

Information Technology

ABSTRACT: The information technology (IT) industry affects virtually every industry in the new economy. During the late 90's, the IT industry contributed 30% to U.S. GDP growth. Additionally, every military service transformation relies heavily on IT. An IT advantage is truly a U.S. competitive advantage. However, to maintain this advantage, several challenges must be addressed. These include ensuring a supply of skilled labor, maintaining an environment that encourages research and development (R&D) and innovation, increasing broadband deployment, and protecting intellectual property rights. Additionally, American society's growing reliance on IT also creates vulnerability that governments and the private sector must solve together. Correcting this vulnerability and maintaining world leadership in the IT industry are crucial to maintaining a competitive advantage for the US. Across all instruments of national power: economic, military, diplomatic, and informational.

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A Healthy U.S. Information Technology Industry is Fundamental to our National Security

I. Introduction. The United States Information Technology (IT) industry has been a major contributor to the growth of the U.S. economy throughout the '90s. Over the last decade, the American economy has grown faster with lower inflation than at anytime since the Vietnam War - largely due to advancements of IT systems and resultant productivity enhancements benefiting most U.S. industries. The global information and communication technology (ICT) marketplace grew from \$1.3 trillion in 1993 to over \$2.4 trillion in 2001 - a compounded annual growth of 7.6%.¹ Major studies have credited the use and production of IT with almost three-quarters of the acceleration seen in U.S. productivity growth from 1996 to 1999.² However, current economic conditions have caused a dramatic decrease in business investment. While, U.S. productivity grew at a 5.6% rate for the 12 months following September 11, 2001, it did so primarily by cutting payrolls to cope with flat or falling prices – not through investment in IT.³

Virtually every American industry has benefited from advances in information management and IT. Simply put—in the New Economy, America's economic competitive advantage is really an IT advantage. IT contributions are not limited to America's economic base; IT is also helping to transform the U.S. military from a Industrial Age platform-based force, into an Information Age, fully networked, capabilities-based force. Every military service transformation plan relies heavily upon IT as a means to substitute speed and precision for mass. Given our heavy dependence on IT and the great importance of the IT industry, the question becomes how do we promote a healthy, robust, and growth-oriented IT industry. This paper examines the IT industry, specifically the current health of the industry, challenges being faced, and a 1 – 10 year outlook for the industry. It then examines the major issues that affect each portion of the IT business cycle. Additionally, this paper will examine the role of government in addressing these challenges and ensuring this country maintains a worldwide IT advantage. The 2003 IT Industry Study Group based this study on a combination of 40+ company and trade association visits in the U.S., Thailand and Japan, and extensive research.

II. Definition of the Industry. The Information Technology (IT) industry is broad in scope, spanning a number of technology-rich industry elements. *Digital Economy 2002 (DE2002)*, the U.S. Department of Commerce's fourth annual report on the impact of IT on the U.S. economy, defines the IT industry as “producers of goods and services that support IT-enabled business practices and processes across the economy, as well as the Internet and e-commerce.”⁴ The Information Technology Association of America (ITAA) refers to the industry as a “collection of products and services that turn data into meaningful, accessible information.”⁵ The IT industry has four main sectors: (1) hardware (computers and networking equipments), (2) software/services (systems and applications software; computer professional and processing services; and Internet service and access providers, and user destinations), (3) communication equipment (wireless and wireline equipment, cable and telephone networks and infrastructure), and (4) communication services (wireless and wireline service providers). Some segments of the hardware sector, as defined by *DE2002*, overlap with the ICAF Electronics industry study (e.g., semiconductor, printed circuit boards, electron tubes, etc.). To improve specific analysis

of the IT industry, this study will use eight of the 52 Standard and Poor's (S&P) Industry Surveys to define the IT industry. The eight selected industry surveys include:

- Hardware (Computer Hardware and Networking)
- Software/Services (Computer Software, Commercial Services, and Consumer Services & the Internet)
- Communication Equipment
- Communication Services (Telecommunications: Wireless and Wireline)

III. Current Industry Conditions. S&P's Industry Surveys provided the basis for most of the analysis in this section, with actual data through 2001. Our visits confirmed the validity of this data and industry projections through 2004. The overall IT market is flat. Numerous corporate executives did not see any major rebound during the remainder of the 2003 calendar year. The empty buildings, offices, and parking lots were a very striking testimony to the industry reduction. Companies are making concerted efforts to focus on core business products while employing IT solutions in-house to enhance their productivity. In addition to becoming leaner, companies within the industry were focused on profits and looking for possible merger opportunities to enhance market share or future growth.

Figure-1 shows total IT industry revenue for 2001 reached \$921.7 billion, a 5.1% reduction from the industry peak in 2000. This is a marked decline from the average 15.6% growth recorded in 1999 and 2000 – a reflection of the burst of the technology bubble. Market values of IT stocks were in decline as evidenced by the NASDAQ composite index which ended 2000 down 39%, the biggest drop in the index's history. Also, an astounding 346 companies, or 35% of those tracked by CNET Networks Inc. Investor, lost more than 80% of their value.⁶

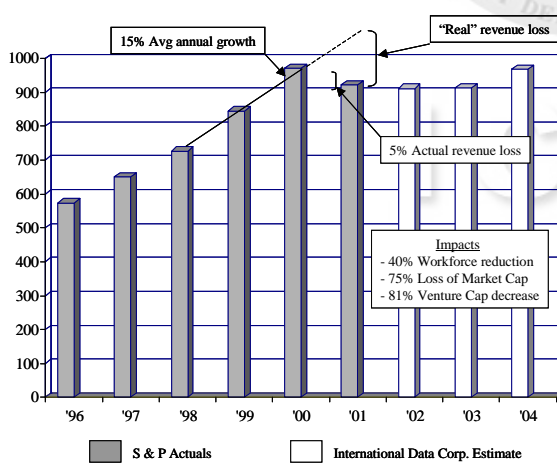


Figure-1 Industry Operating Revenues

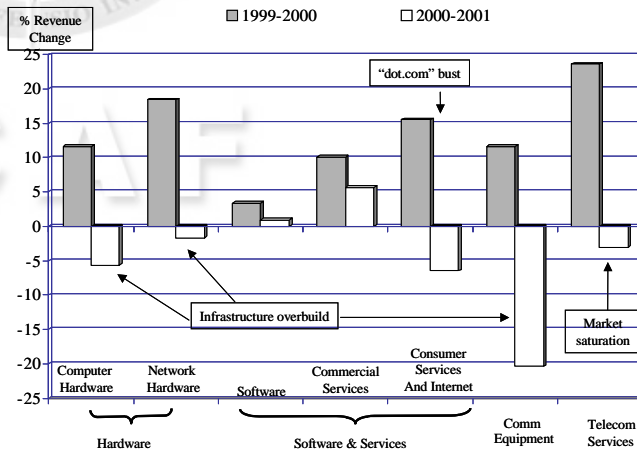


Figure-2 Industry Sector Performance

Current conditions and market performance in the industry varies by sector as shown in Figure-2. Overall, depressed revenues in the hardware-dominant sectors reflect a weak global economy, tight capital markets, declining prices, and prior over-investment in IT infrastructure. Performance within the software & services sector was generally better than that of the hardware, communication equipment, or telecommunication service

sectors, as businesses invested in software applications and technical services to reduce operating expenses and improve productivity while leveraging existing infrastructure.

- **Hardware (Computers and Networking)**

Computers. The computer hardware industry has three main segments, with PC's accounting for 77% of total revenues, servers for 20% and workstations for 3%.⁷ According to the S&P's Industry Survey, total hardware revenue in 2001 was \$216.7 billion, down 5.6% from the market peak in 2000. However, recent data shows that the computer industry may be rebounding – computer sales have risen the last three quarters and consumer spending on computers is up 3.7% from the 4th quarter of 2001 to the 4th quarter of 2002.⁸ The trend for the PC market remains healthy due to the accelerating rate of Internet adoption and associated PC requirements, the prospect of a post Y2K upgrade cycle, and a likely economic recovery in 2003. The near-term outlook for server demand remains lackluster due to the uncertainty in global corporate IT spending. Growth in the workstation segment will remain a challenge due to pricing pressures from the influx of lower priced PC-based systems.

Networking. The networking industry provides equipment that constitutes the infrastructure (Ethernet switches, access equipment, routers, fiber optic cable) of the network, supporting wide area network (WAN) and local area network (LAN) applications. The industry leader, Cisco Systems, Inc., dominates the market by a significant margin. The networking industry is struggling to recover from a steep downturn in the market. The collapse of the telecom market and severe cutbacks in capital spending by other service providers led to the significantly lower revenues. Total (Computers: Networking) operating revenues in 2001 for the 11 companies listed in the S&P's Industry Survey was \$31.3 billion, down 1.7%.⁹

- **Computer Software, Services, and Internet**

Software. The U.S. is the worldwide leader in the software industry – 22 of the 25 top software and service companies have corporate headquarters located in the U.S.¹⁰ Microsoft is the leading software producer, with 2001 revenues of \$25.3 billion. Total operating revenues in 2001 for 64 companies listed in the S&P's Industry Survey for Computers: Software marginally improved to \$72.1 billion, a 0.9% increase from 2000.¹¹ Entertainment and video game software providers enjoyed success. U.S. sales jumped 43% in 2001 to \$9.4 billion. Internet security software is another area of growth with projected 2002 revenues of \$4.3 billion, an 18% increase from 2001.¹² Linux open source software operating system is also on the rise. IDC projects Linux revenues may reach \$21.1 billion in 2004, a four-fold increase from 2001.¹³

Computer Services. Overall, U.S. firms specializing in computer services maintained a strong position in the industry; accounting for nearly 50% of the worldwide IT services market in 2001. Operating revenues of the 36 companies listed in the S&P's Industry Survey, Computers: Commercial Services, were \$85.6 billion in 2001, up 5.6% from the prior year.¹⁴ Independent Data Corporation (IDC) projects continued growth in the worldwide IT services market at a compound annual rate of 10.6%, reaching \$674 billion by 2006.¹⁵

Internet. The Internet Service Provider (ISP), America Online, dominated the market with 34.6 million U.S. subscribers as of mid-2002, four times as many subscribers as the next largest company, Microsoft's MSN.¹⁶ IDC estimates the U.S. ISP market will grow from \$23.9 billion in 2000 to \$80.6 billion in 2005.¹⁷ According to eMarketer, a New York-based online research firm, Business-to-Consumer (B2C) Internet spending in the U.S. will grow from \$50.9 billion in 2001 to \$155.6 billion in 2005. "Pure-play" online retailers Amazon.com, Barnesandnoble.com Inc., Priceline.com Inc., and Hotels.com are some of the market leaders. The Business-to-Business (B2B) segment dwarfs the B2C segment. eMarketer estimates B2B revenues of \$474.3 billion in 2001 will grow to \$2.4 trillion in 2004. Companies like Cisco Systems and Dell Computer are leaders in e-commerce processes. Cisco performs 80% of its sales online, averaging \$43 million per day in revenue, as of April 2002.

- **Communication Equipment.** The communications equipment industry has contracted in response to lower demand. As a result, communications services providers' spending declined by 15% in 2001 and by an additional 60% in 2002.¹⁸ Many communications equipment manufacturers have made large reductions in their workforce (especially Lucent and Nortel), instituted various cost cutting measures, and sold non-essential assets in response to the downturn. However, data suggests the conditions within the communications equipment industry will improve. Network utilization rates are approaching 70% in larger metropolitan area. S&P's estimates that service providers will therefore spend more than \$1 trillion to upgrade equipment and services during the next four years. Another action that should spur industry growth is expected growth in broadband usage, which will require an investment in new infrastructures on the part of Communications Service Providers. A final factor that should help is the continuing growth in Internet customers. IDC forecasts that approximately 100 million new users will access the Internet annually between 2002 and 2006 and estimates that by 2006, 16% of the world's population will connect to the Internet at least once each month.¹⁹

- **Communication Services (Wireless and Wireline)**

Wireless. According to Cellular Telecommunications & Internet Association (CT&IA) estimates, industry revenues for wireless service totaled approximately \$76.5 billion in 2002.²⁰ The CT&IA data shows that the wireless telecommunications industry had approximately 140.8 million subscribers at the end of 2002, an increase of 9.7% from 2001. However, this is significantly below the estimated 13% increase that S&P's predicted.²¹ Between 1993 and 2002, the number of wireless subscribers in the U.S. rose from 16 million to nearly 141 million and the average monthly subscriber bill dropped from \$61.49 to \$48.40.²² Wireless telecommunications has become increasingly affordable and the market appears to be approaching saturation. In June 2002, Moody's Investor Services revised its wireless industry outlook to negative stating, "The market is moving closer to a 'zero sum' game, where one carrier's growth comes largely at the expense of other carriers."²³ For the industry as a whole to increase revenues, the industry must find ways to expand the market and/or find a way to increase average monthly phone bills.

Wireline. Revenues for wireline services have been falling in recent years as wireless telecommunications has grown. Note that the two largest wireless carriers are owned by

Regional Bell Operating Companies (RBOCs), traditional wireline providers.²⁴ Wireline voice service is a mature market characterized by intense price competition. The FCC reported that more than 93% of all households have a choice of at least two local carriers and a myriad of choices for long-distance service.²⁵ “In the ten years through 2000, average long-distance revenues per minute dropped by 59%, from \$0.29 to \$0.12.”²⁶ Although there are hundreds of long-distance service providers, the four market leaders, AT&T, MCI, Verizon, and Sprint, had a combined market share of 69%. Service providers are also moving into the Internet broadband communications area. Broadband communication through wirelines is predicted to increase in the near term. As of mid-2002, residential broadband Internet access through digital subscriber line (DSL) service from telephone companies serviced 5.1 million lines. Another 9.2 million lines received broadband Internet access through cable modems. The Yankee Group (a group which does research and consulting for IT products, services, and software) estimates that 37% of all households will have broadband service by 2006.²⁷

There is evidence to indicate the IT industry is slowly beginning to recover. The Semiconductor Industry Association (SIA) projects a 23.2% increase in semiconductor sales worldwide for 2003, and a 20.9% increase for 2004.²⁸ A March 2003 SIA report notes an average 18-20% growth in semi-conductor revenue from July 2002 through February 2003.²⁹ Global competition will continue to fuel investments in the IT industry. Demand for total customer service, improved productivity, high fidelity inventory management, and integrated information management will motivate businesses to invest. Proliferating Internet use will also drive demand for IT products. IDC projects that the compound annual rate for worldwide IT spending of 9.4% from 2001 to 2006 with total market revenues of approximately \$1.5 trillion. Most recent IDC estimates global tech spending to increase 2.3% in 2003 and 6% in 2004.³⁰

IV. Challenges and Major Issues. The IT industry’s business cycle has a lot in common with others within the high-technology segment of the economy. Its inputs are *Skilled Labor and Capital*, which enable *Research and Development (R&D) and Innovation*. The fruits of these efforts lead, in turn, to *New Products and Services*, which stimulate *Increased Productivity and Economic Growth*. As productivity increases and the economy grows, additional labor is freed and capital becomes available for greater R&D and innovation, and the process repeats itself. The cycle’s outputs are profits for shareholders and an improved quality of life for consumers, the classic “win-win” result of free enterprise.

Of course, this cycle doesn’t occur in a vacuum. What sets the IT cycle apart from others is its newly pre-eminent position within the broader economy. Think of the economy as a massive machine with many intermeshed gears of various sizes. Now, imagine the gears are various industry business cycles, and the cogs are their principle elements. Within this machine, the IT industry is the primary gear, turning many other dependent gears. Information-related technology has been around for many decades, but the past fifteen years have seen the IT industry move from the economy’s periphery to its very core. Today, IT is a fundamental input and enabler for virtually every other industry, from Agriculture to Zoology. As a result, IT is perhaps the single most strategically important industry, both economically and militarily.

So far, the U.S. IT industry has led this remarkable revolution in human affairs, and has reaped the greatest rewards. The transition from the “Industrial Age” into a new “Information Age” has created a huge economic boom with global benefits. The first phase of that boom, generated by the creation and exponential growth of the new IT industry, is coming to an end. Despite the irreversibility of the Information Revolution, many IT companies are struggling to survive the current growth plateau, or lull, in the industry. The industry is currently undergoing a process of rationalization. Many IT companies will be absorbed or go out of business as the industry seeks ever greater “operational efficiency.”

Survival took on a new meaning and additional challenges following the September 11, 2001 terrorist attacks. As noted earlier, the IT industry was stagnant before this event occurred. The horrific events of 9/11, coupled with the continued economic downturn, merely exacerbated an already bad situation for the industry. Significantly elevated security requirements, both in the physical realm as well as cyberspace, followed 9/11. The challenge is to balance these new requirements, particularly those in cyberspace, with individuals’ privacy rights. The USA PATRIOT Act, enacted as a result of 9/11, granted federal officials expanded powers to trace and intercept terrorist communications.³¹ The Act added provisions to allow increased scrutiny of Internet traffic and wiretapping of cell phones. This act essentially updated surveillance rules that had not kept pace with gains in technology.³² However, the quick passage of this act raised issues of privacy and Government accountability.

So, while the IT industry’s business cycle is still flowing – much more emphasis is being paid to bottom line profits. We’ll now examine the major challenges and issues our IT industry faces throughout its business cycle, and propose solutions to them.

a. Inputs: Capital and Skilled Labor. The IT industry enjoys an advantage over many others in that it doesn’t require a large infrastructure or natural raw materials to thrive. It can thrive wherever capital and imagination are brought together, as happened in Silicon Valley in the 1990s. As easy as this sounds, few other areas in the U.S. or around the world have been able to duplicate the Valley’s success, and even Silicon Valley itself has fallen on hard times.

- **Investment Capital.** One of America’s most important national traits is the willingness of its venture capitalists and entrepreneurs to take risks in pursuit of big payoffs. In fact, this isn’t just permitted, it’s encouraged in our schools, culture, and marketplace. Failure in a business endeavor doesn’t result in a stigma; rather it’s accepted as a reasonable risk and even as a valuable learning experience. This enterprising spirit fueled the first phase of the IT boom, and will be necessary to launch the next phase. Because few if any countries possess this essential trait to the degree the U.S. does, it’s highly likely that the “the next big thing” will originate here as long as these conditions for success continue to be nurtured. Right now, a great deal of capital is standing by, looking for the right investment. Since 2000, the amount of IT venture capital has declined from \$58 billion to \$ 11 billion,³³ but this doesn’t mean there is a shortage of funds. This year alone, the world’s largest venture capital firm raised \$ 5 billion. The biggest impediment to investment in IT appears to be caution, a new phenomenon that was notably absent during the 1990’s.

Recommendations: DoD played a seminal role in creating the Information Age through the deployment of its “DARPA.net,” which later grew into the Internet. Similar government-funded concept demonstrations can help lure investment capital back into the marketplace. However, Congress, in particular, must resist the temptation to grant research dollars based on political expedience, as opposed to economic and technological considerations.

- **IT-Skilled Labor.** Because of the IT “dot.bomb” and subsequent generalized recession, there is *currently* an abundance of skilled people to meet the needs of the IT industry. The latest Information Technology Association of America (ITAA) workforce study, the nation’s most complete analysis of IT workforce trends, revealed that despite the workforce turbulence caused by the first dot.com recession and the uncertain economic outlook, the worst for the IT industry might be over. In 2001, IT companies released 2.6 million IT workers, but they hired a total of 85,000 new workers in 2002.³⁴ Employers expect to hire an additional 1.1 million IT workers in the coming months.³⁵ The Bureau of Labor Statistics (BLS) projects that computer and data processing services will be the fastest growing industry in the U.S. economy, with employment expected to increase by 86% by 2010.³⁶ Some high demand white-collar IT jobs should see demand rise by 144% in the same period.³⁷ The BLS predicts that seven of the top ten fastest-growing occupations will be computer or IT related.

Supply and H-1B Visas. During the salad days of the 1990’s, the IT industry was forced to rely heavily on foreign skilled labor to fill the domestic shortfall. To meet the demand, Congress temporarily expanded the limit on H-1B high skilled-workers visas in 2000. The permanent cap of 65,000 was temporarily expanded to 195,000 per year until October 1, 2003. In 2001, the INS granted 163,000 H-1B visas plus an additional 342,000 to exempt organizations. That number dropped to 79,100 in 2002 due to the recession.³⁸

Recommendation: Congress should authorize scholarships, grants, and other incentives to encourage more American students to pursue studies in IT-related fields, and continue its efforts to improve primary and secondary education in math and science in our public school systems. Additionally, Congress could act to create a more flexible cap on H-1B visas that is indexed to the IT industry’s unemployment rate. This would allow for economic expansion without unnecessarily disadvantaging American workers. Continuing the H-1B visa program allows America to draw the “best and brightest” to its shores and away from potential competitors.

b. R&D and Innovation. R&D and innovation are the keys to attracting investment capital and generating new products and services that the market will find attractive. IT is a fast-changing industry, where major breakthroughs occur every year or two. Gordon Moore was thinking about hardware when he predicted this rate of change in 1965, but lately software has also been an area of great innovation and growth. In the 1990s, these two industry segments started to accelerate each other, as computers began to write software, and design software led to faster computers. Now efforts are underway that will eventually yield convergence between previously distinct technologies such as biotechnology, nanotechnology, and IT. Practical applications of this convergence may still be decades away, but the nation that achieves them first will enjoy a tremendous strategic and competitive advantage. Historically, the best incubator for successful ideas

has been the private sector, but the government can play an important role by investing and encouraging others to invest, by minimizing regulatory requirements that constrict innovation, and by working to open additional parts of the frequency spectrum for commercial use.

- **Changing Competitive Landscape.** Microsoft's improbable 1975 vision of having a personal computer on every desktop and every home has been achieved. Microsoft's Windows operating system and Office software are on more than 90% of those PCs.³⁹ However, since the 1990s the corporation has found itself battling an increasing number of anti-trust cases. In November 2002, a federal judge approved a modified Microsoft settlement with the Justice Department and nine of the 18 states that originally brought the case. The settlement required Microsoft "...to refrain from participating in exclusive deals that could harm competition, to allow manufacturers and customers to remove some Microsoft icons, to provide information to help rivals make products compatible with its dominant Windows operating software, and require uniform contract terms for computer manufacturers."⁴⁰ However, the company still faces several private suits from AOL, Sun Microsystems and others. Microsoft is also dealing with challenges from Taiwan and the European Union.

In response to the difficulties imposed by proprietary software sold by companies like Microsoft, the popularity of "open source" software has recently surged in popularity. This alternative source of computer code is beginning to stimulate a mini-boom in software development. This type of software differs from traditional proprietary software in that it's available for public scrutiny and improvement. It is free and total cost of ownership is generally lower than that of comparable propriety software. U.S. sales of Linux, the most widely used type of open source software, soared 73% to \$1.3 billion in 2002.⁴¹ California is considering a Digital Software Security Act, which would limit state software purchases to open source only. This preference for open source is also being considered in almost 70 countries, particularly developing countries where funds are scarce.⁴² Microsoft recently warned in a Securities and Exchange Commission filing that it could see sales decline, and might have to cut prices should "the open-source model" continue to gain market acceptance.⁴³ Thanks to market competition, the days of the Microsoft's monopoly threat might soon be coming to an end.

Recommendation: The U.S. government should consider the merits of both open and proprietary source software for its needs. Government requirements should be open, transparent, and technologically neutral. Additionally, the government must remain vigilant and ensure a level playing field in the market place.

- **R&D Tax Credit.** The R&D Tax Credit was first enacted in 1981 as a temporary measure and has been extended multiple times. It provides a 20% credit for qualified R&D expenditures in excess of a base amount. Current legislation expires in 2004.⁴⁴ The non-permanent nature of the tax credit is the issue. It increases the investment risk in R&D by creating uncertainty in the future cost of capital. This dissuades companies from allocating resources to long-term R&D programs. If the credit became permanent, companies would be more likely to make these investments This is critical to the IT industry – an industry driven by innovation achieved through R&D. The ITAA reports that foreign governments are trying to entice US. Companies to perform their R&D overseas, and that tax credits are an important part of their strategy.⁴⁵ The Organization

for Economic Cooperation and Development found that Spain, Portugal, the Netherlands, Canada, Australia, Japan, and the U.K. provide more generous and permanent fiscal incentives for R&D than the U.S. The opportunity costs of such an R&D migration could be significant – including loss of critical new technologies and the knowledge workers that create them. A permanent tax credit is an important incentive to increasing private sector R&D expenditures – critically needed to advance state-of-the-art technologies in the IT industry. Additionally, tax credits that spur R&D create new, highly skilled jobs for American workers.

Recommendation: Congress should quickly pass legislation that makes the R&D tax credit permanent. A permanent R&D tax credit helps ensure the technological dominance and sustained economic growth of the U.S.

c. New Products and Services. “Build it and they will come,” might work as a business model for baseball parks in mid-western cornfields, but not for IT. During the 1990’s investment boom, the industry over-expanded, leaving it with excess capacity in many areas. Eventually, demand will catch up with supply. But, consumers are staying away in droves from many services due to a combination of government regulations, high costs, and lack of perceived need.

• **Broadband.** Broadband, or high speed Internet, services available for the residential customer are the cable modem, digital subscriber line (DSL), broadband satellite, and wireless broadband. Broadband services may even be available through power line communications to the home in the future. Deployment of broadband technology would have a significant impact on U.S. GDP, with the potential to generate over \$300 billion in consumer savings per year while adding \$100 billion in revenues for the IT industry.⁴⁶ A Brookings working paper even stated, “Failure to improve broadband performance could reduce U.S. productivity growth by 1% per year or more, as well as reducing public safety, military preparedness, and energy security.”⁴⁷ The 1996 Telecommunications Act was meant to spur competition in the cable and telephone industry. As a result, competition in the long distance phone service arena has flourished and competition in the local phone service arena is finally beginning to occur. However, because of the requirement to share all networks at regulated rates, the RBOCs have had no incentive to invest in a broadband network. Meanwhile, the cable industry has remained largely unregulated. As a result, cable providers still maintain a 2:1 margin over DSL service provided by the telephone companies. The RBOCs have been pressing the FCC for relief from the 1996 Act. In February 2003, the FCC voted to end the requirements for the RBOCs to lease to competitors new or upgraded networks for high-speed, or broadband, Internet access at regulated rates. The FCC also voted to preserve regulations that govern local telephone competition, allowing state regulators to continue to decide how much competitors should pay for leasing older, existing networks.⁴⁸ However, while press releases on this ruling have been issued, no official written guidance has yet been released. Singapore and Korea have achieved broadband solutions – both using different technology, but both with strong government support.

Recommendation: Broadband deployment in the U.S. has been slowed by lack of availability of the service in some areas and high cost of service. Increased competition is required to spur innovation and lower the costs of broadband service. Government needs to ensure a level playing field across all platforms. The recent FCC ruling appears to

accomplish this. However, that ruling needs to be formalized and released as soon as possible. Government should work to encourage 1) availability of broadband access to all Americans, 2) promote competition across different platforms for broadband service, and 3) minimize the regulatory environment in order to spur investment and innovation.

• **Telephony.** The first wave of telephony was characterized by fast, reliable, and guaranteed quality of service through circuit switching. The first wave delivered a range of services to most areas of the world through a vast, carefully constructed global network. Cellular technology ushered in the second wave, an attractive alternative for developing countries, as it does not need the extensive hardwire infrastructure. Now, telephony's third wave is upon us in the form of the convergence of voice and data services. Industry seems to be moving toward Voice over IP (VoIP) using wireless technologies such as "Wi-Fi," which will bring real-time connectivity to portable, instant-on, computing devices like Personal Digital Assistants. This will allow virtual private network access, shared enterprise resources, and robust telephony in a single device.⁴⁹ The advent of VoIP could result in an intense struggle between forms of telecommunications, similar to the battle between cable and DSL providers. It's too early to know which form will ultimately prevail in the market.

Recommendation: The government must ensure fair inter-modal competition between all service providers.

• **Third Generation (3G) Wireless.** The introduction of 3G technologies in the mobile phone industry makes convergence between various devices possible. In some parts of Japan, cell phones can also be used as digital cameras, camcorders, game devices, GPS receivers, computers and Internet surfers thanks to 3G. Studies suggest that 3G networks will generate about \$320 billion in revenue by 2010, worldwide, with customized "infotainment" accounting for up to \$90 billion.⁵⁰

The U.S. lags behind other nations in the implementation of 3G technology. U.S. wireless service providers need more bandwidth to support the increased transmission speeds of 3G. However, DoD needs these same frequencies to achieve its transformation objectives. It has invested over \$100 billion in various radio systems, satellite tracking and command systems, air combat training systems, and precision guided munitions that operate in the same band. Sharing the band with 3G, isn't feasible due to mutual interference, and moving DoD systems to other bands is costly and may reduce operational capabilities. Many experts believe that this may delay convergence in the U.S. by at least a decade.⁵¹ Pessimism over 3G implementation is causing reluctance by U.S. venture capitalists to fund convergence efforts.

Another argument against the deployment of 3G services is related to the cost versus demand. The recent 3G-spectrum auction in Europe resulted in crushing debts for the major telecoms due to the high cost of bandwidth and limited return on investment resulting from lukewarm consumer demand. Until these issues are resolved, many U.S. companies will continue to opt for 2.5 G, which uses 2G frequencies, and the promise of expanded 3G-type services in this country will have to wait.

Recommendation: The U.S. must find a way to balance the needs of DoD with the needs of private industry for the RF spectrum. Other nations are surging ahead with 3G implementation. Deregulation of 3G frequencies will make convergent devices more capable, and thus more attractive to investors. While moving DoD systems to a different

spectrum is a costly proposition, prohibiting industry's use of this spectrum is perhaps even more costly. Additionally, the RF spectrum should be auctioned based on percentage of profits rather than on up-front cash. This will allow U.S. telecom companies to avoid the crushing debt burdens that have prevented other nations from building the necessary infrastructure.

- **Data Storage.** An irony of the information age is that we're rapidly increasing the total amount of information in the world, but we're also losing it at an unprecedented rate. Retaining access to archived data is difficult because storage formats and associated software are quickly superseded. For example, the 1970 census was nearly lost because it was preserved only in an outdated electronic format. New storage technology and software offer partial solutions to these challenges, but further steps, like standard formats and the creation of metadata, are required to prevent the further irretrievable loss of important information. As demand for data storage rapidly grows, disaster recovery, privacy, accessibility, power usage, archiving and preservation are issues that must be addressed. Unfortunately, over half of the world's data is on single user computer hard drives.⁵² Continuity of operations and data redundancy are now prime considerations for any business. Of the 350 companies forced to relocate due to the 1993 World Trade Center bombing, 150 ceased operations because they lost access to key data. Incidents like this are increasing the popularity of off-site storage solutions for companies dependent on e-data. Few businesses can afford the cost to rebuild lost files when just one megabyte of lost data costs an average of \$ 3,200 to reconstruct.⁵³

Recommendation: Require companies that maintain data that affects consumer private finances (e.g., banks, brokerages, and insurance companies) to maintain secure, off-site duplicate storage with no more than 24 hours between back-ups. Furthermore, all new software should have "backwards compatibility" to allow it to read data from old software.

d. Increased Productivity and Growth. In a capitalist society, this is the province of the private sector. However, government can set a good example by adopting best practices and reducing the drag it places on economic growth through its bureaucracy. To that end, e-Government can help e-Commerce to grow.

- **E-Commerce.** E-Commerce has two major segments, retail or "business to consumer," (B2C), and "business to business," or (B2B). eMarketer, an online market research and analysis firm, estimates B2C spending will grow from \$50.9 billion in 2001 to \$155.6 billion in 2005.⁵⁴ Companies like Amazon.com, priceline.com, and Hotels.com are leading the market. Most "brick and mortar" companies now have an online operation to expand and compliment their business plans. As impressive as the B2C segment is, B2B spending dwarfs it. eMarketer estimates B2B revenues will jump from \$474.3 billion in 2001 to \$2.4 trillion in 2004, led by companies like Dell Computers and Cisco Computers, which does 80% of its sales online.⁵⁵ The dot.com bust hit e-commerce particularly hard. TheStreet.com's Internet Index declined 74% in 2000, 36% in 2001, and another 50% during the first half of 2002, reducing share prices for many profitable companies to penny stocks.⁵⁶ There are encouraging signs that the worst is over, though. Shutdowns have slowed dramatically, from 544 in 2001 to just 93 in 2002.⁵⁷ The survivors are those who have remained profitable, with cash reserves, and strong business plans.

One possible hindrance to a full recovery of the e-commerce industry is Internet taxation. In 1992, the Supreme Court held that the states' sales taxes were too complicated. With over 7500 taxing jurisdictions, these inflict an undue burden on the seller unless it has a physical presence or "nexus" in the collecting state.⁵⁸ In 1998, Congress extended this concept to e-commerce by passing the Internet Taxation Freedom Act (ITFA), which has been extended until 1 November 2003. It imposed a three year moratorium on "multiple" or "discriminatory" federal and state taxation of Internet transactions.⁵⁹ Unfortunately, the ITFA fails to address the critical issue of collecting sales tax on tangible products sold on the Internet or through mail order catalogues.

Recommendation: As e-Commerce, and in particular, B2C, still has vast growth potential, retail taxes will be as inevitable as they are necessary for state and federal revenues. The federal governments current suspension of Internet sales taxation should continue until "e-retailers" aren't put at a disadvantage relative to catalogue retailers and traditional "brick and mortar" stores. Once state tax codes are sufficiently streamlined to allow a level playing field between all forms of retail, the suspension on Internet taxes should be lifted. Access taxes should never be imposed, as it worse only serve to widen the digital divide.

• **E-Government.** IT can serve a variety of different ends: better delivery of government services to citizens, improved interrelations with business and industry, citizen empowerment through access to information, and improved coordination between federal, state and local governments.⁶⁰ On December 17, 2002, President Bush signed the E-Government Act. The E-Government Act of 2002 aims to enhance the management and promotion of electronic Government services and processes by establishing a Federal Chief Information Officer within the Office of Management and Budget (OMB), and by establishing a broad framework of measures that require using Internet-based IT to enhance citizen access to Government information and services.⁶¹ The Act also: 1) Creates an Office of Electronic Government within OMB to oversee E-Government; 2) Creates a Chief Information Officers Council; 3) Requires a federal internet portal; 4) Orders new government-wide policies on accessibility, usability, and preservation of government information; 5) Orders standards for agency web sites; 6) Creates an IT Training Center; 7) Seeks to improve coordination of information on disaster preparedness and response; 8) Establishes privacy protection; and 9) Promotes electronic Government and the efficient use of information technologies by Federal agencies.⁶²

Recommendation: The U.S. Government should lead by example in the continued implementation of e-Government initiatives. Putting critical government services online by the end of this decade may help spur demand for broadband.

e. External Factors. The gap between the connected and unconnected people around the world is growing in numbers and significance. There are a number of factors affecting the environment and the ability of society to reach its full potential in the Information Age. At the same time, those in the less-developed nations of the world mustn't be allowed to undermine the foundations of progress through the piracy of intellectual property. Governments and criminals shouldn't make connectivity less desirable by invading the privacy of honest citizens through various information technologies. Finally, as the world becomes more interconnected, the impact of local

problems like disease, natural disasters, or financial crises will have a more global impact, as has been the case with Severe Acute Respiratory Syndrome (SARS).

- **The Digital Divide.** The world's population provides a source of both skilled IT workers and IT consumers. Developing an educated public is critical to creating an environment that facilitates knowledge at the "speed of thought". The digital divide within countries and between societies will have a significant impact on organizations, as they become more global. The U.S. National Security Strategy recognizes that the goal of bringing IT to societies is a way to "*Expand the Circle of Development by Opening Societies and Building the Infrastructure of Democracy.*" According to the latest UN Human Development Report, industrialized countries, with only 15% of the world's population, are home to 88% of all Internet users. Less than 1% of people in South Asia are online even though it is home to one-fifth of the world's population. The situation is even worse in Africa - 739 million people and only 14 million phone lines. And, eighty percent of those lines are in only six countries. Additionally, there are only 1 million Internet users on the entire continent compared with 10.5 million in the UK. Even if telecommunications systems were in place, most of the world's poor would still be excluded from the information revolution because of illiteracy and a lack of basic computer skills.⁶³

Recommendation: The U.S. has reaped significant benefits by transitioning into the Information Age and needs to take the lead in assisting other nations with making this transition. Additionally, the U.S. needs to continue to work to minimize the digital divide within this country, with initiatives such as increasing the numbers of computers in schools and libraries.

- **Intellectual Property (IP) Rights and Piracy.** In addition to concern over preventing a monopoly from gaining control over the IT industry in the same way AT&T dominated telephony for many years, judiciaries around the world are grappling with the difficult, but all import problem of protecting intellectual property from patent and copyright infringement. Failure to do so would be a deathblow to investment and innovation. According to one industry source, 40% of software products worldwide were pirated in 2001.⁶⁴ An estimated 54% of software in India, Malaysia and Singapore is counterfeit.⁶⁵ This costs U.S. software companies an estimated \$11 billion yearly in lost sales. The problem will probably only escalate in the coming decade unless governments in Asia do more to crack down on counterfeiting. Piracy is not only an international problem. U.S. college campuses with high-speed Internet access have also become hotbeds for massive illegal file swapping of protected materials such as movies, music and software. "College students ... have an overly casual attitude about file sharing on peer-to-peer (P2P) networks. Some do not even seem to see any real moral, ethical or even legal dilemma with media piracy."⁶⁶

There has been some progress against piracy. Malaysia, recognizing the close ties of organized crime and piracy, has increased enforcement and now requires holograms that contain serial numbers on all licensed products.⁶⁷ The WTO has reported mixed progress in China, who has strengthened its IP laws, but has lagged in their enforcement. The report stated, "U.S. companies complain that, in most regions of China, the police are either not interested ... or simply lack the resources and training required to investigate these types of cases effectively."⁶⁸

Recommendation: The WTO needs to toughen its stance toward transgressor countries. Unless those governments suffer the consequences of piracy in their countries, they'll lack the incentive to enforce IP laws. It also needs to streamline its arbitration process. The average time to resolve a complaint is three years, which is double the life expectancy of any new IT-technology. As a frequent victim of this situation, the U.S. should apply diplomatic and economic pressure on the WTO to become more responsive. Additionally, this issue should carry significant weight in U.S. bilateral relations.

- **Cyber-Security.** From 1999 to 2001, the number of computer security breaches reported to the computer emergency response center at Carnegie Mellon increased from 9,859 to 52,658. A total of 43,136 security breaches were reported for the first six months of 2002.⁶⁹ Cyber crime costs shareholders billions each year, and has the potential to cripple the national information infrastructure by attacking computer control systems. Unfortunately, dollars spent on security are unavailable for other requirements, such as, R&D or shareholder distributions. The business community must recognize that the cost of inaction greatly exceed the cost of implementing appropriate security measures. Technology has advanced to the point where personal privacy in the historic sense may no longer exist. Due to new and emerging threats to national and international security, this technology can be used to the nation's advantage to prevent and detect attacks that could cause harm or damage to national and/or personal security. Conversely, this capability could allow others to look deeper into an individual's affairs in ways never done before. The difficulty lies in maintaining the proper balance of using technology for good and ensuring the constitutional rights of privacy for the individual.

There are technologies available which would assist with cybersecurity. Biometrics is "the emerging field of technology devoted to identification of individuals using biological traits, such as those based on retinal or iris scanning, fingerprints, or face recognition."⁷⁰ Biometrics can be used to protect an individual's personal information by requiring the use of ones physical characteristics to gain access to such data. Coupled with password protected web portals, an individual can safely store personal information on a remote server. Public-key infrastructure (PKI) is another tool that can be used. PKI is the combination of software, encryption technologies, and services that enables enterprise to protect the security of their communications and business transactions on the Internet.⁷¹ A final promising technology is Secure Multipurpose Internet Mail Extension (S/MIME). S/MIME is a secure method of sending e-mail that uses an encryption system. S/MIME is included in the latest versions of the Web browser from Microsoft and Netscape and has also been endorsed by other vendors that make messaging products.⁷²

Recommendation: Government must take the lead, partnering with industry to make resolution of this problem a national priority. Investment in research and development in this area is critical. Biometrics can also be a source of personal information exploitation. Adequate legal and technological safeguards are needed to ensure that biometric databases aren't misused. Lastly, security is expensive. Tax credits should be used to encourage their implementation.

- **Information Infrastructure (Infostructure) Protection.** With society becoming more dependent on computers, the disruption of our networks could seriously affect national security, public safety, and economic prosperity as well as the everyday lives of our citizens. An attack on one network could easily cascade, leading to the failure

of others. For example, the banking and finance infrastructure relies on telecommunications for electronic fund transfers.⁷³ The Internet has opened up a world of information from the desktop while creating a great vulnerability to our information infrastructure. Senator Bob Bennett has said "In bringing us an exciting new era of technology, the Information Age has also given us a new set of security challenges... we must think differently about national security in the new networked world."⁷⁴ Protecting this infrastructure is critically important. Prior to Y2K, most people didn't understand that information systems control or are wholly involved in: telecommunications, electric power, water, gas and oil storage and transportation, banking and finance, transportation (railroads, air, etc), water supply, emergency services, and government services. Approximately 85% of the information infrastructure is owned by the private sector.⁷⁵ Clearly, a partnership between government and industry is required, with industry taking a leading role. However, events such as 9-11, the war on terrorism, and a recessionary economy have taken precedence. Additionally, the Federal cybersecurity czar has been moved from being a direct presidential advisor to being an office somewhere within the Department of Homeland Defense. The Federal leadership void in this area clearly must be addressed.

Recommendation: Government must actively partner with industry to protect critical national infrastructures. While the standup of the DHS is an extremely complicated affair – the government must immediately move out in a proactive manner. Government must also lead by example, investing in security for its own systems.

o **Privacy.** The fourth amendment to the Constitution limits search and seizures without probable cause, but doesn't specifically grant a right to privacy. Nevertheless, the most recent copy of *The National Strategy to Secure Cyberspace* reinforces our inferred right to privacy in the cyber domain. The authorizing legislation for the Department of Homeland Security (DHS), created the position of "privacy officer" to ensure that privacy was balanced with the various mechanisms associated with the National Cyberspace Security Response System. This officer is charged with consulting privacy advocates, industry experts, and the general public to ensure a holistic approach to balancing citizens' rights and cyber security requirements.⁷⁶ One potential challenge to privacy rights is the PATRIOT Act, which grants U.S. officials expanded powers to trace and intercept terrorist communications⁷⁷ through increased scrutiny of Internet traffic and cell phone wiretapping. Basically, the act updated surveillance rules that haven't kept pace with advances in technology.⁷⁸ The quick passage of this act has raised concerns over privacy and accountability. Civil rights lawyers believe the act is too broad and infringes on the liberties of all Americans. Advocates of the Act claim that it has led to successes, such as finding the murderers of Wall Street Journal reporter Daniel Pearl by tracking email routings.

New concerns over privacy have been raised by pending legislation called the Domestic Security Enhancement Act of 2003, dubbed "PATRIOT II," which is intended to fill the gaps left by the original Act.⁷⁹ The U.S. must continually adapt to the challenges it faces following September 11, 2001. The Act would allow the government to create a DNA database of "suspected terrorists," authorize broad new powers of surveillance and widen the definition of who can be secretly watched. It would also permit the surveillance of home computers, multi-use hand devices, and banking/credit devices.⁸⁰

Privacy on the Internet is somewhat precarious. Many businesses monitor the e-mail and web surfing habits of their employees to ensure there is no misuse of corporate systems. The user provides personal information to the ISP and web sites the user visits. Furthermore, various web sites often use “cookies” to provide rapid identification and web tracking for site preferences in order to focus the advertising strategy. Once an individual releases that information or uses remote storage devices, the right to privacy becomes less clear. E-mail is another example of questionable privacy expectations.⁸¹ Once e-mail is sent, it’s relatively easy to intercept and read anywhere along its route of travel.

Recommendation: In order to gain the confidence of the American public and American industry, this office needs to be moved under an agency that traditionally protects civil liberties, or perhaps as an advisor to the President.

o **Identity Theft.** Identity theft and identity fraud are terms used to refer to all types of crime in which someone wrongfully obtains and uses another person's personal data in some way that involves fraud or deception, typically for economic gain. Unlike fingerprints, which are unique and cannot be given to someone else, personal data especially your Social Security number, bank account or credit card number, telephone calling card number, and other valuable identifying data can be used by others to personally profit at your expense. The FBI calls identity theft one of the fastest growing crimes in the U.S. and estimates that 500,000 to 700,000 Americans become identity theft victims each year. Federal Trade Commission data shows that over 86,000 people filed identity theft complaints in the past year. Many of those people suffered significant financial loss. Furthermore, when terrorists exploit identity theft, the financial and human costs to society as a whole can be catastrophic.⁸²

The Internet is an appealing place for criminals to obtain valuable data, such as passwords or even banking information. In their haste to explore the Internet, many people respond to "spam," unsolicited E-mail that promises them some benefit but requests identifying data. In many cases, the requester has no intention of keeping his promise. Some outright criminals have also used computer technology to obtain large amounts of personal data.⁸³

Recommendation: Government must educate the American public on the many forms and methods of identity theft and work with industry to deploy cost-effective security solutions.

• **International Competition.** The IT industry is truly global. Governments around the world recognize that the health of their economies depend on developing a viable IT sector and using IT to increase productivity. This is true despite wide variations in economic development, demographics, and culture. The CEO of one of America’s major IT firms told us he believes that while the industrial revolution increased productivity by 20%, the IT revolution will fuel a productivity rise of over 100%. No country can afford to be left behind. A survey of selected various Asian countries revealed that they all had government policies to “catch the IT wave.”

Using China and Thailand as paradigms of developing countries, we saw several common characteristics. The first characteristic is a lack of IT infrastructure. Typically, major cities exhibit burgeoning IT infrastructure and outlying regions remain underdeveloped. Statistics show that China’s Internet penetration is less than five percent of the population, with those who do use it centered in major population centers.⁸⁴

Secondly, educational systems in developing countries generally don't support the transition to the Information Age. Thirdly, governments, not industry in these countries are leading the IT revolution.

Thailand's IT master plan, first articulated in 1992, stalled due to a lack of resources and political inertia. Recently, however, the Thais have put new vigor in the program. China's government, on the other hand, has enjoyed success in its goal to leap-frog from an agrarian economy to an IT-driven economy, due to the government's central control of the economy. As a result, IT accounted for nineteen percent of China's GDP in 2001.⁸⁵ Its economic growth rate has averaged about seven percent over the last five years, which can be partially attributed to its IT explosion. During our visits we repeatedly heard that China was both the greatest challenge facing the industry, as well as providing the greatest opportunity. Finally, these countries are not satisfied to be merely the "back office" for the IT revolution. They wish to transform themselves into innovation centers rather than as sites for factories that make and assemble products for foreign companies. In Thailand, a government-supported IT center offers incentives for foreign companies to establish innovation centers. Malaysia was the site of the first venture capital IT conference in 2000, with Microsoft's Bill Gates, a keynote speaker, promising to provide mentors for nascent companies that have been twinned with venture capital.⁸⁶

Developed countries, such as Japan and Singapore, have the resources to develop an IT sector, but the agility to "catch the IT wave" varies. In Japan's case, industry has developed a buoyant cell phone sector. Nonetheless, Japan lags behind some developed nations in the degree with which IT is used to enhance productivity. Indeed, the Prime Minister, in discussing Japan's 2003 budget, suggested that the modernization of Japan's IT infrastructure would be part of the government's strategy to pull itself out of a decade-long period of economic stagnation.⁸⁷ In contrast, Singapore has overcome its dearth of natural resources to become one of the most successful economies in Asia, resulting in part from the government's early embrace of the IT sector. Currently, almost all households in the country have a telephone, sixty percent of all homes have a computer, and eighty percent of those homes have an Internet connection.⁸⁸ The government has been pursuing a strategy to upgrade Singapore into a "technology and innovation-driven, knowledge-based economy," in response to stiffer competition from lower cost countries for exports and investment.⁸⁹

Although the U.S. IT sector has recently suffered an economic blow, most executives were adamant that a free market economy was essential in maintaining a competitive advantage. In other countries, both developed and developing, government often has to play a strong role in making the leap to the information age, diverting resources to do so. Other countries are carving out their own strong niches in the sector, from Finland with its Nokia cellular telephones to China with its inroads in the semiconductor industry. Nonetheless, the U.S. continues to lead in innovation, which will continue to spawn future developments and rises in productivity.

The four countries we studied cover a range of development in the IT sector. Each government is devoting resource and political support to the development of the IT sector, a challenge to the purely market-driven development in the U.S. Japan has presented challenges to the U.S.'s primacy in significant areas in the past, such as the automotive industry, although it is unlikely it will meet its goal to be the world leader in IT by 2007. China, given its size and potential, may present the most significant challenge to the U.S.'s

competitive edge in the long-term. The U.S. must continue to depend on the efficacy of open markets for its IT development and press for liberal trade regimes so that trade will be based on market mechanisms.

○ **Severe Acute Respiratory Syndrome (SARS) Impact IT.** Economists have begun slashing growth estimates for key Asian economies hardest hit by SARS. Morgan Stanley of New York cut roughly 0.5 percentage points from the outlook for key economies. East Asia, excluding Japan, is now expected to expand only 4.5 per cent this year, compared with 5.1 per cent previously. Among the major downgrades is China at 6.5 per cent (down from 7 per cent), Taiwan at 2.3 per cent (2.8 per cent) and Hong Kong at 2.1 per cent (2.7 per cent). Reduced business travel, lower tourism and lower retail activity are reasons to expect slower growth.⁹⁰ However, if SARS continues, it will also impact U.S. IT industry as many companies have decided to take advantage of the cheap labor costs in China by outsourcing manufacturing. Companies have already ceased travel to these areas and are closely monitoring the situation.

V. Outlook. The Information Age boom hit a plateau at the beginning of this decade after rapid growth during the nineties. The run-up to the current slow-down occurred as the IT industry formed itself. Due to over-expansion, the industry has entered a period of rationalization wherein excess capacity and bad practices are eliminated. Simultaneously, IT applications are moving beyond the early adopters within the IT industry's own ranks and proliferating throughout other industries. These processes are running their course domestically, and to varying though lesser degrees, abroad. As a result, the U.S. IT industry is poised for the next growth phase. However, rather than leading GDP growth as it did during the first growth phase, this time IT will be pulled along by growth in other industries that are leveraging the power of IT. The resolution of the Iraq crisis and the approaching obsolescence of Y2K hardware may hasten the arrival of the next growth phase.⁹¹ Unfortunately, the unforeseen outbreak of SARS might retard the global recovery.

Although it's unclear when the next growth curve will begin, some things are clear. Sooner or later it will happen and when it does, it will probably begin in the U.S. It will likely be more widespread and sustained than the first growth phase, and it will change the world forever. During the next phase of the information age, various technologies will converge and the "Internet of Computers" will evolve into an "Internet of Things" – a vast network of smart appliances, technologies, and services. This new type of Internet will be brought about by "convergence." Today, that means combining data, voice, and the Internet on a single device.

However, efforts are already underway to converge nanotechnology, biotechnology and IT. Biotechnology allows us to manipulate the fabric of life and nanotechnology scientists are building machines on a molecular level. With the convergence of these now separate sciences, we'll be able to build devices with features small enough to interact with cells and biomolecules. Biological structures will serve as components of mechanical and electrical systems. This convergence promises to bring a boom that could dwarf the Internet revolution of the 1990s. It also promises new treatments for diseases and superfast computers the size of a grain of sand. This isn't science fiction or runaway hype. Sound amplifying proteins that could replace hearing aids, chemical sensors the size of dust

grains, advanced materials that assemble themselves, implants that may restore sight, and much more are already in development.⁹²

Clearly, IT will no longer be a mere application added only as an afterthought. Rather, it will be an integral part of virtually every new system, even at the microscopic level. The impact of these convergent technologies boggles the imagination. If for no other reason than this, the U.S. must remain in the vanguard of this revolution. To be left behind would be to risk irrelevance or foreign dominance.

VI. Government Goals and Roles. The federal government has the responsibility to act in the best interests of its citizens. To the extent that the IT industry benefits the American public, the government should facilitate its success. However, in a capitalist society, it can't become involved in picking winners and losers. Other nations have tried that approach and failed, while some are still trying it. Two of the most notable centrally planned economies provide instructive cases in point. The Soviet Union is no more and Japan's industrial planning miracle has turned into a mirage. Meanwhile, the open and largely unregulated markets of the U.S. have left us in a strong position economically relative to the rest of the world. Still, it can be politically difficult for a democratically elected government to avoid tampering with the market during troubled economic times. Voters want jobs, and it's difficult to ignore their hardships as a result of dislocation, no matter how vital it is to maintaining strong economic growth. Just as with individuals, it can be difficult for a government to watch respected corporations suffer creative destruction, no matter how necessary. But the alternative is worse. Witness Japan's so-called "zombie companies," which produce nothing but debt.

The federal government must achieve a balancing act between nurturing the industry that powers its economy while protecting the individual workers and consumers. There are four ways it can help its citizens: education, privacy enforcement, worker benefit portability, and consumer protection. The IT industry needs the government to: guard intellectual property rights, especially abroad, negotiate fair trade relations with other nations, coordinate the use of the electromagnetic frequency spectrum (as little as possible, but as much as necessary), and to encourage fair and open business practices. One final role of the federal government is to *lead by example*.

The e-Government act should result in a more efficient, less obstructive bureaucracy, setting a good example for all industries while reducing the drag the bureaucracy imposes on the economy. The federal government can help level the playing field for e-commerce by renewing the Internet Tax Freedom Act (ITFA), which expires in November 2003. ITFA prevents the imposition of multiple or discriminatory taxes on electronic commerce and the imposition of new taxes on Internet access. It can also continue to pursue anti-trust actions, like the one against Microsoft, wherever necessary to encourage fair competition. The Commerce Department must take strong stands on protection of intellectual property rights in WTO rounds and during any free trade agreement negotiations. The Securities and Exchange Commission must strictly enforce corporate accountability laws to satisfy investors. The FCC should work to resolve the 3G spectrum conflict. This will stimulate a telecom boom that will generate tax revenues far greater than any amount collected through spectrum auctions or usage fees. The U.S. should maintain a liberal H1B visa policy to encourage the best and the brightest to come to our shores. At the same time, the U.S. government needs to work to prepare America's students for a future in the IT and IT-enabled industries. Scholarships, grants, and school accountability are all important means

of pursuing domestic academic excellence. Lastly, the Office of Homeland Security must act in concert with Department of Defense to address IT-related security and defense issues. These include setting standards for information security and interoperability and protection of critical infrastructure.

VII. Conclusions. In the 1990's, the IT sector powered the U.S. economy to new levels of productivity and growth. As the decade ended, IT constituted about 8% of the U.S. economy, but almost 30% of GDP growth.⁹³ At the same time, the use of IT throughout many American industries led to the near doubling of national productivity growth. Simply put, the IT industry affected virtually every US industry in the new economy. Innovation was and still is the cornerstone for maintaining America's competitive advantage in IT. Other countries are also "catching the IT wave," each attempting to establish its own niche. So far, none have been able to match the U.S. willingness to take risks or capacity to innovate, which are so vital to success.

The industry as a whole experienced a downturn in 2001 with decreased revenues reflecting the burst of the technology "bubble." The communications equipment and communications services sectors were particularly hard hit. Government regulation, enacted to level the playing field, actually inhibited investment in new infrastructure by the RBOCs. Consequently, "last mile" connections have lagged behind other countries.

Today, the industry is undergoing a period of rationalization, with many IT companies consolidating and reorganizing. Today, only the fittest survive and they stand ready to "ride the wave" of the next explosion of IT innovations. Venture capital, too, is available but now requires a sound business plan. As America and the world move beyond the current plateau and continue the IT journey, various technologies will converge - the "Internet of Computers" will evolve into an "Internet of Things." The U.S. IT sector must lead this transition if it is to maintain its dominance, not only in the IT industry, but in many other strategically important industries, too. Today, savvy IT workers are waiting to be recalled to work. The domestic work force is sufficient to meet near-term demand, but projected growth indicates we will soon face a shortage of qualified workers. Unless we improve the quality and quantity of American students pursuing IT careers, we will jeopardize our competitive advantage.

There are many challenges to be addressed. The U.S. government can help by aiding commercial R&D, possibly through tax credits, in order to bring new technologies to market. Similarly, the government must take measures to protect this innovation from piracy and closely monitor the industry to ensure healthy competition. New products and services will continue the trend toward convergence and ever increasing data transmission rates. Similarly, developing countries should be able to take advantage of new technology such as wireless communications to help connect a remote and isolated population without a costly landline infrastructure. E-commerce will continue to grow and could eventually become the business norm. With a smart Internet taxation plan, both state and federal governments could collect needed revenue as e-commerce positions itself for explosive growth. Simultaneously, e-government initiatives should reduce the cost of government to taxpayers while speeding transactions.

Security must keep pace to combat the threat of identify theft while protecting individual privacy rights. Likewise, the nation's critical infostructure must be protected from intrusion. Both the government and private industry have a role to play in enhancing

America's competitive advantage within the IT sector. Instead of being solely a regulator, the government must also catalyze the private sector. Both government and industry benefit from leadership in an industry that directly contributes to the informational, military and economic elements of national power. As the opening sentence of this report says, a healthy IT industry is fundamental to our national security.



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