

of consumption as a growing number of goods and services are distributed to new buyers without diminishing others' consumption.

Human beings have always put their brainpower to use, but today's explosion of knowledge is playing out in an era in which national borders are less of an impediment to the movement of goods, services, money, people and ideas. The combination of knowledge and globalization provides the U.S. with the best of all worlds—the benefits of not only our nation's intelligence but the entire planet's.

Gaining Knowledge on a Global Scale

Today's world teems with knowledge. Remote robotic surgery exemplifies our store of highly specialized knowledge, the vast scientific and entrepreneurial expertise behind our era's great technological leaps. More than 5 million researchers are at work around the world, literally creating knowledge. We're operating more think tanks and publishing more scholarly articles than ever. Each year, the world adds mountains of new information in

computer files and on paper, film and compact disc—enough to fill 37,000 Libraries of Congress, with its 17 million volumes. (*See Exhibit 1.*)

Over the past 35 years, literacy spread from 63 percent to 82 percent of the world's population. Average years of schooling rose from 5.1 in 1970 to 6.7 today. The global supply of college graduates has more than doubled since 1980.

Almost 900 million personal computers are in use worldwide—roughly one for every seven people. The best of them are 40 times



EXHIBIT 1 In the Know

Today's economies are knowledge-rich. The world is better educated, with far more resources dedicated to science and research than just a quarter century ago. Technology facilitates the collection and management of information, as well as its spread around the world.

World Knowledge Indicators	Now	Then	
College degree holders, total	212 million	82 million	1980
Share of population, ages 25+	9.1%	5.3%	1980
Bachelor's degree graduates	9.1 million	4.3 million	1981
Doctoral degree graduates	293,085	114,808	1983
Science and engineering doctorates	154,710	57,217	1983
Science and engineering doctorates in China	10,096	125	1985
College professors worldwide	8.5 million	3.8 million	1980
Think tanks	318	160	1980
R&D researchers	5.1 million	1.9 million	1985
R&D spending	\$667 billion	\$276 billion	1981
Scientific articles published	698,726	466,419	1988
Human genome base pairs decoded	all 3.1 billion	0	1990
Wikipedia articles	5.3 million	0	2001
Patent applications	1.1 million	701,151	1985
Licensing revenue	\$109.8 billion	\$10.8 billion	1980
Information Infrastructure and Use			
Personal computers	898 million	131 million	1990
per 1,000 people	140	19	1990
Landline phones	1.2 billion	333 million	1980
per 1,000 people	217	75	1980
Cell phones	2.7 billion	11.2 million	1990
per 1,000 people	416	2	1990
Countries connected to the Internet	209	20	1990
Secure Internet servers	401,050	0	1990
Internet web sites	110 million	9,300	1990
Host computers connected to the Internet	395 million	313,000	1990
Internet storage (terabytes)	532,897	0	1990
Semiconductor sales	\$248 billion	< \$1 billion	1980
IT capital stock (U.S.)	\$1.05 trillion	\$16.7 billion	1980
Digital video recorders	17.4 million	0	1990
Information Capacity and Speed			
Portable memory storage (megabytes)	16,384	1.44	1990
Data transfer rates (kilobytes per second)	100,000	9.6	1990
Processor speed (millions of operations per second)	21,600	16	1990
Broadband subscribers	217 million	0	1990
Annual information flow via TV, radio, Internet, e-mail, IM, phones (terabytes)	18.8 million	n/a	—
Communication Use			
International telephone traffic (minutes)	145 billion	8.7 billion	1980
Internet users	1.02 billion	2.6 million	1990
per 1,000 people	157	.5	1990
E-mail accounts	1.4 billion	0	1985
Voice over Internet protocol subscribers	24 million	0	1990
TVs per 1,000 people, worldwide	287	126	1980
TVs per 1,000 people in China; India	382; 84	9; 6	1980

more powerful than the machines of just a decade ago. Our capacity to store knowledge has become immense. A single USB memory stick can hold as much data as nearly 11,400 of the 3.5-inch diskettes that were standard issue in the early 1990s. A decade and a half into its existence, the Internet can store the equivalent of 62 stacks of 500-page books reaching to the moon.

Connectivity puts worlds of knowledge at our fingertips. Internet users can tap into more than 110 million web sites. Wikipedia delivers a vast store of information in a fifth of a second at virtually no cost. (See *Exhibit 2*.) The Internet Archive's Wayback Machine offers a digital library of 85 billion documents, images and audio files—a massive compendium of all the information ever posted on the

Internet. The free site receives 300 hits a second.

All this information would be overwhelming without the tools to find what we want. Digital technologies make it easy to scour the world for news, images, business opportunities, job openings, suppliers, and the best prices for all sorts of goods and services. In the U.S. alone, Internet users conducted an average of 213 million searches a day in April 2006. And it didn't cost them much. Like many Internet offerings, search engines deliver highly valued services at minimal cost—in fact, free at the margin.

We possess not only more knowledge but also better and cheaper ways of sharing it. Information once traveled at the speed of foot, hoof and sail. Telegraphs, telephones and teletype machines greatly increased

the information speed limit—but they were expensive and not widely used. Only in the past decade or so have costs fallen enough to ignite a global communications explosion.

Go back in time and consider the telegraph, an 1837 invention that succumbed to progress in 2006, when Western Union discontinued commercial service. In terms of U.S. wages, the cost of a 10-word international message dropped from 93 hours' pay in 1900 to 11 hours' in 1930 to 84 minutes' in 1960. Despite the plunge in cost, international telegrams never reached prices ordinary Americans deemed a bargain. On average, they sent just one overseas telegram every six years from 1930 to 1960. (See *Exhibit 3*.)

Real costs plummeted for U.S. international telephone service,

EXHIBIT 2 An Encyclopedia That Speaks Volumes

Measured in words, Wikipedia passed 100 million in January 2004, 1 billion in February 2006 and 1.7 billion in September 2006. Just as important, the online encyclopedia dispenses information in Swedish, Russian, Chinese, Portuguese and 245 other languages—a testament to the Internet as a truly global information source.

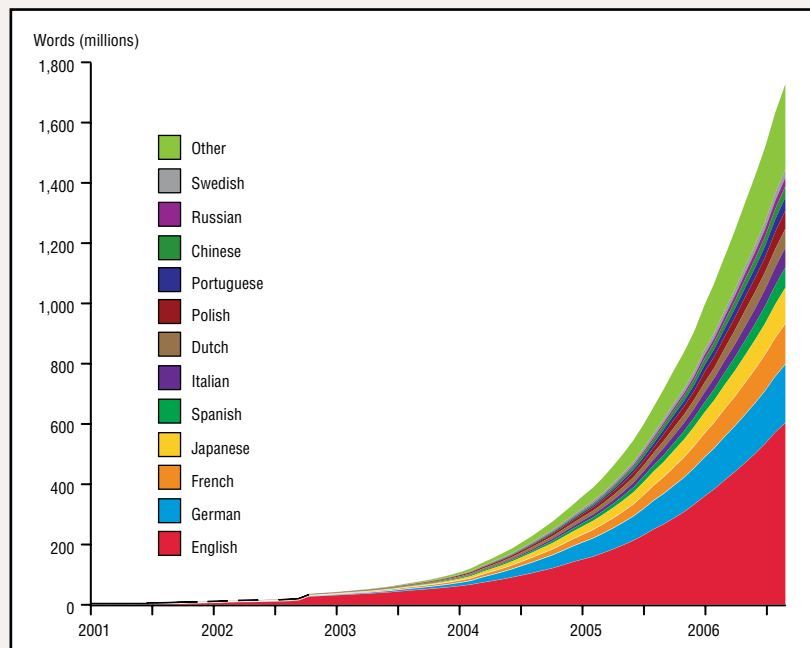
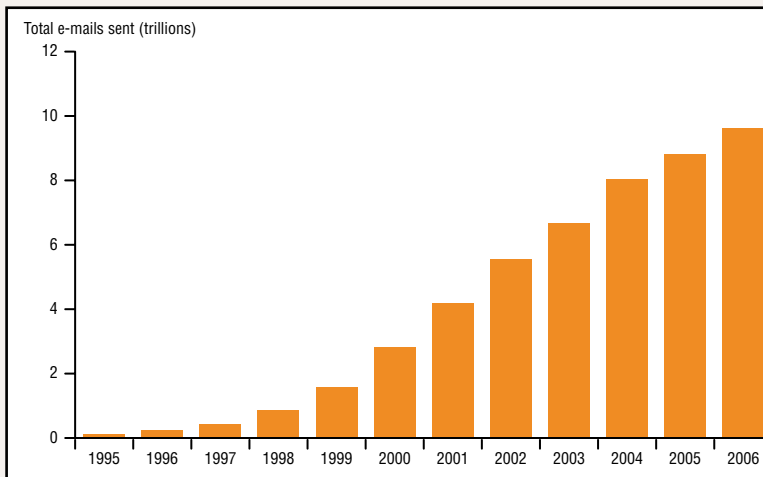
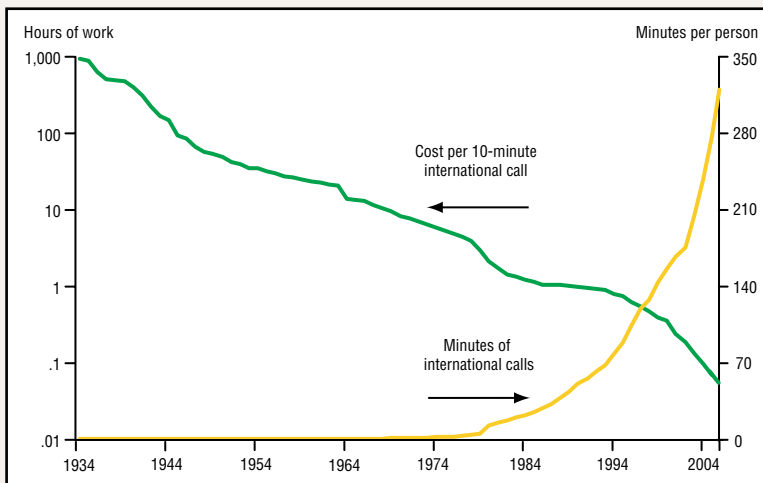
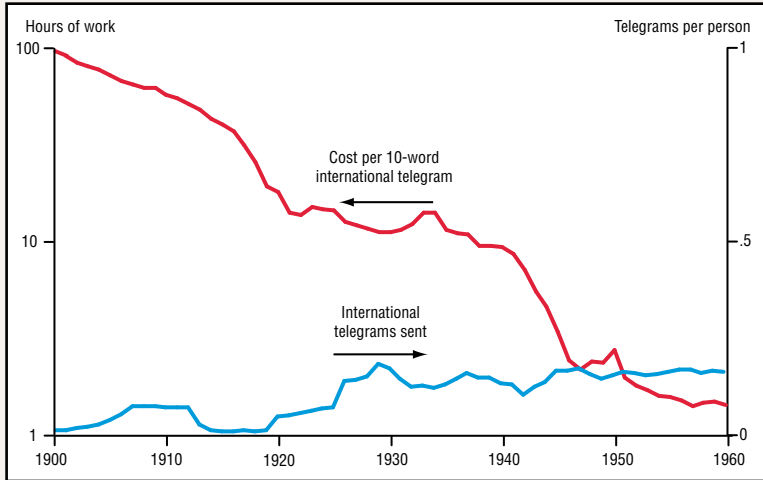


EXHIBIT 3 Ties That Bind

Communications spur globalization because they facilitate the spread of knowledge and information across borders. International connections were once prohibitively expensive, but cheaper telephone calls and the Internet have given them a powerful boost in recent years.



Cheaper Communications

The Telegraph

The work-hour cost of sending a 10-word message overseas fell 98 percent over 60 years. International telegram traffic, however, peaked in 1929 at just one message for every six people.

The Telephone

International call volume languished for decades, despite a long-term decline in the real cost of service. Growth began to take off only in the past two decades as the toll became nearly negligible.

The Internet

E-mailing is cheap—whether messaging someone in town or Timbuktu. The number of messages, even excluding spam and advertising, has surged as more people have become connected around the world.



just as they did for telegraph service. A 10-minute international call fell from the equivalent of 844 hours' pay in 1934 to 10 hours' pay in 1968 and one hour's in 1990. The steep decline didn't spur a boom in international communications. In the past decade and a half, however, U.S. rates have dropped 95 percent, reaching just three minutes' work time in 2006. Over this period, annual international call volume skyrocketed as the service finally became cheap enough for the masses. Use jumped from a half hour per person in 1987 to almost five hours today, an increase twice as large as what occurred in the 70 years after the start of transatlantic service in 1927.

Today, communication is omnipresent, fast and cheap. The world is better connected than ever, with 22 landlines and 42 cell phones for every 100 people. The Internet has emerged as a virtual

global village. A total of 209 nations are now online, up from just 20 in 1990. A sixth of the world's population has regular Internet access, and cybercafes cater to millions more.

Spiderwebs of fiber-optic cables give us the bandwidth to move massive amounts of information nearly anywhere in a heartbeat. Today, the world has 217 million broadband subscribers, with Internet connections capable of transferring the equivalent of 6,100 pages a second. It took 30 minutes to send the same pages at the standard modem speed in 1997.

The sharp decline in computer communication costs has spurred a rapid expansion in traffic. The Internet and e-mail—part of our lives for only 15 years—have spread quickly. We maintained 1.4 billion e-mail accounts in 2006. Worldwide business and

personal e-mail traffic jumped from 18 per capita in 1995 to nearly 1,500 in 2006.

Additional barriers to connectivity will crumble if countries and donors buy into MIT professor Nick Negroponte's \$100 laptop, which incorporates a hand-cranked generator and Wi-Fi transmitter. The device aims at nothing less than bringing the world's knowledge to bright minds wherever they may be—even among the most isolated students.

In just a few years, digital communications have done for information what transportation technology did for goods. In 1956, a North Carolina trucking company owner named Malcolm McLean introduced containerized shipping, featuring 40-foot steel boxes that could be lifted from ships to trucks or trains without repacking.

In the decades that followed, huge container-shipping companies from the U.S., Taiwan, Denmark, South Korea and elsewhere vied for cargo, helping cut real ad valorem global ocean freight rates by 40 percent since the early 1970s. (*See Exhibit 4.*)

Efficiency gains have been impressive in ground shipping, but they've been even greater in air cargo, especially over longer distances. In 1970, doubling airfreight distance would have increased shipping costs by 43 percent. Today, sending air cargo twice as far raises prices only 16 percent.

Brainpower and communications mark our modern economy. The more we know, the more we communicate, the more we can gain from globalization.