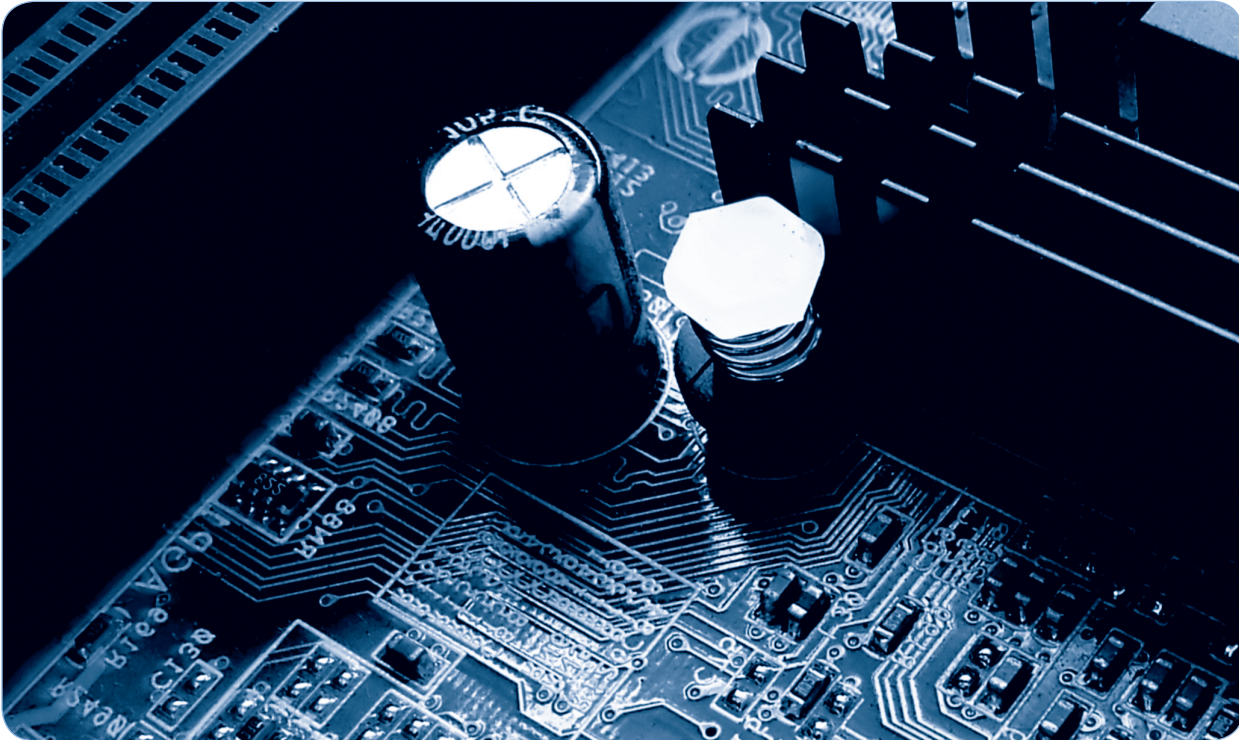# 1. Why Is the Digital Information Revolution So Powerful?

In the new global economy, information technology (IT) is the major driver of both economic growth and improved quality of life. The Information Technology and Innovation Foundation (ITIF) in its 2007 report *Digital Prosperity: Understanding the Economic Benefits of the Information Technology Revolution* documented how IT, since the mid-1990s, has been the principal driver of increased economic growth not only in the United States but also in many other nations.[1] In the present report, we show that IT is also at the core of dramatic improvements in the quality of life for individuals around the world: IT is the key enabler of many, if not most,

of today's key innovations and improvements in our lives and society—from better education and health care, to a cleaner and more energy efficient environment, to safer and more secure communities and nations.

In the 1960s, if someone were asked to name the technology at the forefront of improving society and quality of life, she might have responded, as Mr. McGuire did in the movie *The Graduate*, "plastics." And indeed, in the old economy, breakthroughs in materials technologies such as plastics let organizations more easily manipulate "atoms" to create products that dramatically improved the quality of life for billions of people around the globe. Plastics gave us more durable and easy-to-use materials. Cars and appliances depended on low-cost steel. Aluminum enabled jet aviation. Breakthroughs in chemistry provided us with better drugs, household products, clothing, and a host of other improvements. In short, the "materials revolution" drove both economic growth and dramatic improvements in the quality of our lives.

Today, however, the materials revolution has largely achieved its promise, particularly in developed nations, and relatively few innovations rely on materials technologies. Certainly many advances in the IT revolution depend on hardware innovations made possible by continued advancement in materials technology, but these improvements are not manifest in the physical nature of these devices but rather in their functional performance. Thus the value found in newly-designed microprocessors has less to do with physical properties such as size, weight and durability and more to do with functional prop-

utopians could dream about.

To be sure, advances in information technology have occurred throughout history—from Guttenberg's invention of moveable type, to the typewriter and telegraph, to the telephone and Xerox machine—making it easier and cheaper to create, manipulate, organize, transmit, store, and act on information. And with each information breakthrough, optimists heralded a new era. Thus, for example, with the rise of the railroad in the 19th century, sociologist Charles Fraser stated in 1880, "an agent is at hand to bring everything into harmonious cooperation, triumphing over space and time, to subdue prejudice and unite every part of our land in rapid and friendly communication...and that great motive agent is steam."[2]

Many information innovations occurred after World War II but information remained scarce and hard to use and transmit. The reason was that the processing of information relied on "atoms" to record or transmit information in analog form rather than the "bits" (binary digits of "1s" for on and "0s" for off) used to record or transmit information in digital form. Pen and pencil, industrial offset printers, and Xerox machines recorded information on paper. Needles made scratches in vinyl discs that could be rotated to hear sounds. Light came through a camera lens to excite atoms on chemically imprinted photo paper. Telephones translated voices into electric waves that could be played back on speakers.

At the time of their introduction, many analog information technologies were treated with well-deserved exhilaration. When compared to the quantum advancements of the last decade, though, these

More and better information has always had the potential to improve our lives, but until recently, an information-rich society remained something only utopians could dream about.

erties, such as the number of instructions processed per second. It is now the "digital information revolution" that is driving innovation and enabling billions of people to live better lives. More and better information has always had the potential to make our lives better, but until recently, the potential of an information-rich society remained something only

technologies now seem as archaic as cuneiform must have seemed to those in the industrial era. The digital information revolution enables a host of information in digital form—from a voice on a telephone, to a signal from a wireless sensor of pollution in a bay, to information on disease outbreaks—to be far more easily generated, transmitted, and analyzed than ever

before in human history.

It is only now, when a vast array of information is in digital form and when it is far easier and cheaper to create, manipulate, organize, transmit, store and act on information that we can truly speak of being in the digital information age. The fact that your shoes can now communicate with your iPod when you are running, though seemingly trivial, is emblematic of the digital information revolution.[3] Yet, perhaps because of examples like shoes talking to MP3 players, it has recently become fashionable for skeptics to look askance at the digital information revolution, arguing that it's much ado about nothing and that it is a pale imitation of the really "great" innovations of the past.

At first glance, it appears that they are right. After all the materials revolution brought with it a host of amazing new "things": automobiles, planes, appliances, the telephone, etc. Both society as a whole and individual lives were dramatically different and better because of these. When compared to these world-changing innovations, IT doesn't measure up, so say these skeptics. But in holding the digital information revolution to the standard of "Does it produce big new things?" the skeptics miss the key point of the revolution, which is that most of the big innovations in "things" is over. Most of the things that can be developed have already been developed. But we have only begun to scratch the surface when it comes to making the world alive with information.[4]

Indeed, for the foreseeable future, the most promising advances will relate to the ability to use information more effectively. The materials revolution produced lifesaving vaccines, but the digital information revolution is enabling the creation of a rapid learning network to enable our global health care system to quickly find out what treatments work best and which don't. The materials revolution produced the automobile and the highway system, but the digital information revolution is creating intelligent transportation systems and is letting us "digitally travel" through telecommuting and teleconferencing. The materials revolution produced the telephone, but the digital information revolution is allowing ubiquitous communication from a wide range of devices and places.

In other words, the digital information revolu-

tion is not likely to produce a world that looks significantly different than the world of the recent past. But it is producing a world that functions in radically different and better ways, with individuals and organizations able to access and use a vast array of information to improve their lives and society. Indeed, after 5,000 years of civilization, we are only now moving from a relatively inert and obtuse world to one that is intelligent and "alive with information." So if the measure of a revolutionary technology is whether it changes "atoms," IT fails. But if the measure is the degree of change and improvement a technology system brings, the IT revolution ranks up there with revolutionary technologies of the past.[5]

So what will this intelligent and connected world bring? Clearly, the digital information revolution is opening up an amazing array of information for people to get access to, particularly through the Internet. But to see the information revolution as principally about the ability to more easily access text or video information is to only see the tip of the iceberg. Information access on the Internet is an amazing innovation, but the full breadth and depth of the digital information revolution goes far beyond Web surfing, for the digital information revolution is extending to virtually all aspects of our lives, all parts of society, all organizations and all nations.

Without question, much of how our lives and society work is based on information. A table saw that knows it should immediately stop if the operator's finger touches the blade is using information. A car that that senses if it is about to hit another car and automatically puts on the brakes is using information. A gun that lets only the owner fire it is using information. Sensors that measure water pollution in particular places and transmit that data to regulators and the public are using information. A mobile device that lets the owner know when her friends are nearby is using information. In short, making the world intelligent and more alive with information is the key to improved quality of life and social progress.

In a world saturated with information and with the tools to effectively get it and process it, we are entering a new era where IT is the major driver of progress and change in many areas of our lives and society, among them the following:

- **Improving our access to information.** IT is putting a variety of information at people's finger tips, whether they be students in Ghana accessing Massachusetts Institute of Technology course materials online without ever leaving their homes or people in Holland getting information online to help them better understand a medical condition. One can appreciate this development by noting that Wikipedia (the online encyclopedia that anyone can edit) has well over 2 million English articles with 3.4 million contributors (and versions in 190 other languages), while the 32 volumes of *Encyclopedia Britannica* contain approximately 65,000 articles.[6] Moreover, real-time language translation software is now letting people access information in languages other than their own.

- **Helping us sort out "the needles from the haystacks."** Although the digital revolution has led to an explosion of information and data, without the ability to make sense of it, much of the information and data would be as worthless as an academic library without a card catalogue. Luckily, powerful new software tools are letting data be analyzed to find patterns and connections. In health care, for example, IT systems are creating rapid learning networks to discover which medical treatments work best and which do not work at all.

- **Harnessing the power of markets.** Many areas of life are rightly insulated from markets, such as the workings of much of government and our home lives. But in many areas that involve consumer choices, markets can bring improved efficiency and quality. Well-functioning markets need information and transparency—and IT can provide both. Smart electricity meters can let electricity prices be based on time-of-day use so that consumers have incentives to consume less at peak periods, thereby reducing the need to produce additional peak-load power. Radio-frequency identification (RFID)-enabled recycling bins let communities provide rewards to citizens that recycle more of their trash. Global positioning system (GPS) navigation systems are letting vehicles be charged by the mile driven, providing a much better link between costs and prices. Web-enabled IT tools let consumers know more about the quality of a host of products and services—from health care to home repair services to airlines, and much, much more—enabling them to make smarter purchasing decisions.

- **Letting us substitute information for travel.** If the old economy brought about a revolution in travel, the new digital economy may be bringing about a revolution in the substitution of information for travel. By bridging distance, IT is letting a growing share of activities that used to require face-to-face presence to now be conducted at a distance, saving people time and money and saving society energy and space in offices, roads and airports. Telework is the fastest growing mode of "travel" to work, and millions of workers are choosing this option. "Telepresence" is letting people from around the world meet virtually with close to the same kind of interactions that once could only happen in face-to-face meetings. Telemedicine is bringing top-quality doctors to patients in remote areas; and telemonitoring is letting doctors monitor patient's conditions without having to always see them in person. In addition, e-commerce is giving businesses in rural areas access to markets around the world and giving consumers access to products around the world.

- **Giving us a vast array of choices.** Henry Ford is supposed to have once said that the customer can have any color Model T as long as it is black. Today, the IT revolution is giving people a wide variety of choices, enabling them to get the kinds of products and services that most fit their needs. Internet radio gives people the chance to move beyond the limited formats presented on local over-the-air radio and instead hear hundreds if not thousands of formats from around the world. E-commerce lets people buy a vast array of goods and services that previously might have been difficult to find at local stores. A growing array of edu-

cational software applications lets lessons be individually tailored to student needs in ways that classroom teachers never could.

- **Letting us know more things in real time.** The value of much information depends on its timeliness. Information on road traffic conditions is of little use if you learn it by being stuck in traffic. Knowing that a person on a terrorist watch list entered the nation a week ago is much less valuable than knowing when that person is standing at a customs desk trying to cross a border. Knowing that a factory emitted a much higher level of air pollution last month is of less value than knowing it when it happens. Knowing the actual water levels of local streams and rivers can help local officials have more time to prepare for flooding. In all of these and a host of other areas, IT is enabling information to be collected, organized, and presented in near real time, so that users can make the right decisions at the right time.

- **Letting us monitor our homes and loved ones.** Knowing that our homes and families are safe is perhaps the most important thing we want to know. Now IT is providing us with much greater security. Real-time detection systems can send information to our computers at work or our cell phones to let us know if an intruder is in our home. GPS-enabled cell phones can let parents know the location of their children, and in-vehicle systems can let parents know where their teenage children are driving and even how fast. IT systems can let people know whether their home environment is conducive to an asthma attack at any particular time. Webcams in daycare centers can let parents know how their children are doing throughout the day.

- **Letting us enjoy higher-quality goods and services.** While IT is making information more accessible, it is also dramatically increasing the quality of many goods and services, including making the economy more energy efficient. Significantly more precise medical imaging technology, enabled by IT, is allowing doctors to have much more accurate information about what is going on inside patients. IT is enabling cars to be more energy efficient and enabling new renewable energy technologies like wind power and solar technologies to be efficient. And though high-definition widescreen TVs may not rank up there with medical imaging or more energy-efficient cars in social importance, they do make our lives more enjoyable and entertaining, particularly at playoff time.

- **Making our lives safer.** Safety is often a matter of getting the right information at the right time. And IT is enabling a host of products to be safer. IT is enabling cars to be safer by letting drivers know in real time of impending problems. IT is enabling a host of products, including power table saws, guns, and pill bottles, to become safer. And IT is giving law enforcement and first responders better tools, including gunshot locator systems, chemical and biological weapons sensors, robots for bomb disposal, and integrated communication networks, to make our lives safer.

- **Improving convenience and saving time.** IT is saving people time and giving them new channels by which they can more conveniently conduct their daily lives in many ways: from allowing passengers to check themselves in at kiosks at airports, to allowing consumers to order products online, to allowing citizens to interact with government over the Internet.

- **Improving accessibility for people with disabilities.** A key challenge for many people with disabilities is directly related to difficulties in processing information. But IT is enabling millions of people with disabilities to live better lives. GPS navigation systems with voice prompts are bringing new mobility to individuals with visual impairments, while text-to-speech technology is helping them use computers. Individuals with a hearing disability (and their friends and family) can take advantage of online training to learn American Sign

Language. IT is even providing innovations that were recently only seen in science fiction: IT-enabled artificial retinas, for example, are restoring and improving vision in individuals with visual impairments; and IT-enabled artificial limbs are enabling people who have lost limbs to interact with their physical environment in ways never before thought possible.

- **Facilitating communication.** In the old economy, most communication other than face-to-face communication took place through the telephone and physical mail. Today communication choices have exploded. Cell phones now outnumber land lines around the world by more than 2 to 1.[7] There are nearly 57 billion non-spam e-mails sent daily worldwide, as opposed to 700 million pieces of mail handled daily by the U.S. Postal Service.[8] Police and other first responders can now communicate with each other more easily and thus can more easily make the right decisions at the right time. But it's not just person-to-person communication choices that have expanded; machine-to-person communication has expanded, as well. On-board vehicle communication systems can communicate with emergency operators if the vehicle is in a crash. Airline computers can call their customers' cell phones to let them know that their flight is delayed.

- **Giving people greater control over their own lives.** When information was scarce and often hard to understand, we had to rely on professionals or businesses to help find that information and hopefully make sense of it in ways that helped us. Now IT is liberating and empowering individuals to be able to more effectively take control of their own lives—from a farmer in India who gets real-time information on crop prices on his cell phone to a patient who gets the latest and best health information to enable her to take more responsibility for her own health care to a person in her living room using a digital video recorder so she can decide when she wants to watch a TV show.

- **Holding organizations accountable.** IT is enabling people to hold organizations accountable in a number of ways: from using cell phone cameras to document government acts of repression in dictatorships to being able to go online and use structured Web tools to provide feedback on what government should do. Cell phone cameras and inexpensive digital video cameras, combined with sites like YouTube, are providing a check on government and corporate abuses, from exposing police brutality to documenting abuse of animals in meat packing plants.

Endnotes

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About the Information Technology and Innovation Foundation

ITIF is a non-profit, non-partisan public policy think tank committed to articulating and advancing a pro-productivity, pro-innovation and pro-technology public policy agenda internationally, in Washington DC and in the states. Recognizing the vital role of technology in ensuring American prosperity, ITIF focuses on innovation, productivity, and digital economy issues.

Technological innovation, particularly in information technology, is at the heart of America's growing economic prosperity. Crafting effective policies that boost innovation and encourage the widespread "digitization" of the economy is critical to ensuring robust economic growth and a higher standard of living. However, as in any new and changing situation, policymakers have varied awareness of what is needed and what will work. In some cases legislators have responded to new and complex technology policy issues with solutions more suited for the old economy. And as the innovation economy has become increasingly important, opposition to it from special interests has grown. Finally, the excitement that the press, pundits and decision makers showed toward the information technology (IT) revolution in the 1990s has all too often been replaced with an attitude of "IT doesn't matter." It is time to set the record straight—IT is still the key driver of productivity and innovation.

As a result, the mission of the Information Technology and Innovation Foundation is to help policymakers at the federal and state levels to better understand the nature of the new innovation economy and the types of public policies needed to drive innovation, productivity and broad-based prosperity for all Americans.

ITIF publishes policy reports, holds forums and policy debates, advises elected officials and their staff, and is an active resource for the media. It develops new and creative policy proposals to advance innovation, analyzes existing policy issues through the lens of advancing innovation and productivity, and opposes policies that hinder digital transformation and innovation.

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