

Foundations

For all the breadth of today's technology and business landscape, a surprisingly small number of general principles underlie many patterns of behavior. These principles, however, derive from several areas of the social and behavioral sciences that are usually considered in parallel rather than jointly. At base, the paradox of information technology lies in how much more potential remains to be explored, particularly in the economic realm.

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Introduction

If you watch exponential change for long enough, the effects grow beyond comprehension. In the late 1990s the technology analyst George Gilder was fond of telling the story of “the second half of the chessboard.” Here is one version:

The emperor of China was so excited about the invention of chess that he offered the inventor anything he wanted in the kingdom. The inventor thought for a moment and said, “One grain of rice, Your Majesty.” “One grain of rice?” the puzzled emperor asked. “Yes, one grain of rice on the first square, two grains of rice on the second square, four grains of rice on the third square, and so on through the 64 squares on the chessboard.” The emperor readily granted that seemingly modest request. Of course, there are two possible outcomes to this story. One is that the emperor goes bankrupt because 2 to the 64th power grains of rice equals 18 million trillion grains of rice, which would cover the entire surface of the earth with rice fields two times over.¹

The story highlights one of the critical facts of contemporary life: Improvements in digital technologies are possible at scales never experienced in previous domains. As a 2005 advertisement from Intel pointed out, if air travel since 1978 had improved at the pace of Moore’s law of microprocessor price/performance (one of Gilder’s doubling technologies), a flight from New York to Paris would cost about a penny and take less than one second. Cognitively, physically, and collectively, humanity has no background in mastering change at this scale. Yet it has become the expectation; the list later in this chapter should be persuasive.

Given the changes of the past 40 years—the personal computer, the Internet, Global Positioning Systems (GPS), cell phones, and smartphones—it's not hyperbole to refer to a technological revolution. This book explores the consequences of this revolution, particularly but not exclusively for business. The overriding argument is straightforward:

- Computing and communications technologies change how people view and understand the world, and how they relate to each other.
- Not only the Internet but also such technologies as search, GPS, MP3 file compression, and general-purpose computing create substantial value for their users, often at low or zero cost. Online price comparison engines are an obvious example.
- Even though they create enormous value for their users, however, those technologies do not create large numbers of jobs in western economies. At a time when manufacturing is receding in importance, information industries are not yet filling the gap in employment as economic theory would predict.
- Reconciling these three traits will require major innovations going forward. New kinds of warfare and crime will require changes to law and behavior, the entire notion of privacy is in need of reinvention, and getting computers to generate millions of jobs may be the most pressing task of all. The tool kit of current technologies is an extremely rich resource.

Cognition

Let's take a step back. Every past technological innovation over the past 300-plus years has augmented humanity's domination over the physical world. Steam, electricity, internal combustion engines, and jet propulsion provided power. Industrial chemistry provided new fertilizers, dyes, and medicines. Steel, plastics, and other materials could be formed into skyscrapers, household and industrial items, and clothing. Mass production, line and staff organization, the limited liability corporation, and self-service were among many managerial innovations that enhanced companies' ability to organize resources and bring offerings to market.

The current revolution is different. Computing and communications augment not muscles but our brain and our sociability: Rather than expanding control over the physical world, the Internet and the smartphone can combine to make people more informed and cognitively enhanced, if not wiser. Text messaging, Twitter, LinkedIn, and Facebook allow us to maintain both "strong" and "weak" social ties—each of which matters, albeit in different ways—in new ways and at new scales. Like every technology, the tools are

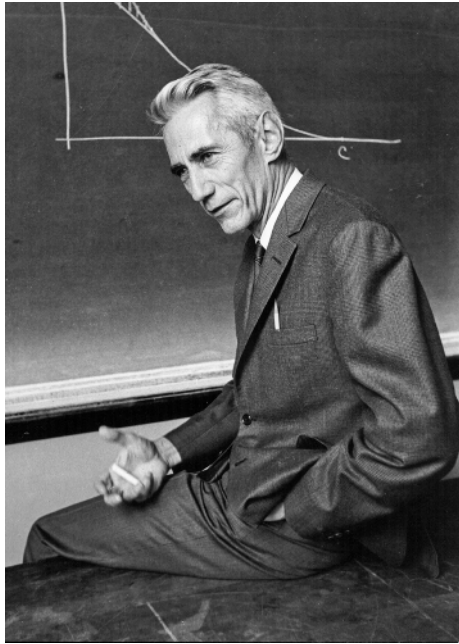


FIGURE 1.1 Claude Elwood Shannon, 1916–2001

Source: Courtesy MIT Museum.

value neutral and also have a dark side; they can be used to exercise forms of control such as bullying, stalking, surveillance, and behavioral tracking. After about 30 years—the IBM Personal Computer (PC) launched in 1981—this revolution is still too new to reflect on very well, and is of a different sort from its predecessors, making comparisons* only minimally useful.

For a brief moment let us consider the “information” piece of “information technology” (IT), the trigger to that cognitive enhancement. Claude Shannon, the little-known patron saint of the information age (see Figure 1.1), conceived of information mathematically; his fundamental insights gave rise to developments ranging from digital circuit design to the blackjack method popularized in the movie *21*. Shannon made key discoveries, of obvious importance to cryptography but also to telephone engineering, concerning the mathematical relationships between signals and noise. He also disconnected information as it would be understood in the computer age from human uses of it: Meaning was “irrelevant to the

*When Al Gore called the Internet the “Information Superhighway” in 1978, it was a perfect example of this disconnect.

engineering problem.”² This tension between information as engineers see it and information that people generate and absorb is one of the defining dynamics of the era. It is expressed in the Facebook privacy debate, Google’s treatment of copyrighted texts, and even hedge funds that mine Twitter data and invest accordingly. Equally important, however, these technologies allow groups to form that can collectively create meaning; the editorial backstory behind every Wikipedia entry, collected with as much rigor as the entry itself, stands as an unprecedented history of meaning-making.

The information revolution has several important side effects. First, it stresses a nation’s education system: Unlike twentieth-century factories, many information-driven jobs require higher skills than many members of the workforce can demonstrate. Finland’s leadership positions in education and high technology are related. Second, the benefits of information flow disproportionately to people who are in a position to understand information. As the economist Tyler Cowen points out, “a lot of the Internet’s biggest benefits are distributed in proportion to our cognitive abilities to exploit them.”³ This observation is true at the individual and collective level. Hence India, with a strong technical university system, has been able to capitalize on the past 20 years in ways that its neighbor Pakistan has not.

Innovation

Much more tangibly, this revolution is different in another regard: It has yet to generate very many jobs, particularly in first-world markets. In a way, it may be becoming clear that there is no free lunch. The Internet has created substantial value for consumers: free music, both illegal and now legal. Free news and other information such as weather. Free search engines. Price transparency. Self-service travel reservations and check-in, stock trades, and driver’s license renewals. But the massive consumer surplus created by the Internet comes at some cost: of jobs, shareholder dividends, and tax revenues formerly paid by winners in less efficient markets.⁴

In contrast to a broad economic ecosystem created by the automobile industry—repair shops, drive-in and drive-through restaurants, road-builders, parking lots, dealerships, parts suppliers, and final assembly plants—the headcount at the core of the information industry is strikingly small and doesn’t extend out very far. Apple, the most valuable company by market capitalization in the world in 2011, employs roughly 50,000 people, more than half of whom work in the retail operation. Compare Apple’s 25,000 nonretail workers to the industrial era, when headcounts at IBM, General Motors, and General Electric all topped 400,000 at one time or another. In addition, the jobs that are created tend to be in a very narrow window of technical and managerial skill. Contrast the hiring at

Microsoft or Facebook to the automobile industry, which in addition to the best and the brightest could also give jobs to semiskilled laborers, toll-booth collectors, used-car salesmen, and low-level managers. That reality of small workforces (along with outsourcing deals and offshore contract manufacturing), high skill requirements, and the frequent need for extensive education may become another legacy of the information age.

In the past 50 years, computers have become ubiquitous in American businesses and in many global ones. IT has contributed to increases in efficiency and productivity through a wide variety of mechanisms, whether self-service Web sites, automated teller machines, or gas pumps; improved decision making supported by data analysis and planning software; or robotics on assembly lines. The challenge now is to move beyond optimization of *known* processes. In order to generate new jobs—most of the old ones aren't coming back—the economy needs to utilize the computing and communications resources to do *new* things: cure suffering and disease with new approaches, teach with new pedagogy, and create new forms of value. Rather than optimization, in short, the technology revolution demands breakthroughs in innovation, which as we will see is concerned with more than just patents.

There are of course winners in the business arena. But in the long run, the companies that can operate at a sufficiently high level of innovation and efficiency to win in brutally transparent and/or low-margin markets are a minority: Amazon, Apple, Caterpillar, eBay, Facebook, and Google are familiar names on a reasonably short list. Even Dell, HP, Microsoft, and Yahoo, leaders just a few years ago, are struggling to regain competitive swagger. Others of yesterday's leaders have tumbled from the top rank: Merrill Lynch was bought; General Motors and Chrysler each declared bankruptcy. Arthur Andersen, Lehman Brothers, and Nortel are gone completely. How could decline happen so quickly?

Given our era's place in the history of technology, it appears that structural changes to work and economics are occurring. To set some context, consider how mechanization changed American agriculture after 1900. Because they allowed fewer people to till the land, tractors and other machines drove increased farm size and migration of spare laborers to cities. Manufacturing replaced agriculture at the core of the economy. Beginning in 1960, computers helped optimize manufacturing. Coincident with the rise of enterprise and then personal computing, services replaced manufacturing as the main employer and value generator in the U.S. economy. In short, *innovation could be to information what mechanization was to agriculture: the agent of its marginalization and the gateway to a new economic era.*

How IT relates to this shift from manufacturing to services and, potentially, a new wave of innovation is still not well understood; to take one example, as Michael Mandel argued in *Bloomberg Businessweek*, a

shortfall of innovation helps explain the misplaced optimism that contributed to the financial crises of the past years.⁵ But rather than merely incant that “innovation is good,” I believe that the structure of economic history has certain limits, and computers’ propensity for optimization may be encountering one such limit. It takes people to innovate, however, and identifying both the need as well as the capabilities and resources necessary for them to do so may be a partial path out of the structural economic stagnation in which we find ourselves.

Consider Dell, which achieved industry leadership in the 1990s through optimization of inventory control, demand creation, and the matching of the two. The 2000s have treated the company less well. Apple, which like Dell boasts extremely high levels of supply chain performance, has separated itself from the PC industry through its relentless innovation. Seeing Apple pull away with the stunning success of the iPhone, Google in turn mobilized the Android smartphone platform through a different, but similarly effective, series of technical and organizational innovations. In contrast to Apple and Google, optimizers like Dell are suffering, and unsuccessful innovators including Nokia are making desperate attempts to compete. Successful innovation is no longer a matter of building better mousetraps, however: The biggest winners are the companies that can innovate at the level of systems, or platforms.

The Macro Picture

At the risk of missing some important nuances, three broad issues—globalization, the shift from manufacturing to services, and stagnant middle-class wage growth—need to be considered in tandem with the technology and associated business changes that serve as the primary focus of this book. It should be noted at the outset that coincidence does not imply causation: To assert that the rise of the information era happened in the same period as a transition from manufacturing to services should not be taken to say one caused the other. In fact, some other dynamic may have caused both. That said, powerful forces need to be acknowledged before analyzing the technology sector by itself. We have more to say about each of the topics in the coming chapters.

Globalization

The rise of globalization (regardless of how it is defined) and the rapid diffusion of the Internet and mobile phones are neatly aligned in time, taking off around 1989. Figure 1.2 shows one effort to measure globalization, building on three factors: Economic, social, and political inputs all inform this index, which was created by KOF, a Swiss think tank.⁶ These

are imprecise measures, to be sure, but it is difficult to argue, even anecdotally, that the world is less “global” than it was 20 years ago.

In addition, the developing world in particular is being transformed by extremely rapid adoption of cellular phones and mobile data. We address this phenomenon in more detail in chapter 12, but note the similarity of the curves in Figure 1.3 showing the same effect in disparate countries: Usually after competition is introduced into a market, people

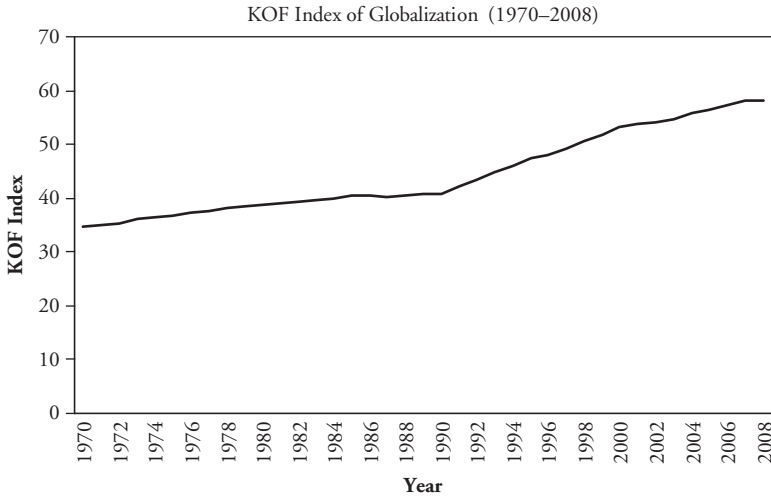


FIGURE 1.2 One Index of Globalization Shows Steady Growth
Data Source: KOF Index of Globalization.

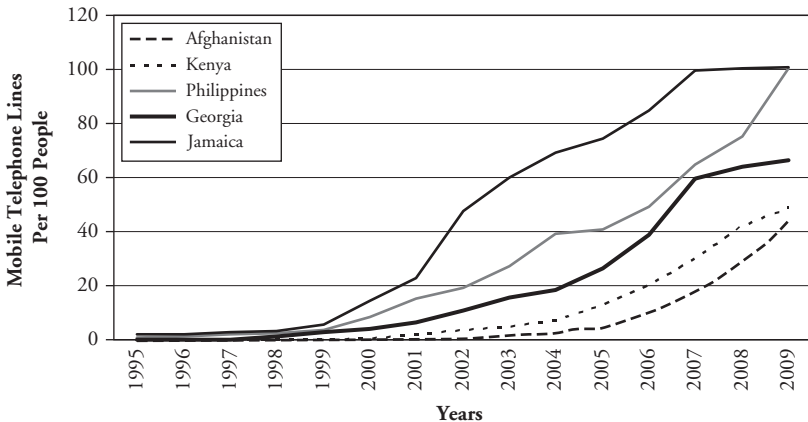


FIGURE 1.3 Mobile Telephone Lines per 100 People: Selected Countries, 1995–2009
Source: UN data.

find a way to either buy or gain access to phones for health, economic, and familial reasons.

Rise of the Services Sector

After about 1950, the manufacturing sector declined as a component of U.S. gross domestic product (GDP). Services, whether provided by banks, retail shops, hairstylists, the health care sector, or professionals such as lawyers for government employees, grew at a stunning rate in both employees and economic impact. As Figure 1.4 illustrates, given that governments lagged private companies in shedding jobs after 2008, government (an additional component of the services sector) was actually larger than goods-producing employment.

Stagnant Middle-Class Wage Growth

In the United States as well as other western nations and Japan, per capita income has remained nearly flat in real dollars since about 1970, as

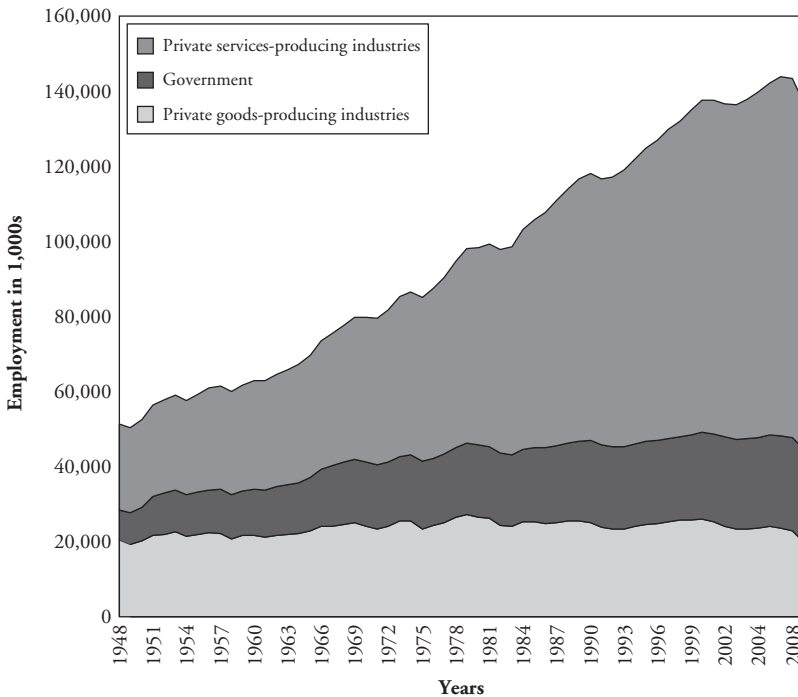


FIGURE 1.4 U.S. Employment by Sector, 1948–2009

Source: U.S. Bureau of Economic Analysis.

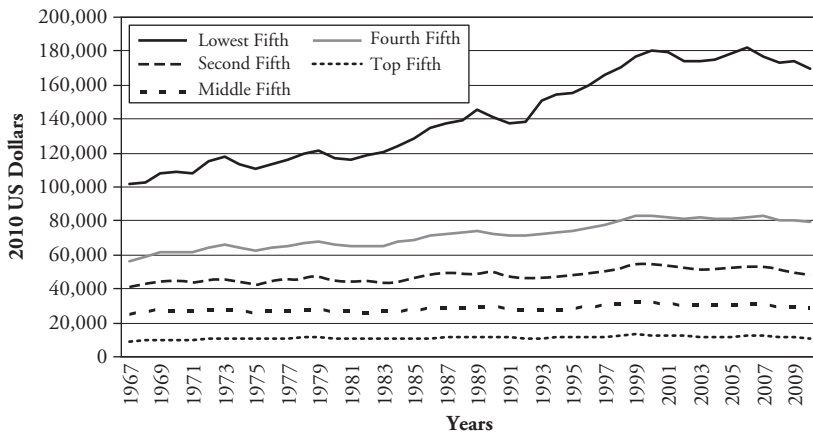


FIGURE 1.5 U.S. Household Income by Quintiles, 1967–2010, in Constant 2010 Dollars

Source: U.S. Census Bureau.

Figure 1.5 shows. Thus, the computer can be argued to have introduced efficiency improvements into the economy, but only the top 20 percent of wage earners harvested the majority of those gains.

In short,

- U.S. workers are competing with producers of goods and services in many lands.
- Most U.S. workers have not seen real wage increases in decades.
- American workers are increasingly unlikely to make things.

Why these things happened at the same time as the rise of computing remains a puzzle.

Earthquakes Every Year

Switching from macro context to the topic at hand, it is a commonplace to state that we live in extraordinary times. Rather than merely assert this, however, it doesn't take a lot of digging to find data: In nearly every year for the past 15, a new industry has been jump-started, an old one crippled, or a new way of looking at the world propagated. Consider a quick timetable that *ignores* such developments as PayPal, Wikipedia, Twitter, Craigslist, AOL, online mapping, or the iPod:

- 1995 Adoption of the Netscape browser goes from 0 to 38 million users in 18 months, the world's fastest technology take-off to date.
- 1996 Windows 95 sells 1 million copies in its first four days on the market, many through physical retailers, and later serves as gateway to the Net for millions of users via Internet networking support, CD-ROM, and native modem drivers.
- 1997 Dell focuses on supply-chain and related innovations as opposed to lab-based research and development, the norm at IBM and HP. As the world's businesses and households strive to join the online migration, the build-to-order model surges in popularity for desktop configuration. IBM soon exits the business, while such manufacturers as Digital, Compaq, Gateway, and others either fade or get absorbed in consolidations. From an also-ran position in 1996, Dell more than doubled its global market share in five years, becoming the number-one PC producer.⁷
- 1998 Linux and Apache explode in market share for server operating systems and Web server software respectively. Linux shipments tripled, not counting free downloads; Apache powered the majority of Web sites as sampled by the Netcraft measurement firm,⁸ particularly as compared to Microsoft's competing Internet Information Server. The fact that neither product emerged from a traditional development process, from a corporation, or from a monetary transaction stymied many industry observers who contended that the open-source model simply could not work.⁹
- 1999 Annual DVD player sales quadruple from 1 million to 4 million, an astonishing rate of adoption for a physical product (as opposed to virtual Netscape software downloads).
- 2000 Shortly after its launch in June 1999, Napster redefined the music landscape. Rather than attempt to use the tool for promotion in the manner of radio, the music industry wanted to shut down all peer-to-peer file sharing. Because it employed a centralized directory structure, Napster was vulnerable to legal action in ways later distributed models were not; much of the enterprise's brief history was spent in or around courtrooms. Twenty-five million users, many of them college students enjoying broadband speeds that few other populations could access, flocked to the service, which shut down in 2001. In a fascinating secondary outcome to the ascendancy of MP3 music, manufacturers including Bose, Yamaha, and Harman International witnessed a 93%—93%!—drop in sales of stand-alone audio components over the next four years.¹⁰
- 2001 After indexing a billion Web documents and contracting with Yahoo to power the latter's search bar in 2000, Google rapidly becomes essential; the American Dialect Society called the verb its

- “word of the year” for 2002, and the term entered both *Merriam-Webster* and the *Oxford English Dictionary* in 2006. Counting partnerships, Google handled about 85% of all Web searches as of early 2004 before Yahoo pulled out of the agreement and built its own capability. A staggering succession of acquisitions—including Pyra (Blogger), Keyhole (Google Earth), YouTube, GrandCentral, and Hans Rosling’s Gapminder—followed, none of which contributed meaningful revenues as compared to the core search business.
- 2002** According to Instat, wireless local area network shipments rose 65% from 2001 to 2002.¹¹ Business shipments of 11.6 million units led the way, and with home shipments of 6.8 million units, the total market revenue totaled \$2.2 billion. Given that the more familiar term for this technology—Wi-Fi—entered the *Merriam-Webster* dictionary in 2005, it’s no surprise that it became a multibillion-dollar industry only three years after launch. Even more significantly, wireless networking entered all those homes and businesses one at a time: There was no “Sputnik moment,”^{*} no tax credit, no policy mandate, no Big Blue[†] or Ma Bell.[‡] Instead, particularly on the consumer side, the rapid adoption represents millions of trips to Best Buy or the equivalent. Combined with wide deployment of cable modems and DSL connections in this same period, lots of U.S. citizens weaned themselves off the acoustic modem in a surprising short period of time, without anyone making much of a fuss.
- 2003** In yet another quiet transition that was barely remarked on, cell phones surpassed landline connections in the United States, replicating the norm in essentially every other country in the world. At about the same time, digital cameras overtook their analog equivalents (Kodak stopped making film cameras entirely in 2004); shortly afterward, dedicated digital cameras would in turn be usurped by cell phone cameras. In one brief moment, two stable, ubiquitous technologies dating to the late nineteenth century were surpassed by digital counterparts.
- 2004** No technology can compare to the wireline phone for reach in the United States, where “universal service” is literally the law of the land. After 100 years, more than 97% of households had phone

*The Russian orbiting satellite that beat the U.S. into space flight in 1957. President Barack Obama argued that America stood on the verge of a new “Sputnik moment” of innovation and discovery in his January 2011 State of the Union address.

†The nickname for IBM at the height of its dominance in the 1970s and 1980s.

‡The nickname for AT&T, in reference to the Bell system of telephone companies.

- service; the average household had 1.3 lines. The 1–2 punch of Voice over Internet Protocol (VoIP; the phone service offered by Vonage, Skype, and cable operators' triple plays) and mobile changed that in a hurry: Wireline penetration is heading south of 40% less than 15 years after peaking. Equities markets took notice of the VoIP take-off and began depressing telecom valuations accordingly, cellular growth notwithstanding. Skype, meanwhile, has grown enormous: As of March 2011, up to 29 million concurrent users are logged in. The total installed base was roughly the same size as Facebook, with 663 million users at the end of 2010, at which time the service accounted for 13 percent of all international calling minutes—on the entire planet. From launch through 2009, users had completed 250 billion minutes of calls.¹²
- 2005** GPS is another technology that seeped into mainstream adoption without anyone making an editorial point of noting a breakout year, yet its ubiquity cannot be ignored. In 2004, GPS on a mobile phone was successfully proven; it rapidly became a key component of the mobile platform. The original \$12 billion investment by the U.S. Department of Defense spawned a commercial market worth \$13 billion in 2003 alone; recent estimates predict a \$70 billion annual GPS market spend by 2013, with location-based services expected to comprise \$10 billion by themselves.¹³
- 2006** Following its launch in April 2005, YouTube soared from 50 million page views per day after barely six months live to hit 7 billion on several days in August 2006. At the time of its acquisition by Google, 100 million videos had been uploaded. Every one of them had the capacity to reach a worldwide audience for zero distribution cost and minimal, if any, production expense. As of mid-2011, 48 hours of content are uploaded to YouTube every minute of every day. The ability to review, catalog, or analyze such a flood of content still lies in the future.¹⁴
- 2007** While Amazon refuses to release unit sales figures for the e-reader launched in 2007, one statistic about electronic books merits mentioning: Kindle book sales in the first quarter of 2011 eclipsed Amazon sales of all print books combined. In other words, a technology dating back nearly to Gutenberg (1398–1468) was eclipsed in market share in less than four years, although it will bear watching to see how much the Kindle converted nonreaders and how much it took market share away from physical media.
- 2008** According to Morgan Stanley analyst Mary Meeker's statistics, the iPhone (counted along with its Wi-Fi-only iPod Touch sibling) reached 50 million customers faster than any piece of hardware in human history and jump-started the entire smartphone market.

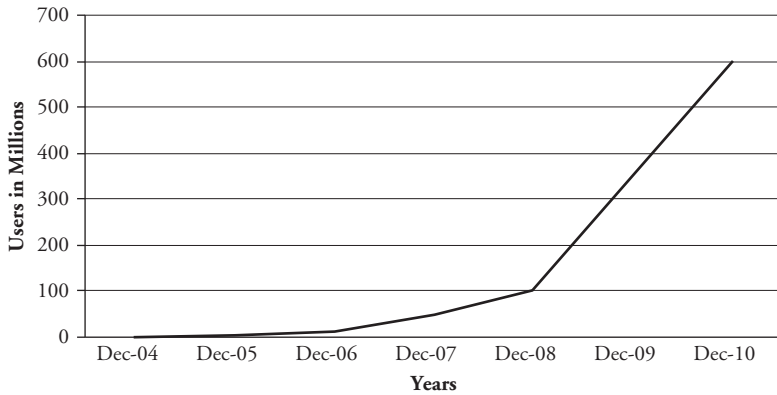


FIGURE 1.6 Facebook User Growth (in millions)

2009 Facebook claimed an incredible 600 million users in roughly six years after launch, as Figure 1.6 illustrates. The breakout year was 2009, as membership doubled off of a substantial base from about 150 million to 350 million.

2010 Apple sold 3 million iPads in less than 90 days. This matches the sales rate of the DVD after five years in the market. Even more telling is the calculation by Deutsche Bank analyst Chris Whitmore that if the iPad counted as a PC, it completely rewrites the laptop market share scoreboard, putting Apple on top by a comfortable margin—after one calendar quarter.¹⁵

Past Predictions

Given this steady pattern of exponential change, it appears likely that the pace of innovation will not slow and, in fact, should increase still further if more people are to share in the economic benefits of the information revolution. For all that is new, though, there's a sense in which this period is somehow familiar: Many technologies and practices related to them are variations on previous ideas.

- *Cloud computing*, the provision of computing resources to many distributed users, typically over the Internet, is a latter-day version of time sharing, a concept developed by General Electric and others in the 1960s to share centralized computing resources

(continued)

among distributed users. James Goodnight, the widely respected founder and chief executive officer of SAS Institute, an analytics software company, stated that “the cloud is nothing more than a damn big server farm.” He elaborated: “Google [and] Amazon had these huge server farms that they had to have to store all the data and they got all these CPUs [central processing units] that aren’t that terribly busy. Why not try to sell them off? Sell some of the time,” he said. “What we’re talking about here is a concept called time sharing. That’s all it is. We’ll sell you a piece of our hardware if you give us X number of dollars. In this case, it’s real cheap. But that’s all it is, time-sharing.”¹⁶

- The notion of a device with access to one’s *personal library of facts, history, and other information* was foretold by Massachusetts Institute of Technology engineering dean Vannevar Bush in a device he called a memex, which seemingly supercharged the microfilm reader*:

Consider a future device for individual use, which is a sort of mechanized private file and library. It needs a name, and to coin one at random, “memex” will do. A memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory.

*It consists of a desk, and while it can presumably be operated from a distance, it is primarily the piece of furniture at which he works. On the top are slanting translucent screens, on which material can be projected for convenient reading. There is a keyboard, and sets of buttons and levers. Otherwise it looks like an ordinary desk.*¹⁷

- For as much attention as the *iPad* and other tablets are receiving, the original design brief can in some ways be traced to Alan Kay, who has been associated with fundamental inventions in object-oriented computing and the windowing behavior of the modern graphical user interface. Explained in a 1972 paper, Kay’s

*A mid-twentieth-century technology for storing magazines, newspapers, and PhD dissertations on long reels of black-and-white film that was magnified in a hood the size of a small doghouse.

Dynabook was tablet size but was targeted primarily at children, not as a toy but a tool for learning programming. Kay was an Apple fellow during Steve Jobs's first tenure at the Cupertino company so Jobs undoubtedly had intimate knowledge of the concept.¹⁸

- *Text messaging* includes as a basic feature community-driven innovations in spelling and abbreviation. But in about 1850, Alfred Vail*—an American co-inventor, with Samuel F. B. Morse, of the telegraph—suggested saving words and concealing messages through the use of agreed-upon code phrases that feel strikingly familiar:

shf Stocks have fallen
 mhii My health is improving
 gmlt Give my love to¹⁹

- Conceiving of *music* migrating from vinyl or polycarbonate platters, to bits on a local hard drive, then to an account in the computational cloud seems very current in 2011; Amazon, Google, and Apple are working on such programs while Spotify is just becoming available in the United States after finding success in parts of Europe. The idea is not entirely new, however: In 1876, music was sent from a centralized location over a telephone wire. Both Alexander Graham Bell and his competitor Elisha Gray thought the market for person-to-person communication was smaller than the chance to bring concert halls to people rather than the other way around.
- Mark Twain, he of *Huckleberry Finn*, foretold *social networking*. In a little-known short story from 1898, he wrote of an invention called the “telectroscope,” a data-centric extension of the then-brand-new telephone system: “The improved ‘limitless-distance’ telephone was presently introduced, and the daily doings of the globe made visible to everybody, and audibly discussable too, by witnesses separated by any number of leagues . . . day by day, and night by night, he called up one corner of the globe after another, and looked upon its life, and studied its strange sights, and spoke with its people, and realized that by grace of this marvellous instrument he was almost as free as the birds of the air.”²⁰

*Vail's cousin Theodore became the first president of AT&T and a significant figure in the history of American business.

Themes

For the purposes of understanding the changes that matter for business, four broad themes inform this book.

Time and Place

As we will see in multiple contexts, the *speed of change* is newsworthy. Innovation breakthroughs that formerly took decades to reach mass audiences now diffuse in mere months. Some consequences of this extreme speed crop up repeatedly, affecting economics, personal life, and the competitive business landscape.

Although the *Economist's* Frances Cairncross announced “the death of distance” back in the 1990s, we continue to see innovations in the definition and *redefinition of place and space*. There are times when the square meter I occupy on the earth’s surface is decisive or meaningful, and there are times when my identity is purely a function of networked bit streams. The interesting zone is of course the middle where physical and virtual locations interact in often peculiar ways.

Finally, it becomes clear that as the *New York Times* columnist Thomas Friedman has asserted on many occasions,²¹ *globalization* and the computing/communications landscape are intertwined. The Internet itself; offshoring and the rise of India in particular; the Arab Spring; cyberwarfare; Somali piracy; global capital flows; complex derivatives and other financial instruments; Skype, e-mail, text messaging, and other low-cost international communications tools; and long, complex supply chains: All of these intermingle globalization and the IT revolution. The year 1989 marks a convenient start to the modern era, punctuated as it was by the fall of the Berlin Wall, Tiananmen Square, and the take-off of cellular telephony. Also in that year, a British computer scientist named Tim Berners-Lee drafted the proposal that, once implemented beginning in 1991, became the World Wide Web. Thus, modern globalization represents a complex convergence of technology, geopolitics, and popular expectation.

To take only a few examples of the intersection of globalization and technology, consider these:

- Global stock exchanges are increasingly correlated.²² Large multinationals use the same networked accounting software packages and audit firms, global financial firms invest in multiple markets using similar algorithms, and markets themselves are better interconnected than ever.
- Whether using air freight or container ships, global logistics networks rely on substantial and innovative investments in information and communications technologies. Real-time package tracking for even

low-value parcels has become the expectation, no matter the origin of the shipment. UPS, which moves and tracks 15 million packages per day, describes itself as “a technology company that just happens to have trucks.”²³

- While it could be said 20 years ago that half the planet had never made a phone call, earth’s overall teledensity—number of telephones divided by the number of people, per 100 people—is now greater than 100: There are more phones, most of them mobile, than there are humans. The poorest and most remote locales, with very few exceptions, are getting connected: Even Afghanistan has 41 mobile phones for every 100 inhabitants, according to the International Telecommunications Union.²⁴

Systems

As a network of networks, the Internet helps enable social and technical systems to be connected at low cost and nearly infinite reach. Accordingly, *systems thinking* is becoming essential: Seeing how individual and collective entities interact, and how unexpected side effects can surprise all concerned, has become more important than ever. In part this impact relates to the speed with which events can unfold. As more people join various facets of the global information grid, formerly separate domains (including security, identity, work, and others) now interact, often at a deep level. When systems design is good, hardware, software, content, and experience converge in a powerfully coherent phenomenon like the iPod. Much more often, disconnected entities combine to form dysfunctionally connected fragments, as with many government Web sites: “You can’t get here from here” often sums up the experience. Mere connection does not a system make.

The other primary impact of today’s systems of systems is incredible complexity. An old saying borne of frustration goes something like this: “To err is human, but to really screw things up requires a computer.” Given the intricacy of today’s systems, errors of malice, incompetence, or plain bad luck can quickly scale out of control; an example would be the Wall Street “flash crash” of 2010 in which equities values oscillated wildly, driven in part by automated trading algorithms. Complexity compromises usability, security, and system performance, yet simplification is often difficult to design in. What some scientists refer to as “emergence”—unexpected outcomes of simple, uncoordinated actions—is reaching new extremes at the level of the global Internet: Such emergent phenomena as the formation of sand dune ridges or bird flocking are orders of magnitude smaller than global financial or information flows, and the science is still catching up. It also appears that twentieth-century structures—traditional

bureaucracies—cannot manage really large systems, so an important aspect of tomorrow's innovation will be organizational and managerial.

Organizations

As events from Finland (the home of the Angry Birds game, Linux, and Nokia), to China, to Egypt testify, the influence of the current technology toolbox on organizational possibility is significant. In particular, the decrease in coordination costs made possible by mobility, social networking, and automated information flows is resulting in the emergence of *new organizational forms*. Wikipedia serves as a powerful example: No corporation or think tank or club, the organizational form of the global information resource is in fact the wiki, a peer-generated editorial platform. Getting people across time and distance to contribute a lot or a little to some larger purpose has never been easier. Two implications of this capability relate to risk and strategic possibility.

Speaking of old-style bureaucracies in particular (since it's too soon to see how Linux will age, for example), most every organization pursues self-preservation as a core value. At the same time that new models of collaboration and coordination are possible, risks to organizations are advancing with frightening speed. *Risk changes shape*. When ubiquitous connection becomes possible, the implications of bad news, threats, and honest mistakes can spread blindingly fast. The definitions of *prudence*, *preparation*, and *protection* are all in transition. Social media enable dispersed people to coordinate responses to perceived danger but also to plan crimes, spread rumors, and scam one another.

Time and again, old foundations of *strategic thought and action*—including barriers to entry, preservation of profit margin, building of market share, and the pursuit of growth—are being rewritten by new business practices, social dynamics, and external forces. What are the benefits and liabilities of scale, for example, in light of recalibrated coordination costs? What are the strategic responses to zero as a practical price point for certain categories of goods? What constitutes an industry, or a barrier? What sector is Amazon really in? eBay took on some capabilities of a bank by buying PayPal; Microsoft, after buying Skype and aligning with Nokia, now feels something like a phone company.

Perhaps the most important legacy of this revolution will be its facilitation of *decentralization*: In the absence of paper, long time lags in business processes, and the imperative for physical colocation, what really is the role of a headquarters? If speed in response to volatile markets and other conditions is becoming more important than organizational mass, can large firms adapt quickly enough? Is “too big to fail” more like a euphemism for “too big to get out of its own way”?

That decentralization can be put to many uses: As longtime Internet commentator Clay Shirky points out, the infrastructure is value neutral. Thus, the same potential for collaboration outside corporations that drives mass efforts to find Steve Fossett's downed aircraft allows terrorist and criminal groups to perform better. They can mount attacks of considerable sophistication, as in Mumbai in November 2008, or strike institutions responsible for the well-being of many people without leaving meaningful evidence. The playing field is more level than in recent memory, but the rules of the game and the nature of the players are changing as well.

Workers

As every piece of information, whether a grocery list or a 3D movie, is reduced to digital form, able to be infinitely copied and instantaneously moved across the globe, *exchanges of economic value* are challenging idea creators in particular. As it gets harder to get paid to be a musician, for example, or a newspaper reporter, some commentators argue that quality in those realms is declining.²⁵ So-called user-generated content—amateur news video, blog posts, Twitter dispatches—alter the role of professional news gatherers, pundits, and performers. Every content industry faces basic challenges to its twentieth-century existence.

In manufacturing, meanwhile, the increasing role of *digitization is raising the skills required of the workforce*. Whether with robotics, enterprise software systems, global sourcing and distribution, or increased software content of manufactured products (such as refrigerators or garage door openers with Internet access), the manufacturing workforce must deliver high levels of computer literacy. At a time of high unemployment and increasing wealth disparity, the road ahead for people without such skills is not promising.

At the same time, a college education is no longer a guarantee of lifetime middle-class status. While some skills, such as nursing, remain in high demand, such tasks as bookkeeping and even legal and equity research are being shifted to lower-wage locales. Other skills, such as engineering and management, can become outdated relatively quickly unless people learned how to learn at the time of their primary training. While the information revolution pays an education premium, it does not do so uniformly or perpetually.

We've Seen This Movie Before

Every generation appears to be fond of calling its experiences unprecedented. But for all of the amazing statistics compiled over the past 15 years, moments of technology disruption and economic transformation are

remarkably predictable. Carlota Perez, currently an economic historian at the Technological University of Tallinn in Estonia, studied the persistent patterns underlying five techno-economic eras. Table 1.1 is adapted from her work.²⁶

Each of these sometimes-overlapping periods has followed a rough sequence of four phases: A new technology appears in the market, often disrupting existing arrangements. There's a period of rapid, often silly adoption from which a bubble emerges. Bubbles burst; for infotech, that happened in 2000. After the speculative excesses burn off, the economic potential of the new technology is explored and exploited, pervading everyday life. Note that the truly substantial transformations occur *after* the bubble. Once the market matures and the transformative potential is largely exhausted, historically a given technology phase is replaced by a new technology paradigm.

TABLE 1.1 Technological Revolutions Follow a Stable Pattern

Revolution	Key Technologies	Begins	Bubble	
			Bursts	Postbubble Changes
Industrial revolution	British cotton factories	1771	1793	Rise of U.S. South as world cotton supplier; Lowell mills integrate spinning and weaving
Steam and railways	Steam engines	1829	1848	U.S. transcontinental railroad; westward U.S. population migration
Steel, electricity, and heavy engineering	Cheap steel; electrical generation	1875	1893	Mass electrification, rise of AT&T, tank warfare
Oil, cars, and mass production	Mass-produced automobiles; home electrical appliances	1908	1929	Interstate highways, growth of suburbs, GM becomes world's largest company
Information and communications technologies	Integrated circuit; software	1971	2000	Facebook, global cell phone adoption, Wikipedia

Source: Adapted from Carlota Perez, *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages* (Northampton, MA: Elgar, 2002).

Such a model puts us squarely in what Perez calls the third, or synergy, phase, in which technology change is merely part of the fabric of everyday life. Bubble valuations are still possible, as Facebook, Groupon, and Twitter suggest. But consider the iPad: Nobody can name the processor or processor speed, hard drive capacity, recommended software configuration, or most any other standard specification of the PC era. Instead, much like a blender whose revolutions per minute are unknown to essentially all consumers, the iPad “just works” to deliver movies, articles, games, weather, and other information. Consumer and employee expectations of technology are rising accordingly, and devices with poor usability will get harder to sell.

The very power of our computational context is raising the standard of execution, however: For the integration of technology to reshape other areas, such as health, public safety, and education, will require innovation at a structural level. (The stance of teachers’ unions relative to online learning as practiced at Khan Academy is one telling example of a failure to innovate.²⁷) That is, Perez’s model of synergy makes sense in terms of historical patterns, but both the economic slowdown and the limited areas of transformation suggest that much is left to be done before this phase of technology diffusion slows down. The good news is that for innovators and entrepreneurs, there are a wealth of opportunities to put the information revolution to work in the service of customers, investors, and employees.

We turn next to a look at the demographic most at home with the new computing and communications landscape, those under 30. To what degree will their lives and careers be dominated by the tools that have become so much a part of everyday life?

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