Despite the rapid-fire introduction of new products in recent decades, we still have a large, relatively untapped stock of technology in the pipeline. The Joneses' lifestyle in 2020 suggests applications for dozens of modern-day breakthroughs. A "smart" bed, for example, could churn out a daily medical report using magnetic resonance imaging, a technology that helps doctors make medical diagnoses by showing the details of soft tissues the way X-rays reveal bones. The SAVVIE system, including faithful, tireless Max, might combine powerful microprocessors, artificial intelligence, voice recognition, speech synthesis, holography, virtual reality, fiber optics, high-definition TV, flat-screen displays and the Internet—all of which already exist, at least in prototype. Entrepreneurs could use the same technologies to produce the sports cybercade, Steve's virtual office, the Joneses' home entertainment amenities and the learning experiences offered by the schools Jane and Ben attend.

The National Automated Highway Systems Consortium, led by General Motors Corp., is at work on a self-driving automobile. The Global Positioning System already helps truckers, taxi drivers and farmers. Satellite-based navigational systems are an option on some 1997 car models. Scientists at New Mexico's Sandia National Laboratories already produce micromachines with gears the width of a human hair. The Human Genome Project to map the location and sequence of 100,000 genes, expected to be finished by 2003, should allow future doctors to detect and treat diseases through DNA analysis.[5]

And the Joneses' lifestyle only hints at what's to come from our laboratories, think tanks and entrepreneurs. The potential boggles the mind. Many of the most promising projects involve tinkering with the basic elements of life and matter. In molecular engineering, for example, scientists are creating whole new materials, forged atom by atom, with astounding properties. How about a fiber stronger than steel yet more elastic than a spider's web, or perhaps one-molecule-thick coatings, more slippery than glare ice, that virtually eliminate friction? Those technologies, and many more, are already being readied for use in new generations of products. Researchers are working within the cells of living organisms. Biotechnology may lead to treatments for diseases and the production of synthetic organs, but it is already making possible clothing that kills germs, bugs that gobble up toxic waste, enzymes that soften blue jeans and cholesterol-eating peanuts with a shelf life measured in years, not months. *(See Exhibit A in foldout: "25 Technologies for the Next 25 Years.")*

America enters the 21st century steeped in a culture of invention and surfing a tsunami of technology. By one estimate, more than half the store of human knowledge has been produced over the past 50 years. In the United States, the number of scientists and engineers working in research and development has doubled since the early 1970s. More than half of U.S. patents have been issued in the past 40 years. The number of new products put on the market annually has tripled since 1980, and with so much R & D occurring, companies are likely to keep offering innovative goods and services at a furious pace.

5 Even the Joneses' three-day weekends draw on recent experience. The average workweek fell from 36.9 hours in 1973 to 34.5 hours in 1990. An equal percentage decline over the next 25 years would yield a 31.4-hour workweek in 2020.

If you think self-driving cars and preprogrammed destinations are far-fetched, think again. Global Positioning System (GPS) technology can already track objects anywhere on Earth via computerized receivers and satellites in space. Right now, GPS technology is being used in some rental cars to provide security and to tell drivers the most efficient route to their destinations. Taxis and commercial fleets are being dispatched and managed using GPS.

Today's inventions are providing big spillovers. The parachute is a very useful product, especially when an airplane's engines conk out at 10,000 feet, but it hasn't had the same impact on the way we live as the internal combustion engine, the telephone or the jet airplane. Every so often, an invention comes along that really rocks the world, largely because it has far-reaching applications and serves as a building block for further invention. The wheel, the plow, the printing press and the steam engine are examples of technologies that generated significant spillovers. Had electricity not been harnessed for use more than a century ago, the modern household would have few of the conveniences we take for granted. No televisions. No refrigerators. No phones. Simply put, some inventions carry more weight than others. *(See Exhibit B in foldout: "Not All Inventions Are Created Equal.")*

In our time, it's the microprocessor—the tiny "brain" of the personal computer—that's producing spillovers and spawning waves of new and improved products. These little electronic marvels make hundreds of other modern creations possible—from fax machines and automatic tellers to air traffic control systems and the dinosaurs of *Jurassic Park*. The microprocessor is adding "smart" features to many everyday products. Today's cars, for example, have more computing power than the lunar landing module of the Apollo 11 mission that put Americans on the moon. And even more applications are just over the horizon, as time and imagination point us to new ways to use microprocessors. Meanwhile, the computer chip is getting even more powerful. At the start of the 1990s, the fastest chips could handle 94 million instructions per second. The next generation, due out this year, will ramp up to 1.6 billion.[6] We may look back on the microprocessor as an invention more pivotal than the printing press. *(See Exhibit C in foldout: "Technology Spillovers.")*

In 1801, J. M. Jacquard devised a binary control system on punched cards to program a loom to weave a preset pattern. Thomas Edison's light bulb gave people a reason for installing electric wiring in their

6 Predicting just how far microprocessor speed could go by 2020 would be about as silly as saying, "Where…the ENIAC is equipped with 18,000 vacuum tubes and weighs 30 tons, computers in the future may have only 1,000 vacuum tubes and weigh only 1½ tons"—*Popular Mechanics*, March 1949.

A computer at the Institute for Genomic Research in Gaithersburg, Maryland, connected to a DNA sequencer automatically produces an image of a section of DNA. Identifying the genetic code of humans at the rate of about 10,000 genes per month with the help of supercomputers, scientists expect that all the building blocks of life will soon be completely mapped. Other researchers are at work building a silicon computer chip with rows of DNA molecules and microelectronic circuitry that will analyze DNA 100 times faster than current methods. The implications for international human genetic research are phenomenal.

homes. Christopher Latham Sholes invented the typewriter in 1867 to produce legible letters more quickly. Ben Logee Baird produced the first working television in 1926. Ted Hoff of Intel Corp. invented the microprocessor in 1971 as the indispensable component of the hand-held calculator. None of these inventors envisioned the PC. Yet binary programming, electricity, the typewriter keyboard, the cathode-ray tube, the microprocessor and hundreds of other inventions were available for the West Coast hobbyists and entrepreneurs who contrived the first crude personal computers in the mid-1970s.

Today, the PC is part of our technology inventory, contributing to new waves of invention. It would be impossible, for example, to envision the Internet, one of today's wonder technologies, without the computer. The Internet and the computer, in turn, pave the way for the next wave of advances—search engines to explore the World Wide Web, high-speed modems, gadgets that access the Internet through the television set, the software to design home pages and intelligent agents that automatically sift through the oceans of information available in cyberspace. The Internet may be particularly powerful in driving technological change because it reduces the cost of new discoveries by putting the latest research online at the touch of a button.

And the ripple effects from the PC don't stop with computer-related industries. Computational biology, a branch of science that uses computers to locate and code genes, illustrates how the PC's increasing power puts technology and progress on an even faster track. Biologists are already identifying six to 10 new proteins a week, and with more powerful microprocessors, the process is likely to be three times faster by the end of this year.

Each invention makes the next one easier because of the way spillovers kindle a fire that feeds on itself—one technology fueling development of another. If there is any alchemy in free enterprise, this is it: technology spillovers.

New products are spreading faster. Although feasible in the late 1800s, electric power didn't become universal until the mid-20th century. The first automobiles arrived on American roads in the late 1800s, but the country still had more horses than cars into the 1920s. The technology for television came in the 1920s, but the invention didn't reach America's living rooms in large numbers until the early 1950s. These examples illustrate a fact of technological life: the time between invention and diffusion can be decades or more.

But as lightning-fast communications spread information faster and consumers grow more sophisticated, new products are emerging more quickly than in the past. It took 55 years to get the automobile to a quarter of the U.S. population. The telephone required 35 years; the television, 26. Now look at some recent innovations:

After vaporizing a sodium pellet with a laser and forming an atomic beam from the debris, researchers at Bell Labs use lasers to slow the atoms' movement and create a thick "soup" of light particles, which cool the atoms to a record 240 millionths of a degree below absolute zero. The final step in the process is to shoot a powerful beam through the area to trap the atoms.

a quarter of U.S. households owned a personal computer within 16 years of its introduction. For the cellular telephone, the time shrank to 13 years.[7] The Internet is coming into commercial use even faster than the PC or the cell phone. *(See Exhibit D in foldout: "The Newer, the Faster.")*

New products follow a pattern. At first, the latest innovations are expensive and perhaps tricky to use, so their market consists of a handful of wealthy gadget lovers. Over time, the products become cheaper and more consumer-friendly through mass production and improved design. What was once a luxury becomes an everyday necessity. The companies that make the products can then expand rapidly, chalking up sales and adding new jobs. Can there be anything better for society—new and better products for consumers, increased sales for companies, more jobs for workers and *more fuel for future progress?*

Markets are getting larger. Larger markets increase the incentive to introduce new technology. It's simply a matter of payoff. Had Alexander Graham Bell lived on a small island with a population of 10, he'd have had little to gain from inventing the telephone. Fortunately for Bell—and 20th century denizens—he introduced his invention into a time with millions of potential customers, spread out on a continental scale.[8] In the 1990s, of course, many new products enter a market of hundreds of millions of customers.

Population is only one way markets grow. Rising incomes add to the number of people who can afford to splurge on the latest bells and whistles. Falling transportation costs and quickening information flows can enlarge markets. The dismantling of trade barriers can open whole new markets to U.S. producers. For many products yet to come, the market will be global, so the rewards for successful innovation figure to be even greater.

7 Even the microwave oven and VCR illustrate the speedup in diffusion with the introduction of the microchip. The VCR was invented in 1952 and the microwave in 1953. When the microchip was introduced in 1971, less than 1 percent of households had either. Riding the cost-cutting wave of the microchip, however, a quarter of American homes enjoyed both by 1986—in just 15 years.

8 Said another way, Thomas R. Malthus had it exactly backward when he predicted that Earth's population would outstrip its resources, leading to ever-growing poverty. In a free enterprise system, growing population (market size) prompts more innovation, which stimulates the growth process. There is no guarantee of avoiding Malthus' dismal scenario in anything other than a market-based system.

However useful for many purposes, total output is a figment which would not exist at all, were there no statisticians to create it. —Joseph Schumpeter

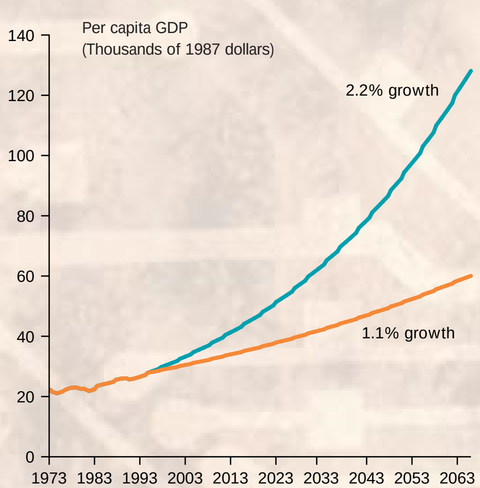
Strict logic is a stern master, and if one respected it, one would never construct or use any production index. —Arthur F. Burns

Estimates of Bias in the U.S. Consumer Price Index

AUTHOR(S)	POINT ESTIMATE
Advisory Comm. to Study the CPI (1996)	1.1
Michael Boskin (1995)	1.5
Congressional Budget Office (1994)	.5
Michael R. Darby (1995)	1.5
W. Erwin Diewert (1995)	1.5
Robert J. Gordon (1995)	1.7
Alan Greenspan (1995)	1.0
Zvi Griliches (1995)	1.0
Dale W. Jorgenson (1995)	1.0
Jim Klumpner (1996)	.4
Lebow, Roberts and Stockton (1994)	1.0
Ariel Pakes (1995)	.8
Shapiro and Wilcox (1996)	1.0
Wynne and Sigalla (1994)	1.0
Equally weighted average	1.1

SOURCE: Moulton (1996).

Bias in CPI Inflation



What a Difference 1.1% Can Make

Exhibit 1

Don't Count On It

GDP statisticians just "can't get no respect." As if their job isn't hard already—figuring out how to tally into one grand number all those apples, oranges and everything else we buy— new measurement problems arrive every day as markets give us more for our money.

Improvements in product quality and new goods create measurement problems that are commonly acknowledged. But more difficulties stem from GDP's failure to value variety and customization. American consumers can enjoy the cuisine of more than 40 countries today, as compared with just a handful in the 1970s. We can choose from among twice as many automobile producers, which offer more makes and options than ever. Microbreweries have brought us an extended array of beers, with some outlets carrying nearly 400 kinds. We have more variety in soft drinks, tennis shoes, magazines, radio stations, martial arts classes, coffee, amusement parks, cereal, sport utility vehicles, toothbrushes and on and on. Variety and customization enrich our lives because they allow us to select characteristics we value highly, but to the statisticians every car is a white Chevrolet.

Then there are preventive goods and services. Antilock brakes and air bags help prevent collisions and injuries. Safety caps on pill bottles keep children from ingesting poison. Fat-absorbing proteins allow overweight people to avoid expensive diet programs. Statisticians can't measure goods unseen: the accident that doesn't happen. A vaccine might someday eliminate tooth decay. Instead of fixing cavities, dentists might build houses or design Web sites, with no effect on overall GDP. But, meanwhile, we would have the benefit of the holes that *aren't* in people's teeth. What aggregate statistic could show this gain?

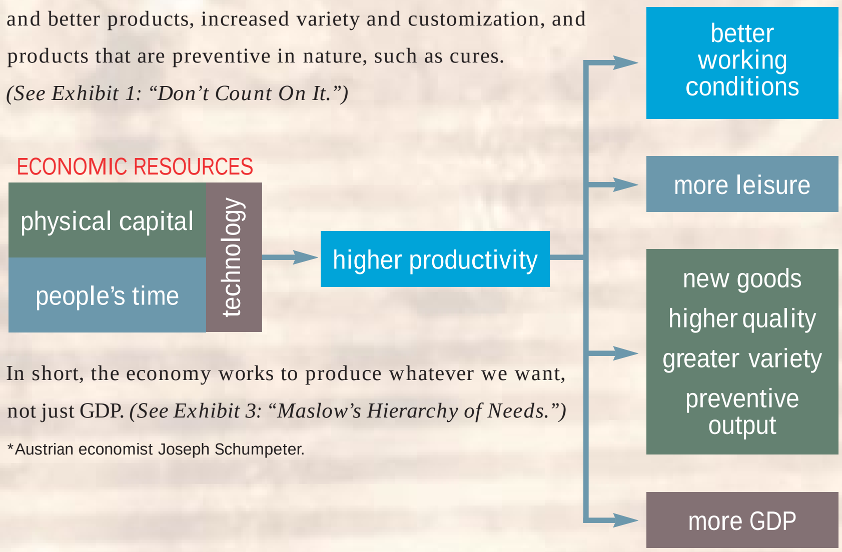
Statisticians are aware of the measurement quandary surrounding GDP and, in an effort to improve the statistics, are likely to reduce the gap between revisions of the inflation index from 11 years to four or five. Economists have recommended changes that would lower our estimates of CPI inflation by an average of 1.1 percent, thus crediting more real growth to the economy. That's a huge revision—indeed, a doubling of our estimated growth rate—considering the fact that GDP per capita grew at an average annual rate of just over 1 percent during the 1973–96 period. It means that per capita GDP could be one-third higher than we had thought possible by 2020 and double what we had expected by 2055.

But even with the changes, statisticians will miss a lot of what's going on.

Exhibit 2
Man Does Not Live by GDP Alone

Far more than any other measure, GDP is used to gauge America's economic progress. Fact is, though, we take our progress in ways other than GDP. "The reduction of working hours is one of the most significant 'products' of economic evolution."* Yet GDP gives the economy no credit for gains in leisure. Although measures of productivity—output per hour at work—credit time off, they generally miss leisure time taken at work. *(See Exhibit 4: "The Way We Work.")*

Both GDP and productivity statistics fail to capture other aspects of improvement in our lives, such as better working conditions. And they fall short of capturing the value of new and better products, increased variety and customization, and products that are preventive in nature, such as cures. *(See Exhibit 1: "Don't Count On It.")*



In short, the economy works to produce whatever we want, not just GDP. *(See Exhibit 3: "Maslow's Hierarchy of Needs.")*

*Austrian economist Joseph Schumpeter.

The Misunderstood Economy

Understanding how free enterprise stimulates progress gives us good reason for optimism about America's future. The system is working to perpetuate and even accelerate advances in our living standards. The irony is that the numbers don't agree. Progress is showing up everywhere but in the statistics.[9]

The problem, in part, lies in the tools we use. The national income and product accounts, developed in the 1940s, arrive at GDP by toting up the value of goods and services the economy produces. These accounts do a reasonably good job of measuring traditional output—tons of steel, bushels of wheat, cases of toothpaste, tables, chairs, haircuts. Add it all up, and you've got GDP.[10]

Much of what we get, however, isn't actually what we buy. We don't really want cars—we want transportation. We don't really want telephones—we want to communicate. We don't really want light bulbs—we want light.

The distinction isn't facetious. The everyday light bulb, for example, is a readily countable object that can be easily included in GDP: all we need to know is how many are sold and at what price. The light it produces, however, isn't so tangible. Yale University's William Nordhaus looked at the price of light and concluded it has fallen from 40 cents per 1,000 lumen hours in 1800 to a tenth of a cent today, a decline of 99 percent. Meanwhile, our measures of inflation show a 180 percent increase in the price of light bulbs and fixtures.[11] The result is an overstatement of inflation and an understatement of true growth.

Such measurement problems occur time and again whenever markets give us more for our money. Improvements in product quality, new goods, greater variety and customization, preventive goods—all can widen the gap between true and measured GDP. *(See Exhibit 1: "Don't Count On It.")*

The measurement problems are particularly acute when technology is moving rapidly. Take, for example, new goods. Today's VCRs provide better service than those that sold for $1,125 in 1981. But the VCR didn't make it into the consumer price index until 1987, after its price had fallen to under $300. The pocket calculator, invented in 1971, harnesses more computing power than a $750,000 room-sized mainframe

9 One notable exception is Wall Street, where a bull market has pushed the Dow up over 250 percent since the start of the decade.

10 To arrive at "real" growth, a common proxy for how well the economy's doing, statisticians adjust the GDP numbers to account for rising prices. If the numbers overstate inflation, growth will come out equally low, suggesting that the economy is weaker than it really is.

11 By progressing from less to more expensive lighting equipment—from candles to lamps to light bulbs—without accounting for the service each provides (lumens), the price of light is recorded as rising, even though it in fact has sharply declined.

Now more than ever, we depend on computers to complete our daily activities. In our service and information economy, computer applications will grow exponentially and improve our lives in ways we have yet to imagine and cannot easily measure.

of the 1950s but didn't show up in the consumer price statistics until 1978, after its price had fallen well below $100.[12] The personal computer was ignored by the statistics until 1987, when its cost to the average American had fallen from a lifetime of work to little more than two weeks' worth. When cellular telephones came on the market in 1984, consumers paid as much as $3,500 for the convenience of on-the-go communication. Now the phone often comes free, an inducement to sign with a cellular service provider.[13] Cell phones won't have a place in the price index until 1998, when at least 30 percent of Americans will own one. The result, in each of these cases, is an overestimation of inflation and an understatement of real growth and progress.

Statisticians wouldn't be stymied if these gains could be instantaneously tallied in the numbers that track the economy. It simply cannot be done. With rapid advances in technology, new and better products are coming at a dizzying rate. We buy cars that last longer and require less maintenance, manufacture stereos that reproduce truer sound, grow tomatoes that don't turn to mush when frozen, make clothes that fit better and require less care, improve mammograms to detect tumors at an early stage and pluck free information from cyberspace. In each case, we're getting more of what we want at the same or lower prices, befuddling the well-intended number crunchers.

Statisticians keep track of cost—that's all they have to count. The economy produces worth—that's what people want. These aren't always the same concept, and they diverge as technology enables the economy to deliver more worth at less cost. If medical science invented a 1-cent pill that cured all our ills, it would be worth a lot but cost virtually nothing. Sound ludicrous? Consider the Internet. In trying to find a way to charge customers for accessing Web sites, companies have decided our smallest unit of money—1 cent—is too much. A 1/10-cent unit is needed. On GDP's radar screen, the Internet is barely registering a blip.[14] Take a moment to contemplate the irony: just when the economy is most successful—when it produces the most worth for the least cost—the gap between true and measured GDP growth is the greatest. The economy can get the least credit when it's accomplishing the most. *(See Exhibit E in foldout: "The Language of Revolution.")*

But the problem is deeper—even more fundamental. Our economy is not simply mismeasured, it's misunderstood.

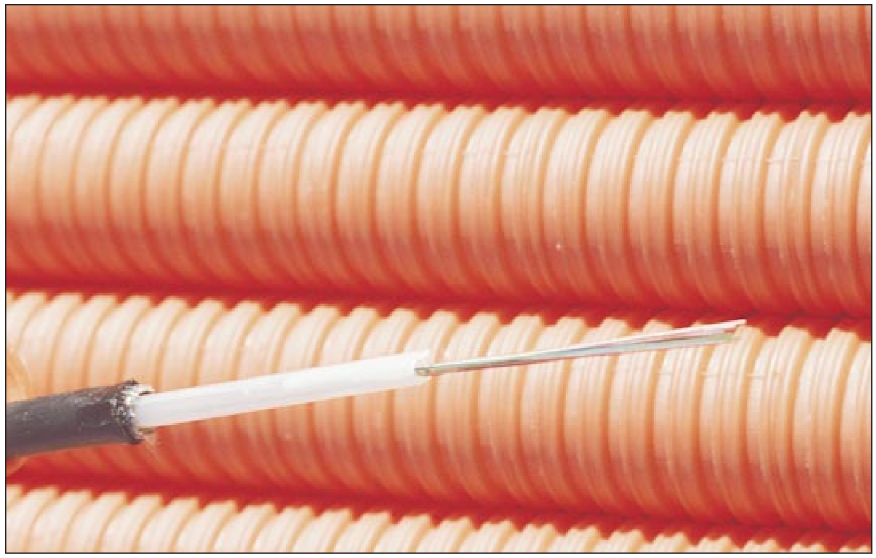
The economy has never *tried* to produce GDP: it tries to produce happiness, or satisfaction. And there's a lot more to life than GDP. *(See Exhibit 2: "Man Does Not Live by GDP Alone.")*

In the information age, our economy is providing benefits beyond those easily captured by GDP. When making a list of needs and wants, most people start with food, clothing and shelter. After that, they move on to safety and security and leisure time, then perhaps to some of the "fun" aspects of life, such as entertainment, travel and cul-

12 The first pocket calculators cost more than $600.

13 Competition has reduced the monthly cost of cellular service, too. The average local monthly bill went from nearly $100 in 1987 to under $50 by 1995.

14 U.S. researchers, say, can travel in seconds from Ukraine to the UK in cyberspace at virtually no cost, whereas alternative modes of travel would cost thousands of dollars.



Global communications have already been revolutionized by the fiber optic cable, which transmits pulses of light instead of electrical current. As researchers expand the technology, market forces will move new products and services into our daily lives with greater speed.

tural enrichment. Beyond that, most of us seek personal fulfillment, such as the satisfaction that comes from a worthwhile or enjoyable job. This list shouldn't surprise us. It reflects the influential work of Abraham Maslow (1908–70), the American psychologist. Maslow's pyramid, a staple of psychology, reveals a hierarchy of needs and wants buried deep in the human psyche. *(See Exhibit 3: "Maslow's Hierarchy of Needs.")* At the most basic level are the physiological needs. With those met, we move up to safety, social needs, self-esteem and, at the pinnacle of the pyramid, self-actualization.

As Americans grow wealthier, our physiological needs are being increasingly met, and there's a shift in wants from basic products to ever more intangible outputs. There are plenty of examples—from personal physical fitness gurus and Internet chat rooms to ecotourism and early retirement. One of the biggest yet most overlooked examples is improvement in our working conditions.

Americans today are less willing to bow to the deity of productivity and devote ourselves to churning out as much as possible. We've progressed from narrow productivity concerns to "have a nice day." What working conditions did Americans tolerate decades ago for the sake of productivity? Foul air, bad lighting, hazardous substances, long hours, inadequate sanitation, inflexible schedules, repetitive tasks, the risk of death. Few of today's workers face the on-the-job risks of their grandparents. Modern workplaces are well-lit and air-conditioned. Workplace deaths and accidents are at all-time lows. Hours at work have fallen for decades. Many workers have flexible schedules, including regular breaks. What are workers' concerns in the 1990s? Meaningful work, respect, empowerment, social activities, wellness programs and family benefits.

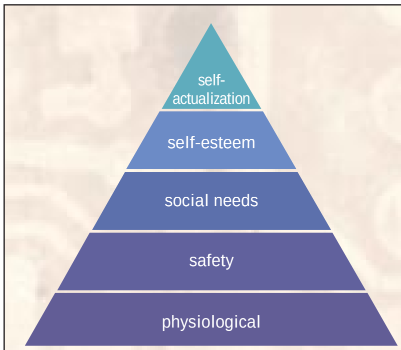


Exhibit 3
Maslow's Hierarchy of Needs

What's more, there's evidence that workers are using more of their on-the-job time for socializing, running errands, attending colleagues' retirement parties, going outside to smoke, selling their kids' Girl Scout cookies, exercising in company facilities—a little bit here, a little bit there. It all adds up: time-diary surveys find that the gap between actual weekly work time and what's reported in government statistics rose from one hour in 1965 to six hours today. But neither the GDP nor productivity statistics reflect job time spent on socialization, personal business or relaxation while at work.[15] *(See Exhibit 4: "The Way We Work.")*

And what about work that's fun? Most folks these days seek work they enjoy. Yet the standard statistics are apt to register economic regression if we

15 Productivity statistics capture the gains in leisure time away from work because they measure output per hour at work. But GDP makes no attempt to include the value of any leisure, whether on or off the job.

Exhibit *B*

Not All Inventions Are Created Equal

From chewing gum to electricity, all inventions are an effort to raise our living standards. A few make it, most don't, but some inventions are clearly more earthshaking than others. Perhaps the best way to judge an invention's significance is by its extent of spillovers—connections to other goods and services that it either makes possible or makes cheaper to produce. This box lists the top 10 inventions and discoveries of modern times—open, of course, to dispute. What shouldn't be overlooked, however, is that four of the top 10 are relatively recent—from the past 50 years.

TOP 10 INVENTIONS AND DISCOVERIES

1	Electricity	1873
2	Microprocessor	1971
3	Computer	1946
4	DNA	1953
5	Telephone	1876
6	Automobile	1886
7	Internet	1991
8	Television	1926
9	Refrigeration	1913
10	Airplane	1903

Exhibit *C*

Technology Spillovers

The microprocessor. First it helped with such minor tasks as addition. Now it's helping us decipher the code of the human genome.

Invented just 25 years ago, the microchip already has enabled the invention of thousands of smart consumer products. The answering machine, pocket calculator, caller ID device, camcorder, CD player, personal computer, digital camera, fax machine, microwave oven, organizer, pacemaker, pager, pocket translator, laser printer, remote control, radar detector, synthesizer and VCR are just a few. The chip resides unseen in most products, its functions vital though increasingly taken for granted. In cellular phones, microchips translate voices to electronic signals and back, reduce interference, and store and execute programmed functions. In automobiles, they control carburetion, timing, transmission, suspension, emissions, brakes, air bags, seat positions, navigational aids, engine diagnostics, keyless locks, instruments and more. The sample of the microchip's varied uses at the right helps tell the story.

But this is just the beginning. As the microchip gets smaller and faster, its applications are gaining momentum. More and more, it's not speed but our own imaginations that limit how and where chips can be used.

MICROPROCESSORS AT WORK

Navigate air traffic in our skies
Guide lasers used to cut metal, diamonds and corneas
Read zip codes and sort mail
Manage weather-tracking systems that span the globe
Create special effects in movies
Scan prices of goods in checkout lines
Keep inventories and records
Track packages at carrier superhubs
Route phone calls worldwide
Run copiers and fax machines in the workplace and home
Direct robots in automobile manufacturing plants
Reduce static and interference in cellular transmissions
Operate automatic teller machines
Pilot sewing machines in custom-fit blue jeans factories
Chart 3-D seismic surveys used in oil exploration
Locate a child in distress
Control temperature and time in microwave ovens
Design new drugs
Fly planes
Mix paint
Translate languages
Coordinate traffic lights
Settle transactions between customers
Monitor optical networks inside dams
Improve the functioning of our cars
Identify us by our fingerprints, iris, voice or scent
Teach parrots to talk
Connect people and information over the World Wide Web

Exhibit *A*

25 Technologies for the Next 25 Years

LASERS

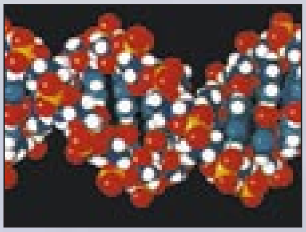
Light amplification by stimulated emission of radiation. Measure velocity and distance. Determine and record shape (cavity). Survey and map. Level. Assess space. Cruise timber (determine tree diameter and height). Clean surfaces. Cut metal, wood, diamonds or corneas. Weld. Drill. Carve objects. Inlay. Remove wrinkles in skin. Destroy tumors. Eradicate garbage. Reduce vascular prominence. Prototype images. Heat treat. Read bar codes, CDs. Measure vibration.

HOLOGRAPHY

The process of recording and displaying information in a three-dimensional lexicon. Replicate 3-D images. Improve ID cards. Secure authentication. Thwart counterfeiters. Record copious data.

VIRTUAL REALITY

The interactive computer-aided simulation of the world humans experience through their senses. Animate roller-coaster rides, hang-gliding. Tour museums, the White House. Walk through orchestras. Explore caves, oceans, other planets. Perform remote surgery, endoscopy, laparoscopy. Guide micromachines inside the human body remotely. Educate dynamically. Train pilots, drivers, surgeons, firefighters. Guide insects beneath earthquake rubble. Practice golf swing.



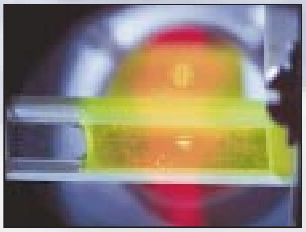
GENOMICS

The study of genes and their sequencing on the DNA structure of chromosomes in the nucleus of cells (the genome), as in the Human Genome Project, an effort to identify, sequence and map the entire human genome. Repair or reverse genetic defects, mutations. Create new vaccines. Improve diagnoses. Engineer cancer-killing proteins or DNA bullets. Trigger hormone production. Strengthen immunity. Cure baldness, pimples. Assess environmental cell damage (from radiation). Advance DNA fingerprinting. Speciate infectious organisms. Clone. Slow aging.

Photos: Rice University Center for Nanoscale Science and Technology

TELECOMMUNICATIONS

The technology of communications at a distance. Talk to anybody, anytime, anywhere.



OPTICS

The genesis and propagation of light and the effects that it undergoes and produces. Magnify and focus. Control visual aberrations. Transmit signals, voices, information. Probe endoscopically. Sense remotely. Illuminate. Coat materials. Detect displacement. Gain vibration immunity (as in telescopes). Control motion. Switch optically. Compute quickly. Stabilize satellites and spacecraft.

PHOTONICS

The generation, manipulation, transport, detection and use of light or energy whose quantum unit is the photon. Detect and destroy airborne pollutants, irritants, allergens, bacteria, radon. Detect and destroy missiles, meteors. Transmit signals. Network wirelessly. Perform fiber optic endoscopy (using lasers). Kill tumors using photosensitive drugs. Navigate vehicles. Electrify with photovoltaic cells (solar energy). Digitize artwork, cinema, multimedia video, teleconferencing. Recognize gestures. Create flat panel displays, LCDs. Measure features of surfaces at atomic scales.

COMPUTATIONAL BIOLOGY

Computer-aided biological discovery. Match bits of DNA to known gene sequences. Search for defective genes, mutation. Assist gene therapy. Discover new drugs.

ARTIFICIAL INTELLIGENCE

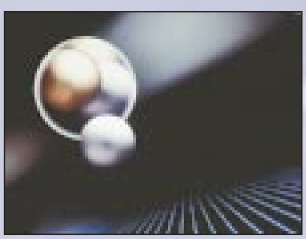
The computer modeling of human mental abilities, as in an intelligent agent—software that enables a computer to react to its environment, learn from experience and direct tasks useful to its specific owner. Manage investments, control smart appliances, monitor household operations, shop for cars—all on behalf of the principal customer. Track specific companies. Search, retrieve and filter information across the Internet—news, weather, sports, products, schools, companies of direct interest to the customer.

INTERNET

An interconnected network (web) of computers, each serving information to whoever is connected. Locate information on any subject, anytime. Send mail, shop, bank, invest. Buy tickets, make reservations, study menus. Visit friends, club members, coworkers. Peruse companies. Job hunt.

INTEGRATION TECHNOLOGY

Computer telephony integration (CTI), including, more broadly, cable, wireless and satellite systems, radio and television broadcasting, traffic control and appliances in an expanded Internet. See who you're talking to. Video conference. Control (block, identify, cull) incoming calls. Visit remotely with intelligent agents. Monitor asthma via modem. Shop, bank, order movies, vote. Control equipment, send digitized images from afar. Meet potential dates.

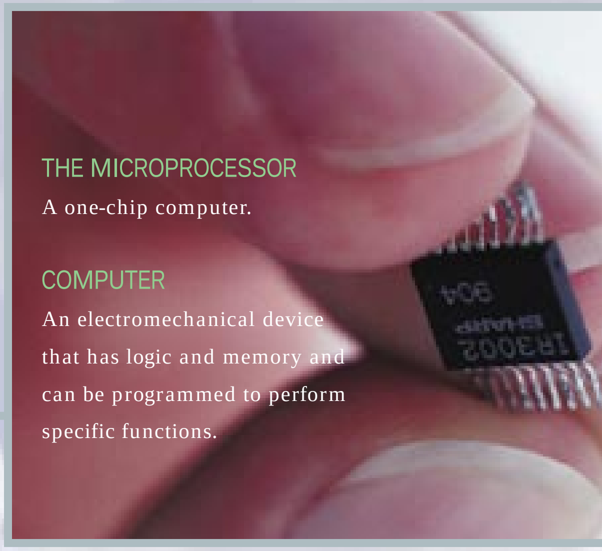


BIOTECHNOLOGY

Applied knowledge of the natural biological factors that affect life. Engineer foods to eliminate undesirable characteristics and add desirable ones. Engineer disease- and insect-resistant plants. Increase food production. Clean up waste and pollutants. Soften blue jeans. Manufacture disinfectants, fungicides, germicides, bactericides, biocides, herbicides and slimicides. Make biodegradable packaging, preservatives, rust and scale removers. Reduce oxidation. Reduce insect problems (fire ants, killer bees). Create new dermal tissue, cartilage, heart valves, blood, hair follicles. Grow human organs in animals. Engineer new drugs, vaccines and pharmaceuticals. Propagate vegetation. Create new life forms. Reverse environmental contamination.

SMART PRODUCTS

Products employing one or more microprocessors programmed to perform specific useful functions. Smart consumer goods: Refrigerators track household food inventory; beds and toilets monitor health; chairs adjust for comfort; cards facilitate exchange; locks facilitate keyless entry; skis bend and stiffen as needed. Smart machines: Cars travel without drivers, collisions; sewing machines tailor to recorded personal patterns. Smart materials: Parts warn of excessive stress, heat; clothing reacts to temperature.

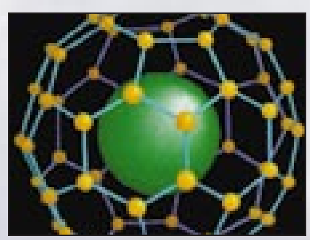


THE MICROPROCESSOR

A one-chip computer.

COMPUTER

An electromechanical device that has logic and memory and can be programmed to perform specific functions.



NANOTECHNOLOGY

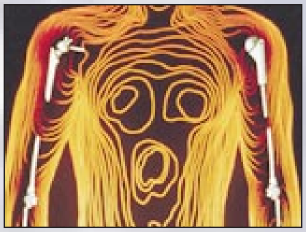
The precise and purposeful manipulation of matter at an atomic level (1 billionth of a meter). Otherwise known as molecular engineering. Make superconductors. Create flawless diamonds, more powerful and perfect lenses, biological sensors. Make thin films (organic, metallic, diamond). Manufacture perfect bearings, rotors. Achieve microscopic adhesion (paint, glue, DNA). Gain or reduce elasticity. Make tiny machines the size of microbes to break down toxic waste, kill pests, attack viral diseases.

RECOGNITION TECHNOLOGY

Identification of people or objects by their characteristic shape, sound or smell. Shape recognition: Recognize faces, features, irises, emotions. Identify objects. Guide robotic arms. Improve quality control. Detect defects, forgeries. Digitize form for patterns, templates. Sound recognition: Voiceprint and identify individuals. Gain keyless entry. Translate languages. Recognize material stress (such as worn brake pads). Smell recognition: Identify individuals. Detect fire, decay, pollution, gas leaks, drugs, bogus perfumes. Analyze breath for illness. Sniff wounds for bacteria, infection. Recognize and remove airborne odor, dust, pollen.

WIRELESS

The remote transmission of analog and digital signals via the wave spectrum. Facilitate satellite and cellular communications: cordless and cell phones, pagers, wireless cable (Direct TV), wristwatch phones, wireless digital modems, cordless appliances.



BIONICS

The merging of biological, electronic and mechanical systems. Develop implants to help the deaf hear, the blind see. Pump drugs to diabetics. Pace or defibrillate hearts. Restore neural sensation. Improve prostheses. Meld microchips and bugs, robots and animals.

MATERIALS SCIENCE

The study of how structural and electronic materials behave at all levels (from quantum to fracture mechanics) so as to improve their performance and devise new materials. Create light, strong, noise-absorbing composites for car and aircraft bodies, high-temperature alloys and ceramics for jet engines, biocompatible materials for surgical implants, fast (3-D) semiconductors, high-temperature ceramic superconductors. Manufacture materials by plasma spraying.

NOISE CANCELLATION TECHNOLOGY

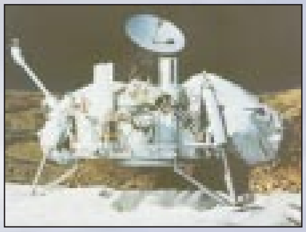
Computer-aided noise negation through the process of inverse wave generation. Reduce noise in airplanes, industrial machinery, household appliances (vacuum, lawn mower). Reduce vibration in engine gears, motors, machines. Reduce road noise. Eliminate static and disturbance in wireless voice and video transmissions. Reduce background noise in speech recognition. Treat tinnitus (persistent ringing in the ears).

MICROWAVE

The transmission, amplification and reception of a very short electromagnetic wave (0.25 to 100 centimeters in wavelength). Transmit voice, data, facsimile and video via satellite and wireless systems. Track weather via Doppler radar. Guide and land aircraft. Cook, heat, dry, clean, sanitize.

GPS

Global Positioning System. Orbiting satellites used to ascertain the exact position (latitudinal and longitudinal coordinates) of an object anywhere on the Earth's surface. Coordinate taxi pickup and delivery. Till soil, bulldoze ground inch by inch. Pinpoint cars, missing children, pets. Help the blind negotiate unfamiliar areas. Plan travel routes.



ROBOTICS

The use of mechanical and electronic equipment to perform the functions of humans. Weld, paint, handle materials, move packages and equipment. Assemble vehicles, computers. Fight fires. Decontaminate facilities. Navigate hazardous areas. Vacuum, clean floors, windows. Farm (field robots using GPS). Cut grass. Perform surgery. Explore the ocean. Mine, maintain aircraft.

MICROMACHINES

The manufacture, at the micron scale, of gears, hinges, motors, pumps and other mechanical structures. Often not visible to the human eye. Probe the body and clean arteries, locate tumors, measure the strength of a single heart muscle cell. Sense strain. Mine intelligently. Make smaller, faster microchips.

Exhibit *E*

The Language of Revolution

"If your PC has enough MIPS and your modem enough bits, then boot up, log on to your ISP and browse cyberspace for the Web site using your favorite meta-search engine. From the home page, download version 2.1 software, move your mouse to the main menu window and surf to the Net chat line. When your E-mail icon pops up, encrypt your response to avoid packet sniffers and Web heads or other hacker geeks trying to export viruses and crash your hard drive."

Huh?

One test of whether times are revolutionary is how fast language changes. And if we're not moving fast, where are we getting all these new words? Just look at how our vocabulary has grown in the past two decades to describe the computer and the Internet. Try finding these words, phrases or acronyms in a 1970 dictionary. If they exist at all, they'll have a totally different meaning.

You won't find *Internet* listed either.

Bit BOOT UP Browser BYTE Cache

CD-ROM Chat line CLIENT/SERVER CPU

CURSOR Cyberspace DISK DOS DOWNLOAD

Driver E-MAIL Encryption FLOPPY Geek

GIGABYTE GUI HACKER Hard drive HITS

Home page ICON IDE ISP LAN LAPTOP

Log on MEGAHERTZ MIPS MODEM

Monitor MOTHER BOARD Mouse ONLINE

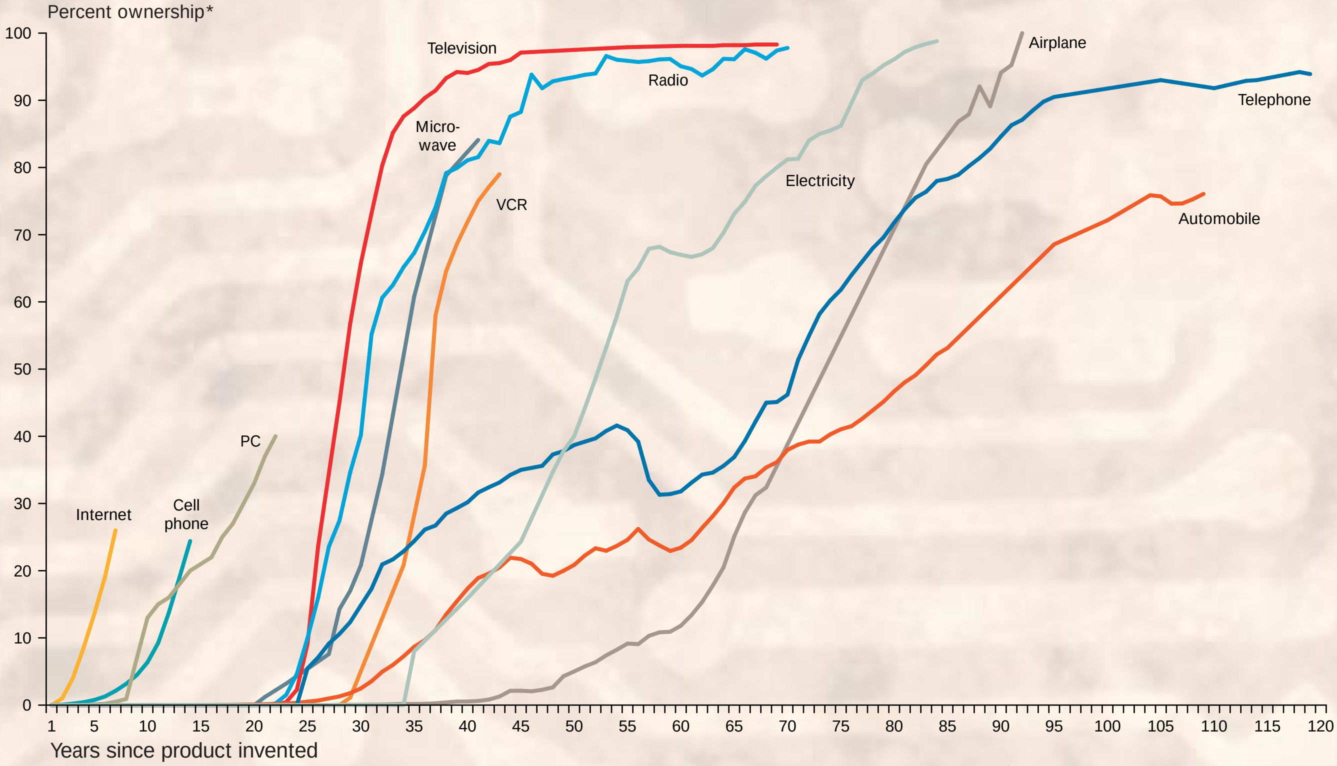
Packet sniffers PC Pixel RAM ROM

SEARCH ENGINE SOFTWARE Spam

Surf the Net URL Version 2.1 VIRUS

Web heads WEB SITE Window

THE SPREAD OF PRODUCTS INTO AMERICAN HOUSEHOLDS



Percent ownership refers to the fraction of households that enjoy each product, except for the airplane, automobile and cell phone. *Airplane* refers to the percentage of air miles traveled per capita relative to miles traveled in 1996; *automobile* refers to the number of motor vehicles relative to persons age 16 and older; *cell phone* refers to the number of cellular phones per registered passenger automobile.

SOURCES: U.S. Bureau of the Census (1970 and various years); Cellular Telecommunications Industry Association (1996); The World Almanac and Book of Facts (1997).

Exhibit *D*

The Newer, the Faster

As the economy evolves, it takes less and less time for new products to spread into the population. It took 46 years for a quarter of American homes to be wired for electricity. Getting phones to a fourth of America took 35 years; cars, 55. More recently, however, the PC required only 16 years, the cellular phone 13 and the Internet seven. Even the microwave oven and VCR illustrate the speedup in diffusion since the microchip's introduction in 1971. Though both products were invented in the early 1950s, as late as 1971 fewer than 1 percent of households had either. Riding the cost-cutting wave of the microchip, however, a quarter of American homes enjoyed both by 1986.

SPREAD OF PRODUCTS TO A QUARTER OF THE POPULATION

Product	Year invented ▼	Years to spread
Electricity	1873	46
Telephone	1876	35
Automobile	1886	55
Airplane	1903	64
Radio	1906	22
Television	1926	26
VCR	1952	34
Microwave oven	1953	30
PC	1975	16
Cellular phone	1983	13
Internet	1991	7

With 25 dishes, Goonhilly Earth Station complex in Cornwall, England, is the largest operational satellite station on the planet. The complex provides the next generation of vehicle tracking and monitoring through Global Positioning System technology. By making use of worldwide satellite coverage, the system can continually track objects (including the family car) anywhere on the planet.

quit a job we're good at but don't like in order to take one that's more enjoyable. It just doesn't make good sense.

We take our progress in ways other than GDP.

The economy today reflects our wealthier society's preferences for harder-to-measure consumption. As we grow richer still in the future, we can expect society to spend more of its time, energy and income addressing needs that are further and further from the physiological. Pity the poor statistician with the job of tracking our increasingly elusive economy.

By their very nature, the foibles of our statistics are hard to overcome. Critics of our national accounts can offer only an educated guess at the inaccuracies. Taken together, however, the glitches imply that the numbers that gauge our economy aren't giving us a fair reading of what's going on. Most important, the inaccuracies probably are worse than they were a decade or two ago, and they are likely to get even worse as we move into the 21st century and beyond. In short, our progress is becoming increasingly hard to capture with our measurement tools.

A Future of Fast Growth

The very notion of economic progress is an artifact of the modern, technology-rich era. Until the advent of capitalism in the 18th century, the world's living standards changed only slowly. The French farmer of the 17th century lived, worked and died pretty much like the Roman farmer of the 1st century B.C. The same cannot be said for our world: living standards rise from generation to generation. We are in the throes of one of history's great bursts of technology, put to use quickly and effectively by a vibrant market economy.

It would, of course, be good to have statistics that capture all the nuances of the economy as it evolves to meet our needs. That's probably too much to expect. Expense and complexity make a daunting task of tracking an American economy centered less and less on tangible output. Our measurement technology cannot keep pace with the rest of our technological progress. Relying on our existing measures, we're going to miss a lot of what happens in the economy as it moves into the 21st century.

We are fast departing a time when progress can be measured by GDP or any other simple tally of what the economy produces. If we become fixated on the numbers and fail to imagine the possibilities, we may miss one of the greatest periods of economic advancement in history. Worse yet, if we judge 21st century progress by 20th century measures, we may infer that our system is failing and in need of repair by government.

That is the bad news.

Free enterprise is America's greatest welfare program. For more than two centuries, the system has worked to make our lives better. Whatever we've wanted—new and improved products, more leisure, better jobs, easier lives—it has provided in abundance.

The pessimists fret that our best days are behind us. They are wrong. We stand poised on the brink of a new era, one endowed with technology and teeming with opportunities. The future offers even faster economic progress. We *can* keep up with the Joneses.

That is the good news.

Exhibit 4

The Way We Work

For most of us, work is a major part of life. And better working conditions have routinely been a product of progress, right along with more GDP. This is evident not just from the steady decline in worker death rates but also from a comparison of our work concerns today versus yesterday. In the early 1900s, our work worries centered on safety, fatigue, long hours, excessive heat, poor ventilation, high humidity, bad lighting, exposure, disease, lack of adequate toilet facilities and rigid schedules. Today, we seek interesting and fun jobs with meaningful work, nice offices, employee activities, flexible hours, empowerment, wellness classes, communication, employee counseling and the ability to telecommute.

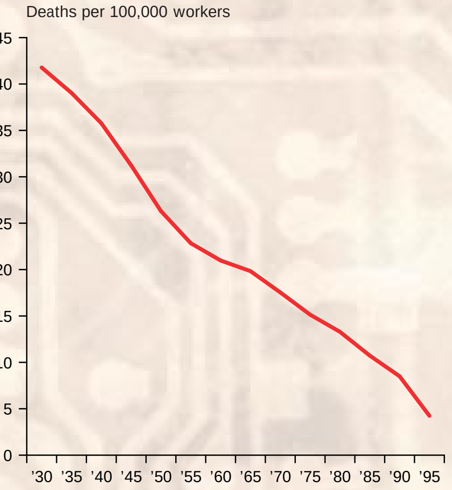
We also appear to demand more personal time at work. Time-diary surveys show that Americans today take up to six hours per week of leisure on the job, as compared with only one hour in 1965.

What are some of the ways employees use their recorded work hours other than to work?

Arrive late after dropping off the kids Leave early to pick up the kids Go to parent–teacher conferences Visit the doctor or dentist Talk on the phone to friends Chat with coworkers Go outside to smoke Give blood Play solitaire on the computer Browse the Internet for personal stuff Attend wellness classes Sell cookies for the kids Raise funds for charities Visit with friends via the Internet Call automated tellers Exercise (even in employers' facilities) Call talk radio programs or contests Read the paper, a book or a magazine Attend parties or showers Write personal correspondence Leave to run errands Make a grocery list Perform club duties Take long breaks Pay bills Nap

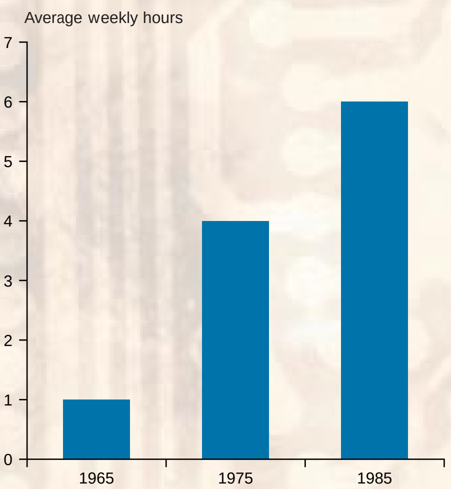
A little bit here, a little bit there, we're spending our day more the way we'd like.

The point is not that American workers are cheating their companies. On the contrary, it's all a part of progress. We're not automatons, enslaved to productivity as if we were still in the fields or on an assembly line. One way we take the gains of technological progress is to simply enjoy life in an economy that, more and more, transcends measurement.



Decline in the Worker Death Rate

SOURCE: National Safety Council (1996).



Time Spent Not Working at Work

SOURCE: Robinson and Bostrom (1994).

ACKNOWLEDGMENT

"The Economy at Light Speed: Technology and Growth in the Information Age–And Beyond" was written by W. Michael Cox and Richard Alm. The essay is based on research conducted by Cox, vice president and economic advisor, Federal Reserve Bank of Dallas.

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Nineteen Ninety-Six:

Throughout 1996, the Federal Reserve Bank of Dallas built upon its long-term goals of economic growth, stability and leadership for the Eleventh District. As part of its continuing emphasis on customer service, the Bank increased its customer base and volume in electronic check imaging services and implemented improvements to the processing of automated clearinghouse (ACH) and currency services. To better serve financial institutions in the Eleventh District, the Bank began implementing a risk-based approach to banking supervision and continued to be a leader in the development of automated tools to assist in the supervisory process. The Bank's public policy and education efforts focused on free market themes and international economics and finance, particularly with respect to Mexico and the rest of Latin America.

ECONOMIC OVERVIEW

The Eleventh District posted its 10th successive year of growth in 1996. The regional economy again outperformed the nation's, although growth occurred at a more modest pace than in recent years. The construction industry posted strong gains in the commercial arena, which offset a modest decline in residential construction. The banking sector continued to do well, with credit widely available throughout 1996. The oil and gas industry performed exceptionally well, helped by higher prices and technological improvements that increased productivity.

High-tech industries continued to rebound. Weak activity in semiconductors, however, held high-tech manufacturing growth to a rate of only 2.5 percent, down from 7.3 percent in 1995. A severe drought hurt the farming and ranching sectors. Although labor supply constraints kept economic growth in check, Texas' unemployment rate in October was its lowest in 15 years.

A strengthening Mexican economy helped generate increased export demand for the District. In the first half of 1996, one-third of all Texas exports went to Mexico. For the year, Texas exports to Mexico grew 34 percent.

FINANCIAL SERVICES

In 1996, the Dallas Fed continued to offer enhanced services for financial institutions in the Eleventh District. Particular emphasis was placed on expanding electronic payments and settlement options for financial institution customers in order to promote the development of a more efficient and effective payments system.

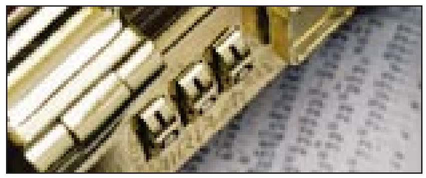
In currency and cash services, the Bank provided additional flexibility for warehousing currency for the Federal Reserve System and the Bureau of Engraving and Printing (BEP). The completion of vault expansion early in the year enabled the Dallas Fed to store 280 million notes for the BEP and ship 61 million notes to other Federal Reserve districts. In currency processing, the Dallas Fed expanded its automated control and perpetual inventory tracking systems to each of its three Branch offices. As Texas phased out paper food coupons in favor of an electronic debit card system, the Bank experienced a 92.9 percent decrease in the number of paper food coupons it received, credited and destroyed. The Dallas Fed consolidated commercial book-entry tenders with the San Francisco District to increase efficiency in the sale of Treasury bills, notes and bonds to financial institutions.

During the year, the Bank expanded the provision of check imaging services to its Houston and San Antonio Branch offices. Other electronic payments system improvements included

The Year in Review

software enhancement to allow electronic transmission of check images and electronic check adjustments, and the added capacity for customers to transmit deposit control documents electronically. The District's volume of automated clearinghouse transactions rose 23 percent in 1996, reflecting the continued success of the Dallas Fed's Alliance 98 partnership with automated clearinghouse associations. The volume of electronic transfers of funds also increased by 15 percent. Conventional paper check volume increased slightly more than 1 percent during the year, despite the growth of electronic services. Processing of ACH transactions was centralized into one national system in 1996, which helped reduce the Fed's automated support costs and lower the price of ACH services for customers.

Working to communicate information to the financial community, the Bank held focus groups throughout the District and check operations seminars in various cities. Presentations to financial institutions and the general business community stimulated use of ACH origination and direct payment services. The Dallas Fed also conducted workshops on the Treasury's new Electronic Funds Tax Payment System.



BANKING SUPERVISION AND DISCOUNT AND CREDIT

Aggregate financial data reported to the Dallas Fed showed that banks in the Eleventh District continued to thrive in 1996. Continued loan growth, combined with stable net interest margins, again produced a solid return on banking assets. Asset quality ratios remained favorable, and capital levels continued at historic highs.

Although consolidations and mergers reduced the number of banks in the District from 1,030 in 1995 to 986 in 1996, five new bank charters were granted. The trend of converting banks to branch offices continued, with the number of branches increasing from 3,008 to 3,184. The Dallas Fed processed 284 applications—compared with 255 in 1995—for mergers and acquisitions, changes in control and management, and other actions requiring regulatory approval.

Reflecting the solid condition of the industry and statutory changes lengthening the time between examinations, the Dallas Fed conducted 308 examinations, 59 fewer than in 1995. Of the 308 examinations, 42 were reviews for compliance with consumer and civil rights laws. As the supervisor of state member banks, bank holding companies and foreign agencies in the District, the Dallas Fed conducts examinations for safety and soundness and for compliance with consumer protection laws and the Community Reinvestment Act (CRA). To reduce the burden associated with supervisory activities and to better serve our stakeholders, the Dallas Fed began implementing a risk-focused approach to bank supervision. This approach should make the supervisory process more efficient and less intrusive, as more time is devoted to planning and preparing for an examination to tailor it to the risk profile of individual institutions. Making greater use of available technology will be a key factor in achieving this supervisory objective. In that regard, the Dallas Fed is the development site for the National Examination Database and has been named the Federal Reserve Bank responsible for coordinating software development for use in the supervisory process.

The Dallas Fed's discount window made 263 loans in 1996, primarily through its seasonal lending program. Total credit extended decreased from $791 million in 1995 to $643 million in 1996, in part because of the highly liquid position of many District institutions.

The 48 state-chartered banks under the Dallas Fed's supervision in 1996 represented 4.9 percent of all insured commercial banks in the District and held about 2.8 percent of insured commercial bank assets. The 505 bank holding companies under Dallas Fed supervision last year controlled 599 insured commercial banks that held about 31 percent of all insured commercial bank assets in the District. About 56 percent of the District's commercial bank assets were controlled by holding companies headquartered in other districts; the remainder were controlled by independent banks in the District. Thirty-four foreign banks from 12 countries operated 16 state-licensed agencies and 27 representative offices.

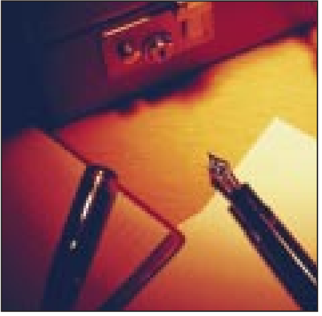
RESEARCH AND PUBLIC AFFAIRS

The Bank's research and public outreach efforts promoted free enterprise and explored the intricacies of America's economic partnership with Mexico and other Latin American countries in 1996. The Bank's Center for Latin American Economics cosponsored the international conference "Policy Rules and Tequila Lessons" with the Universidad Torcuato Di Tella in Buenos Aires. The conference focused on the ripple effect of the Mexican peso crisis and the sustainability of fixed exchange rate systems, and featured former Argentine Minister of the Economy Domingo Cavallo. Among the Bank's major research themes for 1996 were the impact of the peso devaluation on the region and the effects of electronic technology on the U.S. money supply. The Bank also presented two art exhibits, featuring works by Mexican artists Ruben Leyva and Diego Rivera.

The Bank continued to provide programs and publications to communicate broader public policy objectives and key economic topics through its six regular economic publications and several special publications. Other initiatives included a conference on the role of free enterprise in solving public policy problems, "Replanting the Seeds of Free Enterprise: Grassroots Solutions to Public Policy Problems"; the conference "Supervision—Or Will It Be Super Revision?" sponsored by Houston Baptist University in cooperation with the Houston Branch, which focused on shaping a partnership approach to lending; and "Job Creation and Destruction in a Global Economy," sponsored by the El Paso Branch.

The Bank continued its commitment to economic education with numerous programs for university and high school educators, sponsorship of a student essay contest and the production of several publications aimed at students and teachers. The Federal Reserve System launched the Fed Challenge competition in 1996, and a five-member student team from the Eleventh District won the national monetary policy competition. Other activities included a monetary policy conference for the academic community and an intensive week-long program for teachers titled "Exploring Monetary Policy."

The Bank continued to provide information relating to the promotion of community development investments, the Community Reinvestment Act and other consumer laws through education, outreach and technical assistance activities. Along with an annual community development lending conference and the bimonthly newsletter *Banking & Community Perspectives*, the Bank produced *A Banker's Quick Reference Guide to CRA*, which is being used nationally by the Federal Reserve System; *Texas Colonias: A Thumbnail Sketch of the Conditions, Challenges and Opportunities*, a special report on credit needs and community development initiatives along the U.S.–Mexican border; and *Banking on Partnerships: A Digest of Community-Based Organizations in Houston*.



CORPORATE EXECUTIVES

Standing (from left): Helen E. Holcomb, First Vice President and COO, Federal Reserve Bank of Dallas; Roger R. Hemminghaus (Deputy Chairman), Chairman and CEO, Ultramar Diamond Shamrock Corp. Seated (from left): Robert D. McTeer, Jr., President and CEO, Federal Reserve Bank of Dallas; Cece Smith (Chairman), General Partner, Phillips-Smith Specialty Retail Group.

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Seated (from left): Beauregard Brite White, Rancher, J. E. White, Jr. & Sons; Veronica K. Callaghan, Vice President and Principal, KASCO Ventures Inc. Not pictured: Ben H. Haines, Jr., President and CEO, First National Bank of Dona Ana County.

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Assistant Vice President

D. Karen Salisbury
Operations Officer

Effective January 1, 1997

STATEMENT OF CONDITION
(in millions)

ASSETS	DECEMBER 31, 1996	DECEMBER 31, 1995
Gold certificates	$ 433	$ 405
Special drawing rights certificates	399	376
Coin	49	49
Items in process of collection	1,284	333
U.S. government and federal agency securities, net	14,118	12,381
Investments denominated in foreign currencies	1,197	1,414
Accrued interest receivable	127	126
Interdistrict settlement account	218	3,287
Bank premises and equipment, net	190	191
Other assets	14	15
Total assets	$ 18,029	$ 18,577
LIABILITIES AND CAPITAL		
Liabilities		
Federal Reserve notes outstanding, net	$ 15,340	$ 15,570
Deposits:		
Depository institutions	1,730	2,178
Other deposits	12	13
Deferred credit items	374	258
Statutory surplus transfer due U.S. Treasury	15	18
Accrued benefit cost	42	39
Other liabilities	9	9
Total liabilities	$ 17,522	$ 18,085
CAPITAL		
Capital paid in	257	246
Surplus	250	246
Total capital	$ 507	$ 492
Total liabilities and capital	$ 18,029	$ 18,577

These statements are prepared by Bank management. Copies of full and final financial statements, complete with footnotes, are available by contacting the Public Affairs Department at (214) 922-5254.

STATEMENT OF INCOME

(in millions)

	FOR THE YEARS ENDED DECEMBER 31, 1996	DECEMBER 31, 1995
INTEREST INCOME:		
Interest on U.S. government securities	$ 824	$ 804
Interest on foreign currencies	28	53
Total interest income	$ 852	$ 857
OTHER OPERATING INCOME:		
Income from services	$ 53	$ 49
Reimbursable services to government agencies	7	9
Foreign currency gains (losses), net	(104)	67
Government securities gains, net	1	—
Other income	1	1
Total other operating income	($ 42)	$ 126
OPERATING EXPENSES:		
Salaries and other benefits	$ 77	$ 74
Occupancy expense	12	12
Equipment expense	10	9
Cost of unreimbursed Treasury services	2	2
Assessments by Board of Governors	26	23
Other expenses	55	53
Total operating expenses	$ 182	$ 173
Income before cumulative effect of accounting change	$ 628	$ 810
Cumulative effect of change in accounting principle	—	(6)
Net income prior to distribution	$ 628	$ 804
DISTRIBUTION OF NET INCOME:		
Dividends paid to member banks	$ 15	$ 15
Transferred to surplus	11	—
Payments to U.S. Treasury as interest on Federal Reserve notes	453	789
Payments to U.S. Treasury as required by statute	149	—
	$ 628	$ 804

These statements are prepared by Bank management. Copies of full and final financial statements, complete with footnotes, are available by contacting the Public Affairs Department at (214) 922-5254.

STATEMENT OF CHANGES IN CAPITAL
For the Years Ended December 31, 1996, and December 31, 1995
(in millions)

	CAPITAL PAID IN	SURPLUS	TOTAL CAPITAL
BALANCE AT JANUARY 1, 1995			
(4,936,624 shares)	$246	$246	$492
Net income transferred to surplus	—	—	—
Net change in capital stock redeemed (7,663 shares)	—	—	—
BALANCE AT DECEMBER 31, 1995			
(4,928,961 shares)	$246	$246	$492
Net income transferred to surplus	—	11	11
Net change in capital stock issued (210,343 shares)	11	—	11
Statutory surplus transfer to the U.S. Treasury	—	(7)	(7)
BALANCE AT DECEMBER 31, 1996			
(5,139,304 shares)	$257	$250	$507

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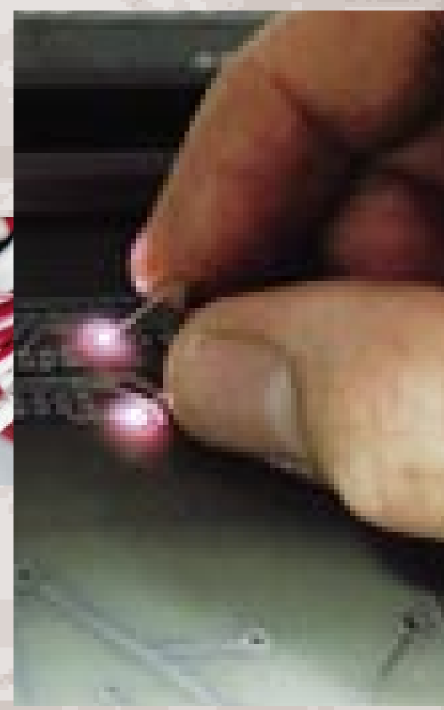
	NUMBER OF ITEMS HANDLED (Thousands)		DOLLAR AMOUNT (Millions)	
	1996	1995	1996	1995
SERVICES TO DEPOSITORY INSTITUTIONS				
CASH SERVICES				
Currency received from circulation	1,425,077	1,328,681	22,064	20,022
Coin received from circulation	836,223	931,406	138	153
CHECK PROCESSING				
Commercial—processed	1,091,459	1,071,311	648,485	614,465
Commercial—fine sorted	265,759	291,637	88,821	87,105
U.S. government checks	29,908	31,411	29,072	30,497
ELECTRONIC PAYMENTS				
Automated Clearing House items originated	154,479	129,472	538,058	351,043
Funds transfers processed	8,183	6,962	12,049,359	10,405,869
Book-entry security transfers	338	400	4,741,244	5,169,920
LOANS*				
Advances made	263	418	657	789
SERVICES TO THE U.S. TREASURY AND GOVERNMENT AGENCIES				
Issues and reinvestments of Treasury securities	25	47	1,192	1,842
Food coupons destroyed	7,672	255,714	35	1,325

*Individual loans, not in thousands

ABOUT THE DALLAS FED

The Federal Reserve Bank of Dallas is one of 12 regional Federal Reserve Banks in the United States. Together with the Board of Governors in Washington, D.C., these organizations form the Federal Reserve System and function as the nation's central bank. The System's basic purpose is to provide a flow of money and credit that will foster orderly economic growth and a stable dollar. In addition, Federal Reserve Banks supervise banks and bank holding companies and provide certain financial services to the banking industry, the federal government and the public.

Since 1914, the Federal Reserve Bank of Dallas has served the financial institutions in the Eleventh District. The Eleventh District encompasses 350,000 square miles and comprises the state of Texas, northern Louisiana and southern New Mexico. The three Branch offices of the Federal Reserve Bank of Dallas are in El Paso, Houston and San Antonio.



Federal Reserve Bank of Dallas

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(915) 544-4730

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126 East Nueva Street

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