

## Chapter II

# The Evolving Online Environment

By Patricia Buckley and Sabrina Montes\*

**D**espite the current recession, migration to the online world continues. More and more individuals, businesses, and government agencies are using network technologies to connect with each other in an ever-growing number of ways for an ever-expanding number of purposes. However, as is the case with most major technological advances, progress is occurring neither smoothly nor along paths envisioned by the original developers. This past year has been marked by extreme turmoil among Internet-related businesses even as the Internet itself has continued to expand far beyond its roots as a tool for sharing research data. It has become a multipurpose, multimedia communications tool serving many different personal and business needs.

Many businesses have only begun to exploit their IT investments by moving their business processes online and the network economies associated with the Internet's growing ubiquity should continue to increase its value to users of all types. Moreover, the rapid rate of innovation in network technology witnessed over the latter half of the 1990s appears to be enduring. Taken together, this evidence suggests that major opportunities remain for networking technologies to continue to affect our economy and lifestyles.

### RECENT CHANGES

The current economic environment is a difficult one for many U.S. businesses, and Internet businesses are no exception. Many online or "dot-com"

companies have failed or have had to scale back operations significantly. The amount of online commercial activity conducted by both individuals and businesses remains at levels significantly below those predicted by market researchers in recent years. Investors have responded to the change in outlook: the extraordinarily high stock valuations and massive inflows of venture capital that became commonplace in the late 1990s have dissipated.

Some early observers thought that online versions of businesses would quickly replace their real-world, "bricks and mortar" counterparts. Sales outlets, in particular, were thought to be at risk from online sellers able to provide wider selections at lower prices. Traditional providers of products and services that could be delivered digitally were also thought to be in danger of competitive extinction—why buy a paper magazine if an online magazine could provide custom content on demand. Transactions between firms also were expected to be transformed as purchases and sales of even the most sophisticated products were revolutionized by instantaneous access to worldwide markets and auction pricing. Nothing approaching these degrees of transformation has yet occurred.

Like Mark Twain's famous demise, however, recent skepticism about the e-economy has been greatly exaggerated. Despite the large number of dot.com closures that occurred in 2001, this type of business is not in danger of disappearing. Rather, these businesses continue to adjust to the realities of the markets in which they operate. And, although the pace may be slower than widely predicted not very long ago, businesses of all types are still increasing their use of IT and the Internet.

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### Dot-Com Shakeout

Online businesses are a very diverse group, operating in a wide variety of sectors, including retailing, publishing, wholesaling, education, health, and business services. Some of these dot-coms have only an online presence, but others are online branches of traditional companies. Although measures of dot-com activity are difficult to develop for several reasons,<sup>1</sup> some private groups are attempting to track the current shakeout. Webmergers.com estimates that 762 “substantial” Internet firms shut down in the two-year period between January 2000 and December 2001.<sup>2</sup> As shown in Figure 2.1, the number of Internet business failures was substantially higher in the later half of the period. However the figure also indicates that the pace of shutdowns slowed markedly in the later half of 2001.

Even with these shutdowns, however, a large number of online businesses remain. Webmergers.com claims that a conservative estimate of the total number of Internet companies that have received

some formal funding from venture capitalists, angel investors or other investors to be in the range of 7,000 to 10,000. Given this base, Webmergers estimates that “at most, ten percent of significant internet companies have shutdown or declared bankruptcy.”<sup>3</sup>

Another indication of the relative impact of the dot-com failures is the effect on jobs. Until its own demise in September 2001, the *Industry Standard* tracked layoffs stemming both from dot-com failures and staff cuts at continuing dot-coms and at the Internet divisions of primarily off-line companies and found that, as of July 26, 2001, there were 134,727 dot-com-related employees laid off since December 1999 from 902 companies.<sup>4</sup> Though the impact of these layoffs on affected workers is significant, the effect on the U.S. economy at large is relatively limited. The Bureau of Labor Statistics estimates that, on average, 301,800 people *per week* filed new unemployment claims in 2000.<sup>5</sup> Further, many laid-off dot-com employees have been successful in finding new jobs.

According to the PricewaterhouseCoopers MoneyTree Survey done in partnership with VentureOne, the amount of venture capital invested

<sup>1</sup> Not every Internet address with a “dot-com” suffix is a separable business. Many are business home pages that are integrated parts of existing firms and are not viewed by their operators as separate business units. Also dot-coms are not limited to online businesses with the suffix “com”. The suffix “net” and the new suffix “biz,” are also used to denote commercial sites.

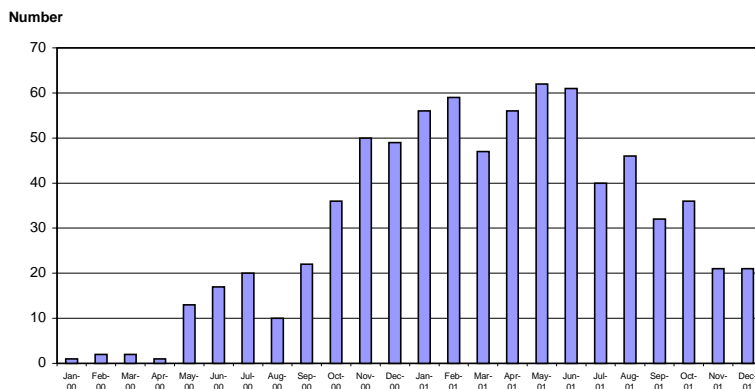
<sup>2</sup> Webmergers.com counts as “substantial” all Internet companies that have received some formal outside funding from venture capitalists or other investors. Webmergers.com, “Year End Shutdowns Report: Shutdowns More than Doubled in 2001,” January 2002. (<http://www.webmergers.com/editorial/article.php?id=49>).

<sup>3</sup> Ibid.

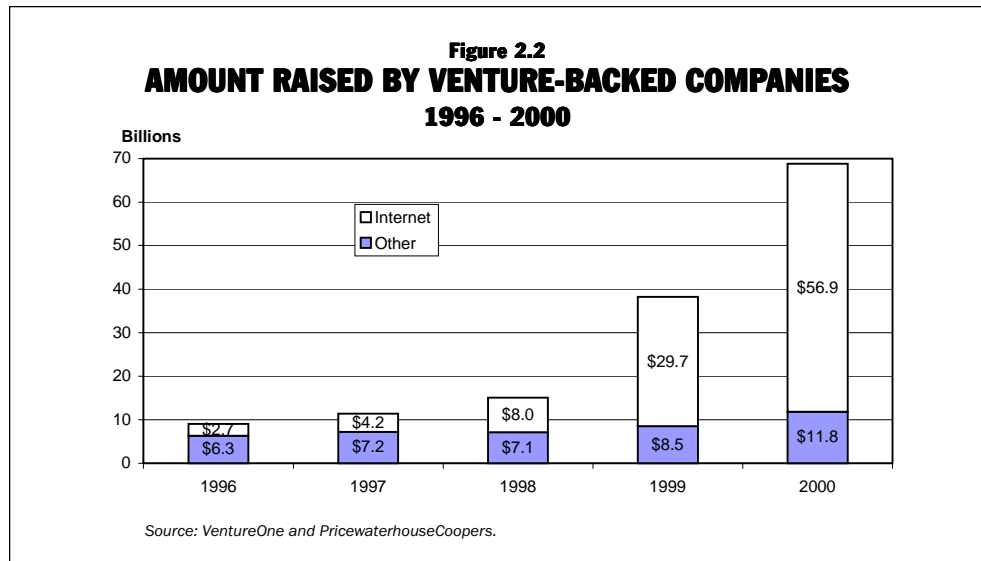
<sup>4</sup> The Industry Standard *Layoff Tracker*, July 26, 2001 (<http://www.thestandard.com/tracker/layoffs>).

<sup>5</sup> Both the Industry Standard number and the new UI claims number can include specific individuals more than once. (<http://www.bls.gov>).

**Figure 2.1**  
**MONTHLY INTERNET SHUTDOWNS**  
**JANUARY 2000 – DECEMBER 2001**



Source: Webmergers.com, January 2002.



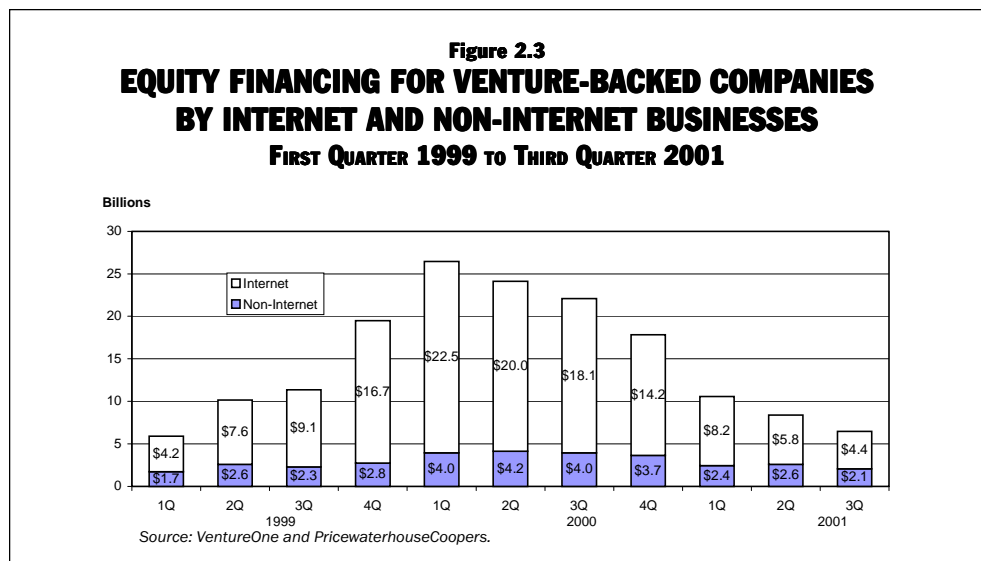
in all types of businesses in 2000 was \$68.8 billion, an 80 percent increase over investment in 1999. The year 2000 marked a high point in venture capital spending; and most of this spending went to online companies (see Figure 2.2). These Internet companies include the dot-coms, as well as new companies that produce goods and services that make e-businesses processes possible. The proportion of funds raised by these companies grew substantially after 1996. That year, Internet firms accounted for 30 percent of dollars raised by venture-backed companies; by 2000, the proportion had risen to 83 percent.<sup>6</sup>

Annual numbers for 2000 were very strong. The \$56.9 billion of financing raised by venture-backed

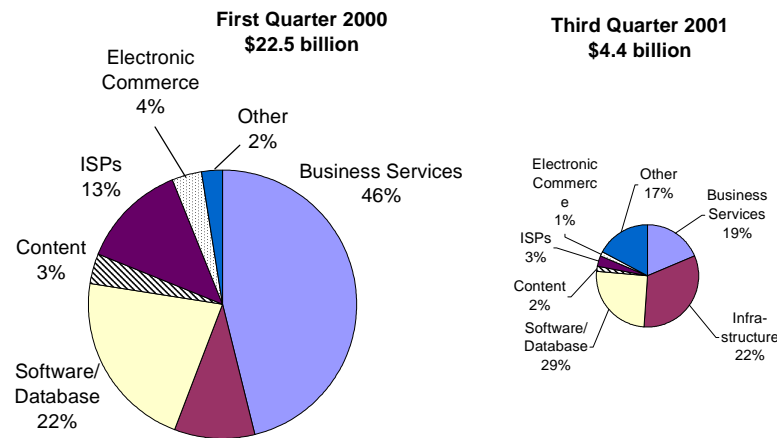
Internet companies in 2000 is equivalent to over 10 percent of total business investment on IT equipment and software economy-wide in 2000. However, the first quarter of 2000 marked the beginning of a slowdown. Figure 2.3 shows that this slowdown has been sharp. According to PricewaterhouseCoopers and VentureOne, venture-

*Investment Tempered by Increases in Biotechnology and Internet Infrastructure," Press Release, February 6, 2001. VentureOne's published US venture data comprises only venture-backed companies—those receiving at least one round of financing involving a US-based, professional, institutional venture capital firm, the division of an investment bank, or firm dedicated to venture financing. VentureOne does not track the investments of SBICs or angel investors. VentureOne does track the investments of corporations or corporate venture capitalists, as well as the interest of entrepreneurial companies in corporate partnerships. (<http://www.v1.com/press/4QPR.pdf>).*

<sup>6</sup> See VentureOne, "Moderate slowdown in Fourth Quarter Ven-



**Figure 2.4**  
**EQUITY FINANCING FOR VENTURE-BACKED COMPANIES**  
**BY TYPE OF INTERNET BUSINESSES**  
**FIRST QUARTER 2000 AND THIRD QUARTER 2001**



Source: VentureOne and PricewaterhouseCoopers.

backed companies raised less money in the third quarter of 2001 than in any period since the first quarter of 1999 and the proportion of those funds going to Internet-related companies fell to 68 percent.<sup>7</sup> (It should be noted, however, that the amount of venture capital invested in 1999 was higher than the total invested in the prior three years combined, with most of that increase due to investments in Internet-related startups.)

The majority of Internet-related venture capital has not gone to the electronic commerce sites that received much of the publicity during the heyday of dot-com mania. Rather, these funds were invested in firms that provide goods and services to other firms—traditional as well as other Internet businesses. Although the sector distribution of venture financing has shifted from the peak in the first quarter of 2000 to the most recent quarter available (third quarter 2001), as shown in Figure 2.4, the fact remains that very little venture capital investment was ever made in electronic commerce firms.

### Hurdles Facing Online Businesses

To date, the Internet has been far less successful as a transaction medium than many early observers thought it would be. Online sales, whether

to individuals or between businesses, remain at relatively low levels in most industries. The slower than expected take-up could, and perhaps should, be viewed as an indication of the hurdles facing organizations when they attempt to incorporate a powerful new technological tool into personal, business, and government processes.

**Online Sales in Perspective.** Current data show that although an ever-growing number of Americans are using the Internet, their online purchases remain only a small percent of their total purchases. For the eight quarters during which the Census Bureau has been tracking the growth in e-commerce sales by retail sales establishments, the proportion of total retail sales accounted for by e-commerce has remained very small—at roughly one percent of total retail sales.<sup>8</sup>

These data show that online sales grew from \$5.2 billion in the fourth quarter of 1999 to \$8.9 billion in the fourth quarter of 2000, an increase of 67 percent. However, by the third quarter of 2001,

<sup>7</sup> VentureOne press release, "Venture Capital Continues Steady Decline in Q3 2001," October 31, 2001. (<http://www.v1.com>).

<sup>8</sup> E-commerce sales by retail establishments are only one part of the business-to-consumer online sales. Not included in these estimates are other types of consumer purchases made by nonretail establishments, such as airline tickets and online brokerage services. E-commerce sales are collected from the seller and not categorized by type of buyer. Retail sales estimates therefore include sales made by retail establishments to parties such as small businesses in addition to purchases by individuals.

online sales of retail firms had declined to \$7.5 billion. Since these online sales had not kept up with retail in general, the proportion of retail accounted for by online sales dropped slightly from a high of 1.1 percent during the fourth quarter 2000 to 0.9 percent in the third quarter of 2001.<sup>9</sup>

Although they provide a very up-to-date accounting of retail e-commerce, these quarterly statistics deal with only a portion of the economy engaged in electronic commerce. Data derived from the Census Bureau's 1999 annual surveys provide more complete coverage. Released in March 2001, the *E-Stats* report covers establishments operating in the manufacturing, merchant wholesales, retail, and selected services industries. As shown in Figure 2.5, 1999 e-commerce transactions accounted for a relatively substantial portion of total shipments by manufacturers (12.0 percent) and total sales by wholesale merchants (5.4 percent). These are industries that predominantly sell to other businesses. The sectors where individual purchasers play the larger role, retailers and selected service providers, have much lower proportions of e-commerce transactions (0.5 percent and 0.6 percent, respectively).<sup>10</sup> Taken together, these data provide evidence of uneven, though widespread e-commerce uptake.

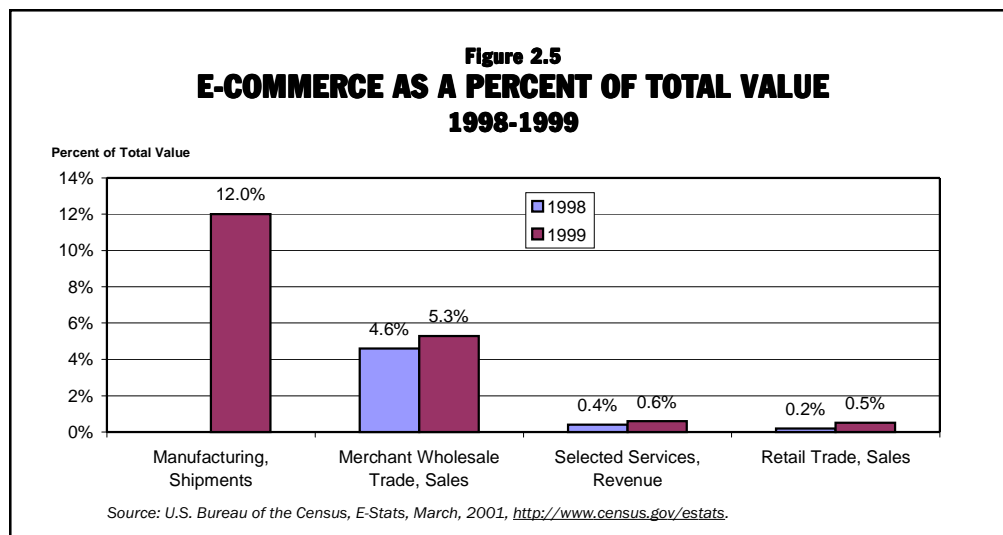
Online sales to individuals remain at levels low enough to explain why some of the dot-coms' targeting individuals failed—the market is not large enough to support the number of competitors that arose. However, the relatively high percentage of e-commerce undertaken in the manufacturing and merchant wholesalers categories translates into significant dollar amounts (\$486 billion and \$134 billion, respectively). Why then have dot-com failures in firms targeting the business-to-business market also been widespread? Part of the reason may be that much of the volume of online business transactions does not use third-party Internet intermediaries. Rather they are transactions conducted on closed proprietary networked systems that occur between parties that have an established relationship.

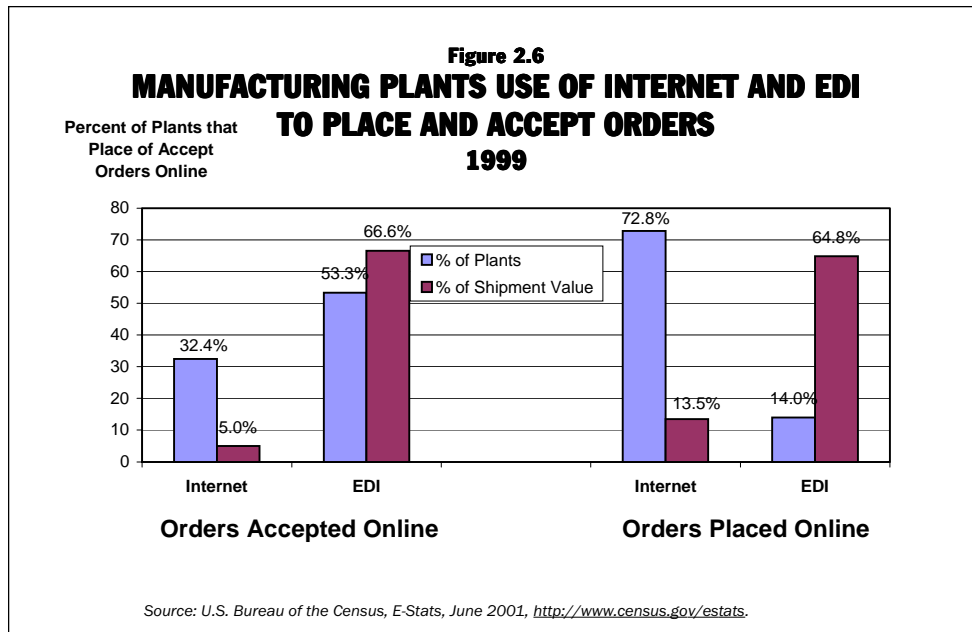
E-commerce is particularly widespread among those manufacturing and merchant wholesale industries that have well-established histories of buying and selling electronically, most particularly the transportation equipment manufacturers (NAICS 336) where online shipments comprise 21 percent of total shipments, and drugs and druggists' sundries (NAICS 4222) where online sales accounted for one-third of total sales. (See <http://www.census.gov/estats>.) These two industries are

<sup>9</sup> U.S. Bureau of the Census, *United States Department of Commerce News*, November 28, 2001, <http://www.census.gov/mrts/www/current.html>.

<sup>10</sup> Data on manufacturers were collected on a special supplement to the Annual Survey of Manufactures and are only available for 1999. Data on wholesale merchants, retail establishments and services were collected for 1998 and 1999 by adding an additional question to established annual surveys for 2000. Total and e-com-

merce estimates from the various survey programs are not additive because they are not collected on the same basis: Estimates for manufacturing are based on shipments; estimates for wholesale merchants and retailers are based on sales; and estimates for services are based on revenues. These data, including industry detail for each of the four sectors, can be found in the March 2001 *E-Stats*, a publication of the Commerce Department's Bureau of the Census. <http://www.census.gov/estats>.





examples of industries that have been trading online using electronic data interchange (EDI) systems over value-added networks for decades—well before the beginning of the commercialization of the Internet in 1995. And for many of the firms in these industries, EDI, not the Internet, remains the predominant e-commerce network.

Until recently, technical and cost considerations had generally limited e-commerce (particularly EDI e-commerce) to large volume trade within established supplier/customer relationships. The Internet, however, by providing a low cost, securable platform, makes e-commerce a possibility for many firms, including those in industries categorized by small sales to individuals. Figure 2.6 shows the well-established position of EDI, as well as the growing role of the Internet in manufacturing. Among those manufacturing plants that place or receive orders online, EDI accounts for the majority of the dollar value of shipments—67 percent of the dollar value of orders accepted online and 65 percent of the value of the orders placed online. However, when one considers online transactions by the percentage of plants that use a particular network, the role of the Internet becomes more prominent—32 percent of plants use the Internet to accept online orders and 73 percent of plants use the Internet to place online orders. These data are consistent with the notion of well-established, high-dollar volume EDI relationships particularly among larger plants and a growing interest among

plants of all sizes in using the Internet as a sales or purchasing channel even though the dollar value of such transactions is currently small.<sup>11</sup>

**Finding a Business Model.** “Too few customers” only tells part of the story. There are reasons that individuals and businesses have not flocked to online sales sites. Some Web sites were difficult to use, had high cost, were subject to delivery delays, or made it hard to return merchandise. Some sites also failed because they could not get customers to change their behavior. For example, the model used by online grocery stores required customers to plan ahead rather than choosing and buying groceries on an as needed basis. People, however, have shown themselves reluctant to change their buying habits. Other dot-coms, such as those that hoped to support themselves through subscriptions, have found consumers very reluctant to pay fees. As a result, most non-sales sites have had to rely on advertising revenue. Online content sites (e.g., media, portal, information, and publisher sites), in particular, are dependent on advertising revenues. The most important means for generating revenue among these sites is through paid links (i.e., a button or click-through to advertiser sites) and e-commerce store hosting fees. This

<sup>11</sup> U.S. Bureau of the Census, E-Stats: Manufacturing 1999 and mid-2000, June 8, 2001. <http://www.cemsis.gov/estats>. To obtain the percent of shipment values, the manufacturing plants included in the survey were asked what type of network was the primary network for making each type of transaction and the total value of all their online transactions were attributed to that network.

type of arrangement is subject to domino effects, particularly since many of the advertisers have been other dot-com companies.

In some areas, however, the new online business models have proved to be successful, offering serious challenge to traditional providers. Online ticketing of travel, for example, is among the largest volume e-commerce segments, with e-commerce revenues of \$5.3 billion or just over 20 percent of total revenues in 1999.<sup>12</sup> Early online entrants in this category, such as Travelocity.com, and Expedia.com, quickly gained market share from traditional travel agencies. More recently, however, these early online entrants are being challenged by the airlines themselves, both directly and through the jointly owned Orbitz.com. Estimates by Media Metrix indicate that Web sites owned by the airlines are gaining new visitors faster than online travel agencies, thereby narrowing the lead of the online travel agencies. Between February 2000 and February 2001, individual visitors to airline Web sites increased 26.1 percent, from 8.2 million to 10.4 million, while visitors to online travel agencies increased 7 percent, from 14.4 million to 15.4 million.<sup>13</sup> While only a portion of these site visits result in ticket sales (visitors may also be checking flight arrival and departure information or just “window shopping”), this increase indicates that the potential pool of online ticket purchasers has increased substantially.

In other industries, the ultimate impact of online businesses on the industries in which they operate is less certain. While Napster was able to attract a large audience to its music-sharing site when the service was free, it is less certain if or when a sufficient base of paying customers will emerge to support a fee-based service.

### **AN INCREASINGLY NETWORKED WORLD**

In spite of the difficulties and uncertainties associated with technological change, individuals and businesses are continuing to move activities online. Having become nearly ubiquitous, the Internet has changed from a technological curiosity to an everyday necessity for a growing number of individuals.

<sup>12</sup> U.S. Bureau of the Census, *United States Department of Commerce, E-Stats*, March 2001. <http://www.census.gov/eos/www/papers/estatstables.pdf>.

<sup>13</sup> Jupiter Media Metrix, “Airline Web Sites Pose Threat to Online Travel Agencies,” Press Release, April 4, 2001. <http://www.jup.com/company/pressrelease.jsp?doc=pr010404>.

Firms in all industries are facing a new competitive reality—one in which the capabilities of IT, particularly network technology, either have already affected or have the potential to affect important facets of almost every business. Furthermore, available evidence suggests that the technological tools that IT users have come to rely on will continue to get better, faster, and cheaper.

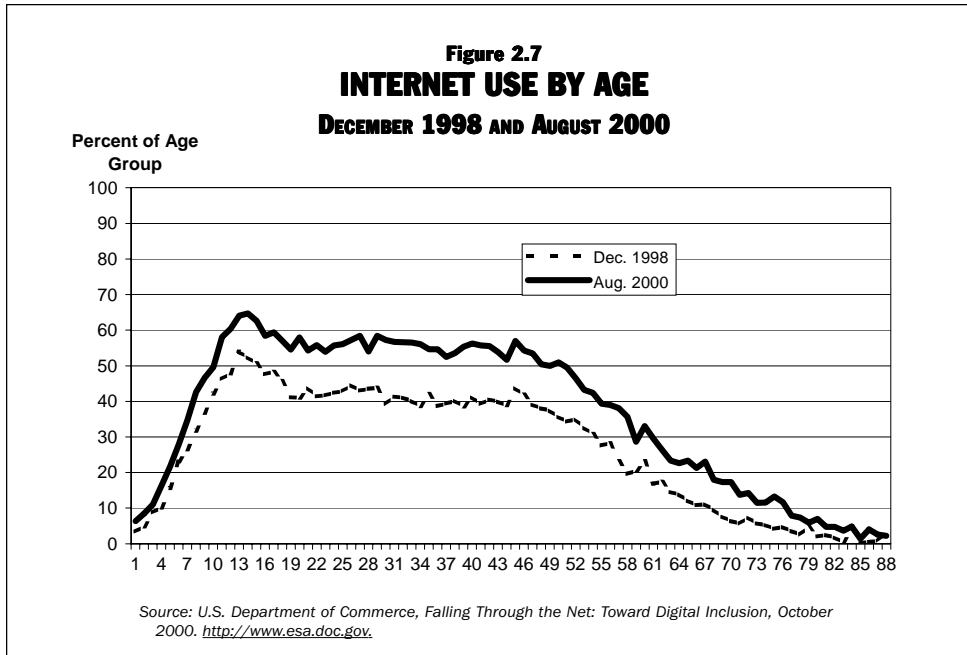
### **Continued Growth of Internet Use by Individuals**

The proportion of individuals in the United States using the Internet rose by one-third between December 1998 and August 2000, from 32.7 percent to 44.4 percent. If that trend held, over 50 percent of the U.S. population currently uses the Internet. As shown in Figure 2.7, the increase was evident across all age groups. The increase is also evident across other demographic and economic dimensions, such as race, ethnicity, income, and education.<sup>14</sup> Nor is the Internet a uniquely U.S. phenomenon. As shown in Figure 2.8, several countries in the European Union have higher Internet access rates than the United States.

The pervasiveness of growth in Internet use reflects the diversity of activities that can now occur over this important medium. As shown in Figure 2.9, people are engaging in a growing array of online activities. E-mail was the most prevalent online activity of individuals, and on a percentage point basis, the fastest growing. E-commerce activity played a small, albeit growing role as the proportion of the U.S. population that shops or pays bills online doubled between December 1998 and August 2000.

These data taken together with anecdotal evidence support the notion that the Internet is becoming an integral part of many people’s day-to-day lives. Some of the activities undertaken online are timesavers. Renewing a driver’s license or car registration online saves a trip to the Department of Motor Vehicles. Online banking provides a faster alternative to check writing. Others types of activities are improved qualitatively, in addition to being provided more quickly in an online world. Online travel services can provide a variety of pricing and timing options unavailable offline and users can check out destinations that they otherwise would

<sup>14</sup> U.S. Department of Commerce, *Falling Through the Net: Toward Digital Inclusion*, October 2000. <http://www.esa.doc.gov>.

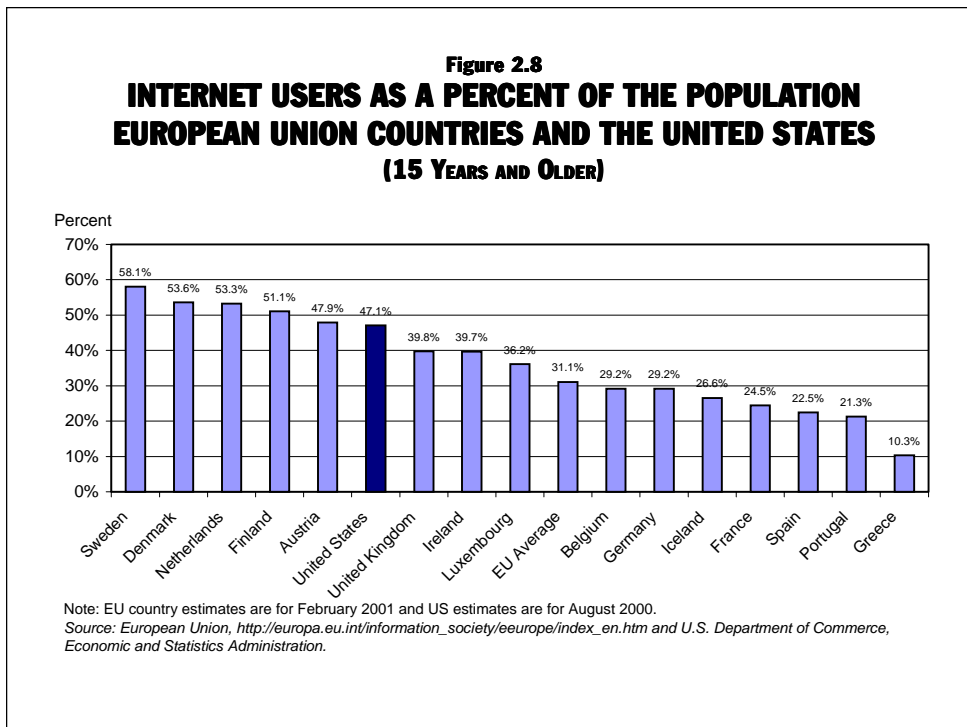


not have considered. Online news services can be quickly searched to find articles of interest. Wedding pictures can be circulated instantaneously to friends and family. Traffic information can be checked before starting the commute home.

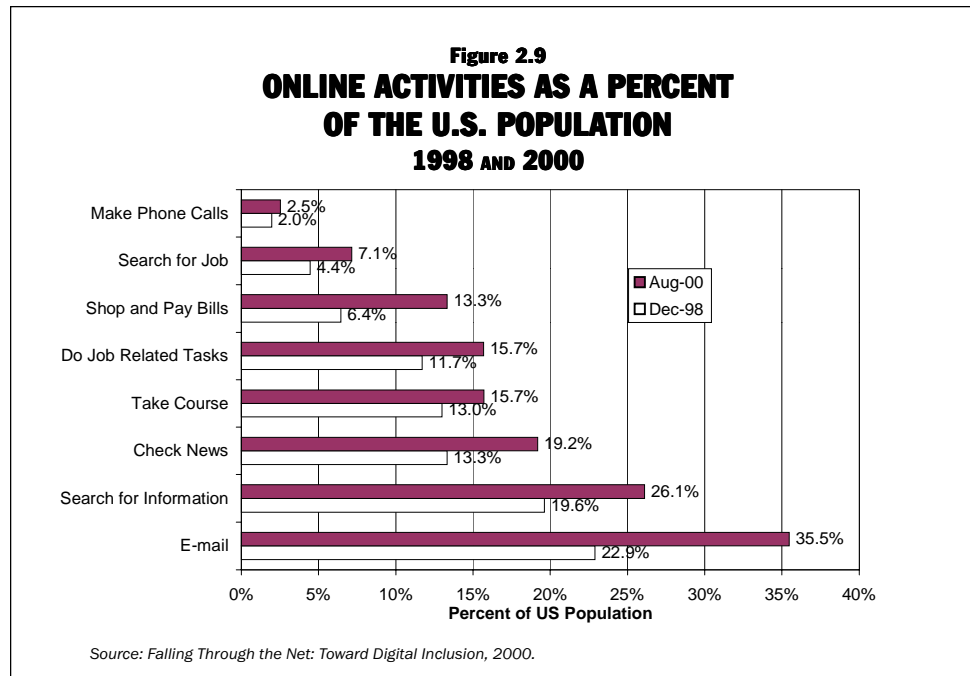
Other online activities create entirely new possibilities. The Massachusetts Institute of Technology recently launched a ten-year initiative to create public Web sites for almost all of its 2,000 courses.

The school plans to post all related class materials including lecture notes, problem sets, syllabuses, exams, simulations, and even video lectures.<sup>15</sup> Since this program does not provide access to instructors, labs, or diplomas, it will never be the equivalent of actually attending MIT, but it will of-

<sup>15</sup> Carey Goldberg, "Auditing Classes at M.I.T., on the Web and Free," *The New York Times*, April 4, 2001. <http://www.nytimes.com>. The MIT case is discussed more fully below in Chapter VII.







for anyone with Internet access, anywhere in the world, the opportunity to obtain the basics of a world-class education.

The Internet is even becoming integrated into everyday activities in ways that do not require all participants to be Internet users. For example, some little league baseball teams have team information officers who manage web sites that track schedules, scores, and rankings. While viewing that information requires Internet access, coaches can also use the system to place automated telephone calls to all players and track telephone responses. These and other new applications will be further supported by technology still under development.

### **Networked Businesses: More Than Online Sales**

The Census Bureau's *E-Stats* data presented earlier painted a picture of uneven e-commerce uptake. However, the prospect of increased efficiency, lower costs, improved customer service, and global reach has caused most businesses at least to consider how networking tools, such as the Internet, could be used to increase their competitiveness.

Network technologies are not only enablers of new sales and purchasing channels; they can be used to improve a variety of business processes. Another report from the Census Bureau considered

online processes in manufacturing plants.<sup>16</sup> This report, based on a mid-2000 survey, found that almost 90 percent of the respondent plants had some type of computer network in place at the plant and over 80 percent indicated, specifically, that they had Internet access. However, even though a large majority of plants had computer networks, only 31 percent of those plants (representing 41 percent of employment) reported accepting orders online and only 34 percent (representing 48 percent of employment), reported making online purchases. Only 16 percent of reporting plants both accepted orders and made online purchases, while 49 percent did neither.

Among plants responding to the *E-Stats* survey, the most often-reported e-business process was e-mail. Over three-fourths of reporting plants used e-mail to communicate with vendors and customers, while 70 percent used e-mail for employee communications within the plant. Smaller numbers of respondents used other e-business processes, for example, 19.2 percent reported providing online support to customers and 7.1 percent reported engaging in online bidding. Other e-business processes covered in the June 2001 *E-stats* report included, on the sales side, 11.1 percent of responding plants received online payments and 19.2 per-

<sup>16</sup> U.S. Bureau of the Census, *E-Stats: Manufacturing 1999 and mid-2000, June 8, 2001.* <http://www.census.gov/estats>.

cent provided online sales support, and on the buying side, 8.6 percent made online payments and 7.1 percent engaged in online bidding.

The fact that e-business process use in manufacturing plants is not yet widespread suggests that firms are still in the early stages of exploiting the potential of network technologies. Several factors may help to explain why online business processes are not yet widely used in manufacturing plants. Some companies interested in purchasing online may find that their vendors are not yet online or those wishing to sell online may find that their customers are not ready to make a switch to that way of doing business. However, many corporate purchases, particularly purchases of mission critical or custom components, rely on long-standing relationships. There is a degree of trust and a record of dependability that may have been built up over a period of years that purchasing managers are reluctant to abandon.

Finally, moving even a portion of purchasing online is not costless. Purchasing activities must be integrated with the firm's other internal electronic activities. The learning curve may be steep and training cost considerable. Nonetheless, competitive pressures will likely drive greater volume to this trading channel if companies continue to see savings from online purchasing. Reported savings are considerable. For example, Raytheon Company, a manufacturer of electronics and aviation equipment, reported savings of 25 percent on \$100 million worth of goods purchased at three online auctions.<sup>17</sup> However, not all participants in online marketplaces are as satisfied. In one recent survey, only 10 percent of companies participating in online exchanges felt that the exchanges had met their expectations. In general, participants agreed that organizational changes, such as standardizing and developing new procedures, improving and introducing new technology systems and introducing integration technology, are needed to capture benefits from exchanges.<sup>18</sup>

Shifting other business processes online, such as warehouse management systems, bring additional upfront costs and concerns as companies

cope, not only with integrating their various systems internally, but integrating systems between companies. While technology may one day make this integration process easier and cheaper, at present interface difficulties remains a major barrier to firms realizing the full benefits of electronic business processes.<sup>19</sup>

### Continued Technological Innovation

The foundation technologies of the digital economy—processing power, data storage, and data transmission—are dramatically more powerful now than they were only a decade ago. Furthermore, all evidence suggests that the rate of increase in the raw capabilities of these technologies will continue. However, today's online activities do not completely tap the capabilities of today's IT tools. Slow Internet connection speeds for many businesses and individuals are a particular bottleneck.

**Technological Foundations.** As shown in Figure 2.10, processing power has doubled roughly every 18 months. This has resulted in super computers and personal computers with processing power that is orders of magnitude greater than computers manufactured only a few decades ago. There is, however, no guarantee that this rapid growth in processing power will continue. As the number of transistor per chip grows, chip making becomes technically more difficult and more expensive. However, industry participants are working towards new chip production processes based on new lithography technologies that would keep costs down and enable the continuation of today's processing power trends.<sup>20</sup>

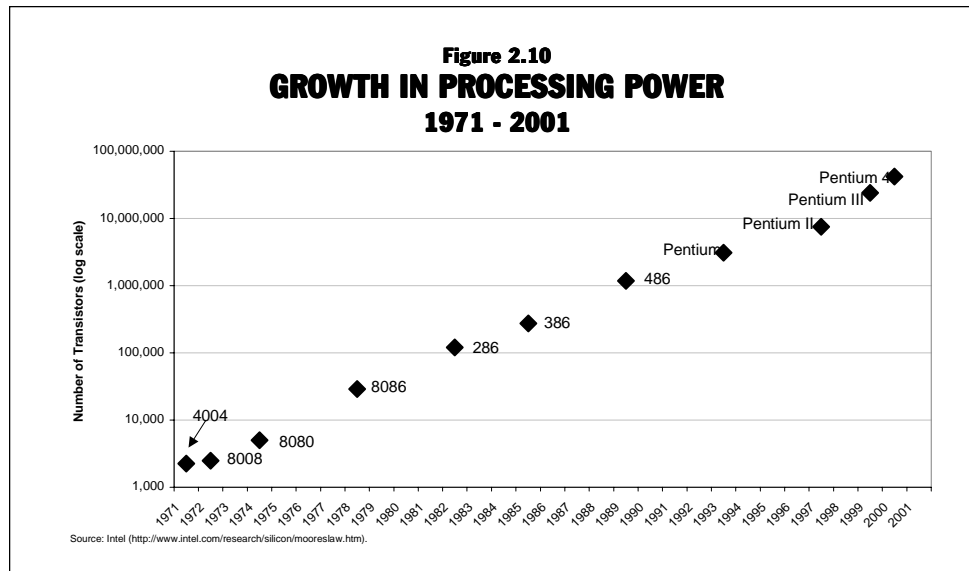
In the meantime, researchers have begun developing a techniques to get more computing power out of existing resources. For example, "grid" or "distributed" computing take advantage of unused processing power across various computer networks, such as an office computer network or even from across the Internet. In grid computing, a central computer parses a problem into discrete components and distributes the computational work over an array of networked computers. Each of

<sup>17</sup> Bob Tedeschi, "E-Commerce Report: Companies in No Hurry to Buy Over the Internet," The New York Times, March 5, 2001. <http://www.nytimes.com>.

<sup>18</sup> Giga Information Group/Booz Allen Hamilton Study: B2B Exchanges Not Yet Delivering Benefits, News Release, November 19, 2001. <http://www.gigaweb.com>.

<sup>19</sup> James Aaron Cooke, "Making the Right Connections," Logistics Management & Distribution Report from Logistics Online, February 2001. <http://www.manufacturing.net/magazine/logistic/archives/2001/lm0201.01/lm0201system.htm>.

<sup>20</sup> Gary Stix, "Getting More for Moore's Law," Scientific American, April 2001 ([www.sciam.com/2001/0401issue/0401innovations.html](http://www.sciam.com/2001/0401issue/0401innovations.html))



the networked computers computes its portion of the project and sends the completed work back to the main computer. The result is massive total processing power achieved not through better hardware, but through software coordination of existing hardware. The Departments of Defense and Energy, the National Science Foundation (NSF), and the National Aeronautics and Space Administration are each financing grid projects.<sup>21</sup> The NSF granted \$53 million to fund TerraGrid, a “grid” computing project that will link four U.S. supercomputer sites.<sup>22</sup>

In the longer term, quantum computing—using circuits created out of individual molecules—has the potential to yield advances in processing power that dramatically exceeds what is possible today. If realized these molecular-scale processors would enable the development of computers capable of addressing computational problems that are, for all practical purposes, unsolvable using current technologies.<sup>23</sup> Even in today’s environment where investors are skeptical of technology investments, quantum computing and other nanotechnology research appears to be drawing investment money.<sup>24</sup>

Transmission speeds are also on the rise. Transmission speeds over fiber optical cable have been

<sup>21</sup> Steve Lohr, “I.B.M. Making a Commitment to Next Phase of the Internet,” *New York Times*, August 2, 2001.

<sup>22</sup> Jeffrey Benner, “A Grid of Supercomputers,” *Wired News*, August 9, 2001 ([www.wired.com/news/business/0,1367,45977,00.html?tw=wn20010810](http://www.wired.com/news/business/0,1367,45977,00.html?tw=wn20010810)).

<sup>23</sup> “Quantum Dreams,” *The Economist*, March 7, 2001 ([www.economist.com](http://www.economist.com)).

<sup>24</sup> “The Smaller the Better,” *The Economist*, June 21, 2001 ([www.economist.com/science/tq/displayStory.cfm?Story\\_ID=662220](http://www.economist.com/science/tq/displayStory.cfm?Story_ID=662220)).

doubling every 12 months. French and Japanese companies have each announced experimental results in which they transmitted more than 10 trillion bits per second through a single optical fiber.<sup>25</sup> Researchers are also working on developing all-optical networks, which would even further increase transmission speeds by eliminating the current requirement of converting optical signals to electronic signals to route them.<sup>26</sup>

Advances in digital data storage technologies have taken place concurrently with those in data processing and communications technologies. Disk capacities have been doubling every nine months.<sup>27</sup> As in the case of processing power, these advances have also come at decreasing costs. The price per megabyte for hard-disk drives fell from \$11.54 in 1988 to \$0.04 in 1998, and an estimated \$0.01 in 2000.<sup>28</sup> (Figure 2.11) There also has been a proliferation of inexpensive and portable consumer-oriented digital data storage technologies.<sup>29</sup>

**Overcoming the Broadband Bottleneck.** While the transmission speed of communications technologies, such as fiber optics, is increasing, these high-

<sup>25</sup> Jeff Hecht, “Fiber Crosses the 10-Trillion-Bit Barrier,” *Technology Review*, March 27, 2001 (<http://www.technologyreview.com/articles/hecht032701.asp>).

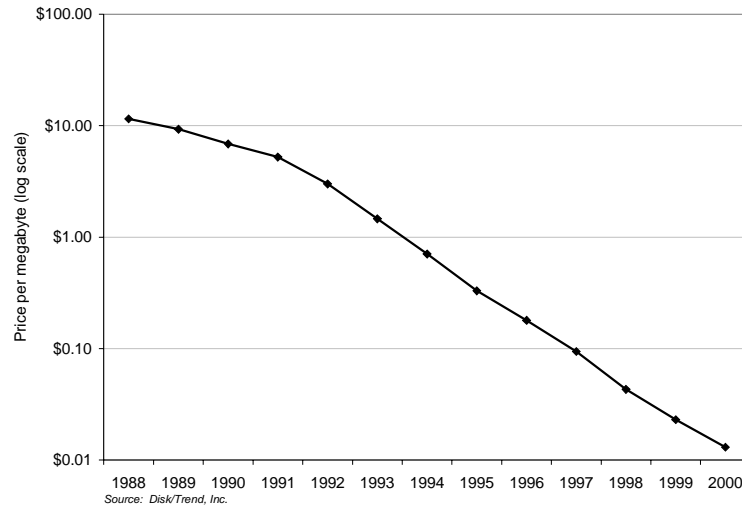
<sup>26</sup> Peter Heywood, “Optical Networking In Five Easy Pieces,” *Business Communications Review*, May 2000.

<sup>27</sup> Jon William Toigo, “Avoiding a Data Crunch,” *Scientific American*, May 2000, (<http://www.sciam.com/2000/0500issue/0500toig.html>).

<sup>28</sup> Correspondence with James N. Porter, *Disk Trend*, on October 1, 2001.

<sup>29</sup> Michael Marriott, “In the Storage Race, Will Consumers Win?” *The New York Times*, April 5, 2001.

**Figure 2.11**  
**DRAMATIC DECLINES IN THE COST OF DIGITAL DATA STORAGE**  
**ILLUSTRATED BY FALLING AVERAGE COST PER MEGABYTE**  
**IN HARD DISK DRIVES**



speed technologies are not distributed throughout the networking infrastructure. This creates transmission bottlenecks.

The most dramatic advances in transmission capacity can be seen in long-haul infrastructure, which is largely constructed using fiber optic cable. Because of the costs associated with installation, however, fiber is generally not used in the “last-mile” connections to homes and businesses.<sup>30</sup> In time, fiber may be used to bridge the last-mile. Today, however, communications companies are trying to provide higher bandwidth communications by upgrading existing infrastructure.<sup>31</sup> Most home and businesses already have at least one communications line that can be upgraded to provided high-speed Internet access. At the close of 2000, there were 5.2 million residential and small business subscribers to high-speed communications lines in the United States.<sup>32</sup>

<sup>30</sup> A few communications companies have instituted trials of “fiber to the curb” and “fiber to the home” in new housing developments.

<sup>31</sup> The diffusion of broadband depends largely on the communications section—a sector that is fundamental to the Internet and the IT-driven changes that are underway and a sector that is being wracked by both these new forces and the current economic slowdown.

<sup>32</sup> Federal Communications Commission, “Federal Communications Commission Releases Data on High-Speed Services for Internet Access,” Press Release, August 9, 2001 ([http://www.fcc.gov/Bureaus/Common\\_Carrier/News\\_Releases/2001/nrcc0133.txt](http://www.fcc.gov/Bureaus/Common_Carrier/News_Releases/2001/nrcc0133.txt)).

In addition, broadband wireless communications—e.g. satellite and “fixed-wireless” technologies, such as LMDS (Local Multipoint Distribution Service) and MMDS (Multipoint Microwave Distribution System)—can substitute for broadband home access. Communications companies are also developing broader bandwidth wireless networks for mobile use.

Wireless communications networks, however, have bottleneck problems of their own. At present, wireless data applications are relatively rudimentary because most wireless networks still operated at low bandwidths. Today’s fastest wireless (“second generation wireless”) data transfer rates are about 14 Kb/sec or four times slower than the average dial-up connection.<sup>33</sup>

Although there have been many press reports about the “third generation” (3G) wireless, promising speeds as much as 150 times faster than current data rates, the combination of a slow economy and the technological complexity of 3G has caused many communications companies to delay their 3G deployment plans. Faster wireless bandwidth will ultimately be deployed, but 3G has been temporarily set aside for interim technologies that exploit the existing wireless infrastructure.

<sup>33</sup> “Sprint Leads Evolution to 3G with Nation’s Clearest, Fastest, Most Economical Migration Strategy,” PR Newswire, March 20, 2001.

### Outstanding Policy Issues

Adopting network technologies has proved more challenging than many observers originally thought. Not only have businesses, governments, and individuals had to cope with rapidly changing technology, uncertain business models, and shifting economic conditions, but a variety of public policy concerns have proved difficult to address.

One of these is privacy. In order to provide service to customers, online businesses must be able to track the customer at least from the point at which the customer signals they want to make a purchase. Privacy concerns focus on the uses of that customer information beyond the point of that immediate need.

Businesses operating online also face specialized variants of consumer concerns in the area of security, authentication, and fraud. Security (e.g., protecting credit card numbers from misuse) and authentication (e.g. verification of a seller's identity) are concerns that are being addressed by a combination of encryption technologies and legislation, such as the consumer consent provision of the Electronic Signatures in Global and National Commerce Act (ESIGN). Fraud, in particular, remains a source of concern—particularly Internet auction fraud, which has accounted for 64 percent of all Internet fraud reported to the Internet Fraud Complaint Center (IFCC).<sup>34</sup>

### CONCLUSION

As the 1990s closed, the marketplace was littered with failed ideas related to the provision of some good or service over the Internet. Some were unsustainable business plans—there was no way

to generate enough revenue to cover costs, much less make a profit. Others did not pass the test of the market—business and consumers simply did not want or need the products and services at the price offered. Today, the environment is much more cautious and there is a great deal of uncertainty about what businesses and consumers do on the Internet, what products and services they want, and what they will be willing to pay for them. The continual barrage of reports on Internet use and opinion surveys attests to the effort underway to divine the Internet's future.

The digital technology revolution has not ended, but the costs of change are easier to see. The uptake of technologies has been slower and more uneven than expected as businesses sift through a myriad of options to find IT solutions suited to their needs. Numbers of dot.com companies have closed their doors; but many more remain.

If we consider the history of other technological revolutions, none of this should be a surprise. Of nearly 1,000 U.S. companies that tried to build and sell gas-powered automobiles before 1927, only 200 survived long enough to bring a commercially suitable vehicle to market.<sup>35</sup> Of these, fewer than a handful operate today, but they account for a substantial share of a much larger economy. The lesson is that technological revolutions take time, and the digital technology revolution has barely begun. Throughout the current economic slowdown and retrenchment in the dot.com sector, U.S. companies have expanded their use of IT and networking technologies in a continuing search for competitive advantage. More slowly than we might have predicted, but no less relentlessly, these efforts are transforming our economy and our lives.

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<sup>34</sup> The Internet Fraud Complaint Center "Internet Auction Fraud," May 2001. The IFCC is a partnership between the Federal Bureau of Investigation (FBI) and the National White Collar Crime Center (NW3C). (<http://www.ifccfbi.gov/strategy/pressroom.asp>).

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<sup>35</sup> Lawrence H. Seltzer, *A Financial History of the American Autoas cited in General Motors, "Competition and the Motor Vehicle Industry," a Study submitted to Subcommittee on Antitrust and Monopoly of the Committee on the Judiciary of the United States, April 10, 1974.*

