The Innovation Edge:

Meeting the Global Competitive Challenge

Bay Area Economic Forum

A Partnership of the Bay Area Council and
The Association of Bay Area Governments

September 2006

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Introduction

This report presents a series of essays by nationally recognized thought leaders on business, technology and the global economy. It addresses the challenges posed by global competition to U.S. leadership in science and technology, and ultimately to the U.S. economy. In a global environment where the competitive strength of other countries is growing rapidly, the economic future of the United States, California and the Bay Area lies in their capacity to create value through innovation – in technology, services and business models. In addition to discussing issues and trends, the report discusses elements of a national, state and regional agenda that can sustain our economic competitiveness and quality of life, and identifies key initiatives that are underway to support U.S. leadership in science and technology. Success will require investment and a sustained commitment by government, business, labor and educators at all levels.

The Bay Area Economic Forum

The Bay Area Economic Forum is a public-private partnership of business, government, university, labor and community leaders that develops and implements projects that support the competitiveness of the regional and California economies, and enhance the quality of life of its residents. Sponsored by the Bay Area Council, a business organization of more than 250 major employers, and the Association of Bay Area Governments, representing the region's nine counties and 101 cities, the Bay Area Economic Forum produces economic policy analyses and provides a shared platform for leaders to act on key issues affecting the future of the region.

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Fundamental change is afoot in the world's economy, shifting the competitive equation for nations, states and regions. Our ability to recognize the forces behind that change and devise new strategies to harness them will be critical – in the U.S., California and the Bay Area – to sustaining a position of economic leadership and the quality of life we have come to expect.

Cross-border capital flows, immigration, offshoring, globally distributed manufacturing and a nearly unimpeded flow of information are producing a complex economic stew that is increasing opportunities abroad. These same forces have also brought global competition to the doorstep of nearly every community and company. Increasingly, global is local, and segments of the economy that were once protected by distance are being challenged to engage with new partners and competitors. In this environment, economic success will require strategies and decisions that embrace global as well as local imperatives. Increasingly, that success will be determined by our ability - as a region, state and nation - to lead in service and technology innovation.

Drivers of Economic Change

In a 21st Century version of the Big Bang, market reforms are expanding and reshaping the world's economy. The multilateral free trade network has increased from 23 nations in 1945 (GATT) to 149 today (WTO). The number of bilateral and regional free trade agreements, the vast majority of which do not involve the United States, has also grown rapidly and now numbers several hundred. Even as barriers to the movement of goods, services and capital are falling, the full-scale entry into the world market economy of China, India and the former Soviet Bloc, with a combined population of nearly 3 billion people, is reshuffling the economic deck. Vast new markets for U.S. exports of goods and services are being created. India's burgeoning middle class, for example, now has a purchasing power estimated at $420 billion and growing, and an appetite for American products.

Newly energized, these countries are also building their educational, research and industrial capacities, intensifying global competition in a range of industries. In a recent report, Goldman Sachs calculates that in the next 40 years the economies of Brazil, Russia, India and China (the BRICs) will be larger than the economies of the current G6, with only the U.S. and Japan remaining among the world's six largest economies. If this is even remotely correct the implications are profound, including shifts of capital and portfolio investment, currency realignments, and a growing influence of these economies on markets and commodity pricing. China's surging steel consumption, which has helped drive up global steel prices by as much as 40%, and its growing thirst for oil (China has become the world's second biggest consumer of oil), is a taste of things to come.

The globalization of trade, investment and labor markets has been accelerated by telecommunications technology and the pervasive spread of digital infrastructure. Companies in the United States and India, for example, can now exchange data at less than 1% the cost of what it was in 1996. This is enabling the global redistribution of business functions, particularly those based on information. Architectural schematics, product designs, financial analyses and medical records can be exchanged real-time across the globe for less than the cost of a phone call. The combination of lower trade and investment barriers with improved telecommunications has enabled outsourcing and offshoring (international outsourcing), which are opening large parts of the business value chain to outside contracting and global competition.

Another driver of global change is the shift, particularly in developed economies, from manufacturing to services. Since the mid-1990s large numbers of service jobs have been added to the U.S. economy, while manufacturing employment has dropped. From 2000-2003, 312,000 California manufacturing jobs disappeared, 17% of its base; the U.S. as a whole lost 16% of its manufacturing jobs in the same period. This shift reflects both the rising importance of services and the growing efficiency and productivity of manufacturing operations. The relative decline of manufacturing employment isn't confined to the United States. In the same period, more than 20 million factory jobs have disappeared globally: Japan has lost 16% of its manufacturing base, Brazil 20%, and China 15% (despite booming foreign investment in Chinese manufacturing operations.)

Offshore manufacturing isn't new, but is attracting new attention because of its growing concentration in China. While manufacturing and services are shifting overseas to take advantage of lower labor costs, inexpensive labor is only part of the story. As economies like China and India grow, companies are also moving a range of operations there to take advantage of their growing capacity for high quality research, design and manufacturing, and to be closer to their expanding markets.

For technology companies in particular, product design, manufacture and marketing takes place on a global scale. In a typical case, a product may be designed at one location, assembled at another from components sourced in several countries, and sold into national, regional or global markets. Hewlett Packard printers, for example, are designed in the U.S and India, assembled in Taiwan from components manufactured in Hungary, China and Mexico, and distributed globally.

The global spread of manufacturing and services, particularly by multinational corporations, points to another factor driving economic change: demographics. In the United States, people over age 65 will comprise 18% of the population by 2025, compared to 14% in China and 8% in India. China's population is expected to peak in 2015 and then decline, while India's will continue to grow. In the Bay Area, the same number of people are about to retire as are entering the workforce, which means we will have to attract people from elsewhere in the U.S. or overseas to support a growing economy. Up to now immigration has offset U.S. labor shortages, providing an advantage compared to Japan and the EU, which are also aging but have more restrictive immigration laws or have failed to fully integrate their immigrant populations. Future immigration policies will therefore have a significant bearing on our economic position.

Global and Domestic: the Barriers are Down

When the United States was an economic and security island, it could afford policies that segregated domestic and international factors. That approach is obsolete in the early 21st century, when global terrorism can strike at home, more than a quarter of the U.S. economy is tied to trade, and American workers are competing across a broad front with workers not just in Europe and Japan, but in China, India, Hungary and Mexico. These realities increasingly touch Americans' lives, and their understanding and reactions to the pressures of the global economy will ultimately determine the political limits and reach of U.S. policy. International economic policy is therefore about much more than trade, foreign investment or exchange rates. It is also about how Americans perceive their place in the world and their vulnerability to its changes, and how national competitiveness is defined at a time when American economic leadership is being challenged on multiple fronts.

The Innovation Edge

As economic globalization has taken root in both developed and developing countries, the criterion that sets the standard for competitive success is innovation. In economic terms, "innovation" can refer to technological advancement, or to the process by which companies create new economic value by using resources more effectively. Invention, while critical, is only one aspect of innovation. Increasingly, whether the subject is technology research or business development, innovation is taking place through networks that span and connect different scientific, technology and business disciplines, and often different geographies.

As the global economy expands, openness to the global exchange of people, goods, information and capital is key. While the few economies that have closed their doors to trade and investment are non-competitive (and therefore irrelevant), nearly all the others are working hard to climb the economic ladder. And increasingly they are succeeding. For advanced economies, innovation is the critical, differentiating factor.

The second half of the 20th century, for example, saw Japan transformed from a source of cheap manufactures to a global technological leader renowned for quality. It was followed up this ladder by Taiwan, Korea, and more recently China. The collapse of the Soviet bloc has injected Eastern Europe – with its advanced technological base and educated workforce – into this mix. Each country, feeling pressure from below, is working to advance to higher levels of economic and technological sophistication. Mexico, having lost many of its lower-value assembly operations to China, and faced with rising imports of inexpensive vehicles from Asia, recently closed its iconic Volkswagen Beetle plant in order to shift production to the New Beetle. By doing this, it ceded the low-end market to imports, but targeted instead a higher-value product for sale into the more lucrative U.S. market. The race is on, and those who reach and hold the highest rungs of the innovation ladder will benefit the most.

The dimensions of this challenge are brought home by offshoring. 94% of Northern California semiconductor and software companies interviewed in a recent study were using offshore resources, and half of the remaining 6% were considering it. The offshoring of research is a new phenomenon. While the U.S. holds a solid edge in advanced research, a growing amount of R&D is being performed abroad. This mirrors an important trend in which less corporate research is being done in-house, and more is being performed globally. While most core (innovation) research is still done at home, companies are becoming global technology integrators, using distributed R&D networks. R&D can be done at third-party organizations, at wholly owned, or at joint venture facilities. Intel, for example, conducts advanced research in Israel, India and Russia. In addition to New York and San Jose (Silicon Valley), IBM has advanced research laboratories in Switzerland, China, Israel, Japan and India. Procter & Gamble employs more than 7500 researchers in 20 global R&D centers, including China. More than 70 multinationals, including 100 of the Fortune 500, have recently set up R&D facilities in India.

Most of this research is related to product development for local and regional markets. China, for example, is aggressively expanding its semiconductor sector, based on domestic demand for products such as cell phones. A country with a small domestic market but a global strategy, Singapore is investing heavily to attract top biotechnology researchers to new, state-of-the art facilities. Efforts such as these may or may not fully succeed, and for the moment are not at the same level of sophistication as in the U.S. The foundation is being laid, however, for long-term technological expansion, which will bring them to the center of the global technology stage within a short time.

Investment overseas in research is being mirrored by investment in education. While the quantity of degrees produced cannot be equated with quality, at its top level the quality of engineering education in India rivals the United States. An Indian software programmer, however, earns $20-$30/hour versus $50-$100/hour here. Architectural, engineering, financial and other professional services can now be provided cost effectively from India, with documents exchanged real-time through the internet. Research by A.T. Kearney predicts that up to 8% of employment in the U.S. financial services industry will move offshore by 2008.

As other nations and their research capacity advance, the U.S. no longer has a monopoly on invention. One indicator is a declining share of papers, including most-cited articles, published by Americans in leading scientific journals (See Appendix II). Another is the falling share of global patents registered by Americans. According to *Technology Review*, two dozen countries now have a significant capacity for technological innovation, and nearly half of U.S. patents are now awarded to foreign companies and inventors.

As these trends continue, the United States will be challenged to retain its undisputed technological lead. Innovation is occurring rapidly, in shorter cycles, and with fewer geographical barriers, based on collaboration across both disciplines and borders. While the United States holds a commanding lead in innovation, in the fluid environment of today's global economy its long-term leadership is anything but assured.

A Changing Paradigm

Changing patterns of global economic activity will challenge existing policies and business strategies. Some paradigm shifts are particularly worth noting:

Trade is more than exports: The trade arm of the U.S. Commerce Department that supports small and medium sized business, the U.S. Commercial Service, is tasked with export promotion, as are the dozens of trade programs run by U.S. states. While exports are critical and the chronic U.S. trade deficit is a concern, an international trade strategy based solely on exports misses the point of how today's global economy actually operates.

When measuring trade, solely relying on bilateral balances can be deceptive. In manufacturing, for example, the global distribution of research, the global sourcing of components, and their assembly into products at worldwide locations frequently blurs the distinction between what is a U.S. and what is a foreign product. A growing segment of international trade (intra-firm trade) is conducted between U.S. multinational corporations and their affiliates (see Appendix II); despite the nominal trade imbalance with China, much of the value from this trade accrues to the U.S. Much also accrues to companies in Hong Kong, Taiwan and Japan, which have shifted manufacturing to China. Foreign-owned enterprises account for more than half of China's exports, and are its primary beneficiaries.

Services account for a growing segment of both national economies and global trade. International business is increasingly done through trans-national partnerships, where companies in different countries share R&D, develop joint ventures or create marketing alliances. Yet Congress and most state legislatures remain fixated on merchandise exports. Trade development strategy should expand its focus to include the promotion of partnerships that link U.S. and overseas companies for shared business development, including exports, imports, research, investment, and marketing.

Foreign Investment Creates Jobs: Foreign direct investment (FDI) contributes powerfully to U.S. employment and economic growth. According to the Commerce Department, in 2004 foreign investment in the United States supported: more than 5.1 million jobs, or one in twenty U.S. workers; 14% of private R&D expenditure; and 10% of capital investment. Foreign-owned companies are responsible for 20% of U.S. merchandise exports, and purchase 80% of their intermediate inputs from domestic suppliers. More than half of Japanese cars are now made outside Japan. The Ford Mustang, an iconic American car, uses 65% U.S. and Canadian parts, while the Toyota Sienna XLE, which is manufactured in the United States, uses 90% U.S. and Canadian parts.

It is not safe to assume that the United States will continue to capture the dominant share of the world's FDI, particularly if xenophobia or political expediency lead to poor policy choices. Market reforms, growing economies, educated workers and growing technological capacity is increasing the attractiveness of many countries – including China and India - as investment sites. Foreign investment in China alone ranges between $50 billion and $60 billion per year. Despite the importance of foreign investment to the U.S. economy and anxiety over offshoring, multiple federal agencies are tasked with promoting exports, but no office promotes inbound foreign investment. Recent Congressional anxiety over Chinese and Arab investment, and efforts by Congress to intervene more deeply in CFIUS (the Committee on Foreign Investment in the United States) risk politicizing the process and may discourage future FDI. Since the California Technology, Trade and Commerce Agency was closed in 2003, the State of California has lacked the institutional capacity to either plan or implement an international trade and investment strategy.

Manufacturing Matters: Despite the decline of manufacturing employment, manufacturing continues to play an important role in the economy, as a reservoir of skills and as a source of good paying jobs. Manufacturing job loss the U.S. has been driven partly by a quest for lower costs, and partly by businesses moving production closer to growing markets. The biggest factor, however, is increased productivity, as technology permits more production with fewer people.

This trend will continue. Nevertheless, much of today's manufacturing (contrary to the popular image of rusting, smokestack industries) either produces or is based on high technology, and requires significant levels of education and training. These skills matter. Manufacturing anchors research, design and engineering activity at the front end of the production process, and logistical jobs at the back end. Larger manufacturers also anchor smaller suppliers. The NUMMI (New United Motors Manufacturing Inc.) automobile plant in Fremont supports a network of 25 California parts suppliers with 3,900 employees.

While manufacturing may never again be a major source of new jobs, it remains an important component of a healthy and diversified economy. If research is decoupled from production, we risk losing much of the value and employment created by our scientific skill, and the critical mass of economic activity that is vital to future investment. The future of manufacturing in California and the U.S. will depend on better management of business climate issues (such as tax and other policies that impact business costs), and on innovation in technology, management and production processes.

Technology Empowers Services: As the size of the service economy grows, technology is driving service innovation. Services, for example, are transforming manufacturing. According to Deloitte Research, many of today's best-performing manufacturing companies generate half of their revenues from services; profits from services often are higher, and are growing faster, than for other business operations. IBM, for example, generates 51% of its revenue from services. Caterpillar, another major American manufacturer, is committed to delivering spare parts anywhere in the world within 24 hours. In Caterpillar's case, improved logistics and customer service are contributing powerfully to the bottom line. Information technology and pervasive digital networks enable this process.

Technology companies in particular are transforming themselves into business service providers based on the integration of engineering, management and marketing. In this model, technology is a platform for delivering new and innovative services. The technology behind the Apple iPod, for example, has created an entirely new market. Companies like Yahoo, Google and eBay follow the same pattern, where the product delivered to the market is a service that draws on the creative capabilities of technologists, engineers, managers, advertisers and marketers. Just as cross-disciplinary research (for example, between information technology, biotechnology and nanotechnology) is leading to new responses to a range of market and societal challenges, the integration of technology and non-technology disciplines is generating new ways to create economic value. Open, collaborative business processes are taking root, and service innovation is emerging as an increasingly important driver of economic growth and value.

Scientific Research Builds Competitiveness: Much of the nation's scientific research is funded by the federal government, through the Departments of Defense, Energy, Homeland Security, and Health and Human Services. Federal investment in basic research is critical, particularly since large private research centers such as Bell Labs have all but disappeared, and corporate investment is focused on product-related research. Primarily funneled through universities, federal investment in long-range, innovation research provides a critical foundation for technology breakthroughs, and defense and consumer products.

Despite its importance to U.S. technological leadership, and ultimately our security and quality of life, the federal effort is slipping. Government's share of national R&D expenditures has been steadily declining, even as other nations are ramping up (see Appendix II). Singapore, for example, has successfully focused on its semiconductor sector, and is investing heavily to develop an advanced capacity in biotechnology. Japan, Germany, Korea, Taiwan, the UK, China, Switzerland, Singapore and Australia are investing heavily in nanoscience, and have established early leads in a number of key applications.

China in particular is closing the technological gap. According to analysis done at Georgia Tech for the National Science Foundation, from 1993 to 2003 China rose from 20.7 to 49.3 on the Technological Standing Index, and ranks fourth in the world for publications on emerging technologies, after only the United States, Germany and Japan. Its R&D spending on nanotechnology ranks fourth in the world after the U.S., Japan and the EU. Reflecting these shifts, between 1989 and 2001 the ratio of China's high technology output to U.S. technology output rose from 7.1% to 27.3%, a trend reflected in rapidly growing technology exports.

Federal R&D investment has grown in recent years. This has been primarily due, however, to rising expenditures for weapons development and homeland security, and a commitment to double the budget for the National Institutes of Health (NIH). Support for research in physical sciences has been stagnant for thirty years when adjusted for inflation, and has fallen 37% as a percentage of GDP.

In response to a number of high-profile reports that have raised alarm over declining American competitiveness, in his 2006 State of the Union address President Bush proposed an American Competitiveness Initiative under which research in physical sciences and engineering, through the National Science Foundation, the Department of Energy and the National Institute of Standards and Technology (NIST), would grow 7%, from $9.8 billion to $10.7 billion. Additional funding would also be committed to math, science and technology education at the K-12 level.

This commitment to physical science research (particularly computer science and engineering) has been welcomed in the science and technology community. However, in a continuation of recent priorities, applied R&D on weapons and space vehicles (the D side of R&D) accounts for most of the growth. This, plus cuts in research programs other than NSF, DOE and NIST, means that overall federal investment in research (excluding development) would decline 3.4%, extending a three year fall. Total R&D funding (including development) would grow 1.9% to $137 billion, but this growth rate is less than inflation, and in real terms federal R&D investment would decline for the first time in ten years.

Apparent high levels in research funding thus mask a changing balance between basic (innovation) research and applied research. In the favored area of defense, new priorities for the Defense Advanced Research Projects Agency (DARPA), which laid the foundation for today's internet, will continue the shift of research from long-range, high risk/high return research, in favor of near-term applications.

Looking at R&D investment from a different perspective, federal subsidies for agriculture total more than $20 billion. Judged by return on investment and strategic value alone, these priorities are misplaced.

Human Capital is Critical: A globally competitive workforce requires a world class educational system, from K-12 through the graduate level. The shortcomings of the nation's primary and secondary education system, and particularly its underperformance in mathematics and science, are well documented. Average scores for eighth graders on national science tests have failed to improve in the last ten years, and scores for high school seniors have declined. This is a particular challenge for California, which fares poorly in math and science tests compared to other states (See Appendix II).

The ability of America's higher education system to meet the needs of a globally competitive economy is also under pressure. Currently, for example, the United States produces 140,000 engineers, computer scientists and technologists with four year degrees. China now produces 350,000. In the last three years, China and India have doubled the number of 3-4 year degrees in these disciplines, while numbers in the U.S. have remained stagnant. During the 1990s, the U.S. share of bachelors degrees awarded globally in engineering dropped by half, from 12% to 6%. According to the McKinsey Global Institute, within the next several years the number of trained engineers in developing countries will equal the number available in the United States.

The National Bureau of Economic Research reports that at the bachelor's level, the U.S. now produces a lower percentage of degrees in science and engineering (17%) than the world average (27%), and a much lower percentage than nations such as China (57%). Since the mid-1990s the number of American Ph.D. graduates in physics and engineering has declined by 15% and 22% respectively. This has occurred even as the number of Ph.Ds graduating from European and Asian institutions in these fields is increasing and may soon overtake the U.S. If current trends continue, by 2010 the European Union and China will each produce twice as many science and engineering PhDs as the United States.

Applications by foreign graduate students to U.S. institutions, which we depend on to fill the gap, have also fallen. International students receive approximately 35% of US doctorates in physical sciences, and almost 60% of doctorates in engineering. The foreign-born share of students earning bachelors and masters degrees in science and engineering at U.S. universities is only slightly lower. In the wake of 9/11, however, and the adoption of more strenuous security procedures, the number of overseas applicants to leading U.S. universities has fallen, particularly at the graduate level. The decline is most evident in applications by Indians and Chinese, and in fields such as computer science and engineering.

Foreign-born graduates populate the U.S. technology community, particularly in California (see Appendix II). At the National Institutes of Health, 46% of the doctoral level staff are foreign-born, while many more are naturalized citizens. Foreign-born graduate students often work as teaching assistants in fields such as mathematics, computer science and engineering, compensating for the lack of U.S. students in those fields. Foreign-born workers and executives comprise a significant segment of U.S. companies' research base.

In Silicon Valley, one-third of high technology start-ups have been started by immigrant entrepreneurs. According to surveys by U.C. Berkeley economist AnnaLee Saxenian, approximately 80% of Taiwanese, 80% of mainland Chinese, and 55% of Indians came to the U.S. through universities. American universities are a magnet for many of the world's best minds, providing a critical talent pool and competitive edge for industry.

With its baby boom generation aging, the United States will, like other developed countries, see an increase in the proportion of its population over 65, and a declining percentage of its native population that is employed. Until now our ability to attract talent from around the world, particularly through universities, has compensated for this. The U.S. share of the global education market is declining, however. The U.S. share of international graduate students among leading host countries (the US, UK, Australia, Germany and France) dropped from 47% in 1997-98 to 41% in 2003-04. Among the three leading English-speaking host countries the U.S. share has dropped even faster, from 65% to 56%. From 2000 to 2003 the U.S. share of Chinese students studying in English-speaking host countries fell from 81% to 46%. Part of the problem stems from increased capacity in home country institutions, and increased global competition for foreign students. High U.S. tuition is also a factor. But part of the explanation lies in a new, negative image of the United States as a place to live and study. With the tightening of immigration procedures since 9/11, the U.S. is perceived as a less welcoming environment for foreign scholars, students and scientists. Difficult visa processes and negative experiences among applicants have created barriers that threaten to constrict the pipeline of global talent.

In industry, Silicon Valley companies have come to rely on skilled technology workers from overseas to augment their domestic workforce. In 2001-03 the U.S. provided 195,000 H-1B visas annually for these workers, a number that later dropped to 65,000. The annual quota for FY2006, which began in October 2005, was already filled in August 2005. An additional quota of 20,000 visas for holders of advanced degrees from U.S. universities, approved by Congress in 2004, filled almost as fast. While Congress and the media have debated the terms of entry to the US for low-wage, low-skilled workers from Mexico and Central America, the country's need for educated, high-skill workers has been largely lost in the noise.

This is even more problematic as applicants from many countries, including China and India, face a 5-7 year wait to apply for green cards, the documents that permit skilled foreigners and advanced degree holders to work in the U.S. on a long-term basis. This discourages skilled foreigners from contributing to our economy.

Scientific, student and cultural exchanges have political as well as economic dimensions. The relationships and identification with the United States that are produced by the experience of living, working, and studying here have created a global support network of incalculable strategic value. Many of the world leaders who President Bush and Secretary of State Colin Powell contacted for support in the global war on terror after 9/11 had visited the United States early in their careers through student or cultural exchanges. It is easy to think of these exchanges as unimportant activities; they are not. Politically and economically, they are a good investment and should be expanded.

While the needs of national security can't be second guessed, the risk that a fortress America – or the perception of one - will undermine our ability to attract the world's best minds is real. Hauling up the drawbridge threatens to push away not just students and scientists but also businesses that have difficulty bringing employees, partners and clients to the country. A recent survey by eight national and bi-national business associations estimates that US companies suffered losses of over $30 billion between July 2002 and March 2004 due to denials and delays in processing business visas. The Air Travel Association of America has reported similar effects on international tourism.

As an unintended consequence, these difficulties are adding to the pressure for U.S. companies to move their operations offshore. Delays and unpredictability in securing visas for foreign partners, customers and employees have led to project postponement, and to pressure to relocate employees or activities overseas. According to one estimate by U.S. District Export Councils, the medical community alone is losing $1 billion annually in revenue from outpatient care due to visa problems. One response by institutions such as the Mayo Clinic has been to move the most affected facilities and patient services out of the U.S. For the same reasons, the U.S. has also lost major scientific conferences to other counties.

The Departments of State and Homeland Security are working to address these problems, but a great deal of damage has been done and it will take a concerted effort to make up for lost ground. The United States benefits powerfully from maintaining an open door for business, talent and ideas. Our economic policy should therefore consider immigration policy as not just a defensive mechanism, but as a strategic tool to attract and retain the world's best talent.

The U.S. Economy: Alone or a Global Hub?

While the idea that the U.S. should control as much of the global economic pie as possible is attractive, it is increasingly at odds with reality. Too much economic activity is now happening elsewhere to put the genie back in the bottle. While the U.S. continues to have the largest and richest global market, and hosts the world's best educational institutions and its most powerful R&D base, the rise of China and India and continued growth elsewhere in Asia and Eastern Europe are spreading the fabric of global competition and cooperation. The U.S. will therefore be challenged to retain its lead in areas of strength, and to redefine its economic role in relation to an increasingly diverse set of partners.

If the virtual monopoly of the United States and Western Europe on research, advanced manufacturing and educated workers is fading, then our new goal must be to serve as an indispensable hub for these new global networks. The United States should be the place where global capacities converge, are integrated, and redeployed. To do this, it needs to leverage its core strengths with the best resources and capabilities elsewhere. Nowhere in the U.S. is better positioned to play this role than the Bay Area.

A growing body of economic literature points to the benefits of cooperative global networks, in which economic activity is distributed but the U.S. serves as a core player. A 2003 study by the McKinsey Global Institute finds that for every dollar in labor cost offshored, $1.47 in value is created, of which $1.14 is captured by the U.S. and 33 cents by the host country.

Most corporate research was once considered proprietary and was performed inside a company's own laboratories. A 2004 study by Forrester Research, however, documents the spread of "innovation networks", where companies specialize in areas of competitive strength, and leverage other research needs through networks of global partners.

Despite recent erosion, the U.S. still has impressive competitive advantages in higher education, scientific research, advanced manufacturing, finance, and business and service innovation. Success in positioning the United States as the preeminent crossroads for global exchange will depend on our ability to leverage these assets, and on an open climate where barriers to the international flow of goods, services and financial and human capital are minimized.

Who Cares?

Across industries, value today is tied less to physical assets and more to knowledge, placing a premium on innovation and human capital. While the implications are being played out every day in business, they have yet to be fully recognized in government.

Understanding by the public of how the U.S. shapes and is being shaped by global forces is notoriously weak and permits this failure. Only when labor disputes shut down West Coast ports in 2003 did many realize that domestic production lines could close for lack of imported parts, that store shelves might not be stocked for Christmas, and that farmers would suffer because agricultural exports were blocked.

Despite its pervasive impact, global economics receives little or no attention in American schools. When the mechanisms of trade, investment and global exchange are so poorly understood, it's no wonder that students fail to appreciate the forces at work in the world around them, or that economic issues lack informed debate. For local governments, systematic information on the jobs created (or eliminated) by international trade and investment is scarce to non-existent. In recent years the U.S. Department of Commerce has actually reduced its data gathering and analysis in this key area.

Investing in Competitiveness

The time is overdue for economic policies that connect the dots between the forces that are shaping the global economy. At a minimum, there is a growing need to: engage the public on global economic issues; strengthen investment in higher education, basic research, and workforce training; engage U.S. technology in the global fight against poverty and ignorance; reclaim the U.S. position as the U.S. as the world's premier destination for scientists, technologists and students; minimize barriers to trade, investment and the exchange of human capital; position the United States as the indispensable hub of emerging global business and technology networks; and integrate these elements in a strategy for technology and service innovation.

Combined, these are the ingredients of economic productivity, the ultimate measure of competitiveness. If our economy creates more wealth, then more resources are available for higher wages, higher shareholder returns, more savings and investment, better government services and a higher standard of living. Lower productivity means weaker competitiveness, fewer resources and fewer services. It's that simple.

At the national level, this means linking policies – international and domestic - that until now have been treated separately. Federal immigration policy should encourage overseas students in priority fields to remain after graduation, through expedited access to permanent residence (green cards). U.S. citizens need more graduate fellowships in mathematics and science, and particularly in physical sciences and engineering. The need for more investment in physical security (defense) should not diminish the priority of economic security, and the investment in long-range, high-risk research that requires. Rather than feast or famine, the federal research commitment should be sustained across disciplines and over time. And federal, state, university and corporate R&D capacities should be leveraged through accelerated commercialization programs, and reduced barriers to public-private collaboration.

At the state and local levels, greater up-front commitment is needed to build a qualified and credentialed corps of K-12 math and science teachers. The rising global challenge also calls for focused investment in continuous workforce training; where appropriate this should be done in partnership with industry, to assure that community colleges and other educational institutions are producing a globally competitive workforce that meets the needs of a rapidly changing economy. For incumbent workers, more and better workplace training can support flexibility, security, and skills development. In California, particular attention needs to be given to educational opportunity for Hispanic and other minority populations who make up a growing share of the population. We must ensure that the potential inherent in the state's diverse workforce is developed, and that large segments of the community are not consigned to low-wage, low-opportunity jobs, or hobbled in their future ability to compete with counterparts in China, India or Korea.

Other priorities for California and the Bay Area should include: investment in the University of California, California State University, and community college systems; investment in California's physical infrastructure, particularly the ports, airports, roads and bridges that are needed to move both goods and people; strategies to improve worker mobility in a changing job market; strategies to promote business and technology networks that leverage our rich base of human, research and entrepreneurial assets; and a business climate that takes account of global competition by reducing the cost to businesses of investing, hiring and producing.

For the private sector, the growing capability of companies around the world to conduct advanced research, manufacture to high standards, and deliver quality products will place new pressure on businesses to continually assess their competitive position. As that occurs, higher premiums will be placed on R&D, product innovation, service innovation, and productivity improvement. Companies will be challenged to develop new business models that access global markets, and leverage the technology and human resources of global partners.

The Bottom Line

The U.S. today continues to be the world leader in science and technology, with a preponderant share of scientists and R&D spending, and a university infrastructure that is unmatched in its size, scope and sophistication. We lead in productivity in every major industry. The U.S. also benefits from a dynamic private sector and an entrepreneurial culture that is unmatched in its ability to create new enterprises and transform ideas into products. Nowhere in the world has a better record of doing this than California and the Bay Area.

We should therefore be careful not to overstate the challenge posed by economies like China and India. Both have underdeveloped infrastructure, looming environmental problems, large rural populations, uneven educational systems, and formidable governmental challenges as they struggle to keep up with growing populations with rising expectations. Even at the high growth rates they currently enjoy, it will take many years before they catch up with the per capita income levels of advanced economies like the U.S., EU and Japan.

Structural changes are underway in the global economy, however, that are causing the economic ground to shift. In the world we are entering, innovation is the new foundation for competitiveness, and productivity is its measure. That competition is increasingly global. Unless they can innovate faster and better than their competitors, the economies of the United States, California and the Bay Area, and the standard of living of their citizens, will erode. The sooner we recognize this and act with strategic purpose, the more likely it will be that our technological leadership – and the security, prosperity and quality of life of Californians and other Americans – will be sustained.

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The Emerging Global Labor Market

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Offshoring raises difficult questions. Some policy-makers fear that companies will move almost all service jobs from developed economies to low-wage countries, where a limitless supply of graduates is ready to seize them. But can so many jobs be moved? And do companies really want to move them? Certainly, many companies are hiring offshore in pursuit of lower costs. But rising wages for graduates in cities like Bangalore and Prague suggest to some observers that the supply of suitable offshore talent may be running out already. Is it?

Questions like these have serious ramifications for policy-makers, companies, and employees in both high-wage and low-wage economies. Only hard facts can settle them. So far, however, facts about offshoring have been in short supply.

The McKinsey Global Institute (MGI) has conducted detailed research to fill this data gap looking out to 2008. By analyzing the potential and likely demand for offshore talent in eight sectors[1], and the potential supply of suitable talent from 28 low-wage nations, we can assess the dynamics of the supply and demand for offshore talent at an occupational, sectoral, and global level, and thus the likely impact on employment and wages. This gives us, for the first time, a panoramic view of the offshoring phenomenon. What it reveals is a relatively small emerging global labor market, one which threatens no sudden discontinuities in overall levels of employment and wages the United States or other developed countries.

Our research shows that, even theoretically, only 11 percent of all U.S. services jobs could possibly be performed offshore. This is mostly because a large percentage of service jobs – for example, shelf stocking, dental work, medical care, and network installation – require face-to-face customer interactions or a worker’s physical presence. In two of the largest sectors in the service economy – health care and retail – only 8 percent and 3 percent of jobs respectively could be performed remotely for this reason. And the industries in which the highest percentage of jobs could be performed remotely – packaged software (49 percent) and IT services (44 percent) – represent only 1 or 2 percent of overall employment.

In reality, only a small fraction of the service jobs that could theoretically be performed offshore actually will be. There are several reasons. First, about one-third of U.S. workers are employed by companies with less than 100 employees and these companies lack sufficient scale to justify the cost involved in offshoring. For a company with, say, just three to five finance and accounting people, the potential wage savings from moving the tasks to India are too small to justify the management time and effort required.

1 The eight sectors we analyzed are: automotive (services), health care, insurance, IT services, packaged software, pharma, retail, and retail banking.

Even larger companies find offshoring is more complex than they expect. Many would need to put in place a comprehensive package of measures to streamline and adapt their processes and information systems before offshoring could be feasible. Other companies have little global experience and this makes them hesitant to employ people offshore. In fact, our research finds that management resistance is a significant factor holding back offshoring today, while government regulations are not.

All these factors mean that just a fraction of the jobs that could potentially go offshore actually will. We expect that U.S. companies will create some 200,000 to 300,000 offshore jobs per year over the next 30 years. By 2008, our research shows that offshoring will affect less than 2 percent of all service jobs.

Jobs performed in low-wage countries do not necessarily represent jobs lost at home. In fact, many of these jobs would not be viable at higher wage levels. For example, a U.S. airline has found that, because of lower wage levels in India, it can employ additional staff to pursue much smaller delinquent accounts than it could afford to chase before.

There is a growing body of evidence that offshoring will not lead to massive net job losses. The U.S. Bureau of Labor Statistics reports that only 1 percent of service layoffs involving more than 50 employees in the first quarter of 2004 was due to offshoring. A new academic study confirms that, in the U.S. and the U.K., those service sectors subject to offshoring do not experience net job losses. Put another way, these sectors are creating as many – or more – new jobs as the ones that move offshore.[2]

Because offshoring has such a limited impact on the U.S. job market, the effect on wages in the U.S. will be negligible. This is the case even in the computer and data-processing industry, one of the sectors most affected by offshoring. In the U.S., overall employment in that industry has been growing at over 2 percent per year since 2000, compared to 0.4 percent for the rest economy. Although many programming jobs have moved offshore, more positions for better paid systems analysts and software engineers have been created in the U.S. And average wages have actually grown at a faster pace than elsewhere in the economy, since the new jobs have higher productivity and create more value.[3] For these reasons, the impact on U.S. wage levels will be negligible.

Worries about job losses have diverted attention from the substantial benefits offshoring generates. Past MGI research shows that U.S. companies gain on average 0.58 cents for every dollar of cost that they move offshore. That means more to invest in new technologies and business opportunities that create jobs both at home and abroad, and more to distribute to shareholders (as higher dividends) and consumers (as lower prices and better quality). Overall, the U.S. economy receives a net benefit of $1.14 for every dollar of cost offshored.

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[2] "Demystifying Outsourcing: The numbers do not support the hype over job losses." Mary Amiti and Shang-Jin Wei, December 2004. *Finance and Development*

[3] In the UK, employment in the sector grew at 6.6% per year from 1998-2004, while employment decreased by 1.8% per year across all occupations. Wages in the sector grew slightly less fast than overall wages, however.

And don't forget that the U.S. also benefits from being on the receiving end of offshoring. In 2004, the U.S. received $121 billion of foreign direct investment, more than any other country. Foreign subsidiaries provided jobs for 5.4 million U.S. workers in 2002 – 5 percent of all private sector jobs. The Bay Area, with its large concentration of technology workers and the highest output per employee in the country, is a particularly attractive offshoring destination for many countries. But these jobs would be at risk of retaliatory measures from other nations if the U.S. restricted offshoring, as would the substantial trade surplus in services the U.S. continues to maintain, even with India.

Ease the transition for displaced workers

That is why protectionism is not the answer. But openness to global competition undeniably makes individual jobs less secure. Rather than a single career with one or two companies, most U.S. workers can expect to change employers several times and move into new fields, often involuntarily. Workers thus need policies to help them cope with this accelerated pace of job change, not a ban on offshoring.

Government can offer employers retraining credits to encourage them to hire and retrain displaced workers. Making continuing education grants can help workers to build skills for the future, particularly in growing areas of the economy. Portable medical insurance plans and pension benefits are also essential to a workforce changing jobs more frequently.

Companies can help displaced workers by awarding more generous severance packages. They could also fund wage insurance programs that make up some or all of the difference between workers' previous wages and their new ones. We estimate that U.S. companies could make up 70 percent of lost wages for all full-time employees displaced by offshoring, as well as give them healthcare subsidies for up to two years, at a cost of just 4 to 5 percent of their cost savings from offshoring over the same period.

Similarly, engineering, computer science, and other science programs at U.S. universities should adapt their curriculum to develop graduates able to weather frequent and far-reaching shifts in companies' demand for labor. U.S.-based IT jobs that require business knowledge, teamwork, and interactions with technology users in various fields will continue to grow. So student engineers will need to combine their IT skills with, for instance, business knowledge, psychology, and anthropology.

Industry associations, unions and companies can also combine to help workers anticipate job change, by monitoring occupations where domestic employment demand is rising – in healthcare, education, and social services – and plot potential career transition paths for workers switching into them. Software programmers may be required to become systems analysts; radiologists may need to become specialists in treating diabetes.

Remain attractive to offshoring investment

Although the U.S. is a world leader in receiving offshoring investment from foreign companies, it still needs to take care to maintain this enviable position and offset those jobs lost to offshoring. Two potential weaknesses are its telecommunication infrastructure and rising health costs. The quality and breadth of U.S. wireless networks lag behind most other developed countries – and even many emerging markets. The U.S. has fallen to 16th in the world in broadband connectivity. At the same time, employee healthcare costs have been rising – by 38 percent between 2001 and 2004 – and this is imposing a huge burden on employers.[4] CEOs and other executives regularly mention rising health benefit costs as a factor in their decision to offshore. U.S. policymakers cannot avoid addressing both of these issues if the country is to continue being a magnet for foreign investment.

For the Bay Area to remain an attractive offshoring destination for overseas companies it must address the high cost of living and high cost of doing business. Although the Bay Area is more productive than any other region in the country, when adjusted for the cost of living, the region's productivity dipped from 143 percent of the national average in 2000 to 131 percent two years later. If the Bay Area's leaders fail to address its problems, productivity could drop further, making it less attractive to foreign investment.[5]

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[4] David Wessel, *"Capital: Healthcare costs blamed for hiring gap"*, The Wall Street Journal, March 11, 2004

[5] *Downturn and Recovery: Restoring Prosperity,* the January 2004 report by the Bay Area Council, the Bay Area Economic Forum, the Association of Bay Area Governments, and McKinsey is available online at www.bayeconfor.org.

How India, China Redefine the Tech World Order

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India and China — with their fast-growing markets and rapidly-expanding, innovation capabilities — are threatening to redefine the historical US-centric — and unipolar —world order for the tech industry. But instead of throwing up barriers and viewing India and China as competitive threats, US tech vendors are building global high-tech Innovation Networks: multipolar ecosystems that exploit the huge markets and the growing talent pools in India and China. The interplay of accelerators and decelerators will impact the performance of both Asian giants and will shape high-tech industry relationships between the East and the West over the next two decades (2005-2025).

India and China Growth Herald a Shift in Locus for the Tech World Order

A new high technology world order is emerging. The center-of-gravity of supply and demand for high-tech products and services is shifting on a global scale — moving ever further away from its historical single-country locus within US borders. The catalyst is the rapid growth of India and China — both countries' GDP has been growing at 7% to 10% annually — which is spurring diffusion of demand in the global high-tech market. This is particularly happening as demand for consumer technologies grows among the Indo-Chinese middle class. China already boasts nearly 100 million Internet users and 350 million cell phone subscribers, and India is signing up more than 2 million new cell phone subscribers *every month*.

IT-hungry Chinese and Indian corporations and cities now outspend American firms in enterprise IT. For instance, an astounding 67% of Indian firms are increasing their IT budgets, mostly on innovation-seeking IT initiatives — compared with 39% of North-American firms. Already, America's share of total revenues of 35 of the world's largest enterprise IT vendors has shrunk from 43% in 2001 to 37% in 2005. In 2004, Asia Pacific countries outspent America on high-tech products and services, and in Q1 2005 accounted for a record $45.6 billion in revenue for U.S. tech vendors.

As markets in India and China develop and both countries' talent pools expand, the US-dominated, unipolar tech world order is thus giving way to a multi-polar tech world order. Rather than resisting this shift, US tech vendors are striving to weave in rich innovation linkages that span US, Indian, and Chinese markets, by engaging their Indian and Chinese partners in collaborative scenarios. For instance, in 2005, Microsoft opened a research lab in Bangalore staffed with 700 software inventors. Intel has formed a $300 million VC fund to finance promising startups in India and China. In pursuit of a new global business model, US-vendors are integrating with Indian and Chinese partners in global high-tech Innovation Networks — new market structures that let technology firms fluidly match global innovation demand with worldwide talent supply.

As a result, linkages among tech vendors from all three countries are beginning to both produce and consume the four value-delivery services that comprise Innovation Networks – Inventor, Transformer, Financier, and Broker. *Inventors* such as the Indian Institutes of Technology and Microsoft's Beijing Lab, create patentable inventions. *Transformers,* like Flextronics and Dell, convert inputs from inventors and from other transformers into useable and successfully marketed products and services. *Financiers,* like Warburg Pincus and Intel Capital, fund Innovation Network service providers — especially Inventors and startup Transformers. *Brokers,* like the Indus Entrepreneurs (TiE) and the US-China Business Council, are market makers and facilitators that find and connect worldwide Innovation Network service providers — Inventors, Transformers and Financiers. The result is global technology Innovation Networks that let the US, India and China integrate their specialized innovation capabilities.

Three Scenarios for the Global Technology Sector's New World Order (2005-2025)

While the US-centered innovation model for the technology sector is waning, giving way to global Innovation Networks, the migration path remains unclear. US firms lead today's emerging global Innovation Networks. As India and China's role in these networks takes shape, however, these two Asian giants will significantly influence how these networks evolve. A number of accelerators and decelerators for India and China, such as their domestic market growth rates and government support for free market activities, will determine how the world's new technology order emerges.

India has established itself as a player and a partner for US firms, and that is unlikely to change. Only the *pace* at which it can change remains in question. China, on the other hand, remains a true wild card — with its tremendous potential balanced by its centrally controlled and sometimes volatile communist government and its slow move to adopt Western business norms – such as intellectual property rights enforcement. To depict how these global technology Innovation Networks might emerge and evolve, Forrester proposes three possible scenarios, each defined by how these accelerators and decelerators play out over the next two decades:

- **Scenario 1: Chinese Mirage.** In this scenario, the shaky fundamentals of the red-hot Chinese economy – epitomized by a real-estate bubble fueled by bad loans – fail to sustain that country's astounding growth (a repeat of the 1997 crisis that affected other parts of Asia) and ultimately lead to China's collapse by end of this decade. As a result, the domestic technology market in China is stifled. The purchasing power of the tech-savvy Chinese middle class vaporizes as millions find themselves unemployed. Western vendors start pulling out of the increasingly anemic Chinese market, crippling the export-dependent Chinese high-tech manufacturing sector. The collapse of China's giant emerging market drives US tech vendors – as well as vendors from Japan, Korea and Taiwan – to look for Invention and Transformation opportunities in other places, as new markets like Brazil and Russia become the global technology sector's growth engine.

- **Scenario 2: Cold War II.** China defines this scenario as well — this time playing the role of a belligerent giant consolidating its power. Here China experiences continued strong economic performance. By 2010, China has doubled the size of its 2000 GDP, supported by liberalization of supply-side capabilities in its domestic high-tech sector. This, in turn, creates strong Chinese brands such as Huawei and Lenovo, which — through partnerships and acquisitions — dominate US and Europe market segments such as consumer electronics and communications.

  However, growing public calls for political freedom by the swelling middle class forces the Communist leaders to reinforce their legitimacy by channeling national emotions toward external threats, such as the US and its allies Japan and Taiwan. To sustain domestic support for nationalistic assertions abroad, the Chinese government shifts national economic investments, including high-tech R&D funding, to the military. Reacting, conservative US politicians use China's growing power to vindicate their long-standing position that China is the 21st century Soviet Union, and drag the US into a new cold war, severing US vendors' high-tech links with the Middle Kingdom.

- **Scenario 3: Pax Indo-China.** In this scenario, the US National Intelligence Council's 2005 prediction that India and China combined would supercede US dominance in science and technology innovation by 2010 becomes reality. Rapid economic development in India and China, fueled by massive infrastructure investments, regulatory overhaul, and the expansion of local entrepreneurial ecosystems - makes those countries' combined markets of 2.6 billion consumers the twin engines of growth for the global high-tech industry.[6] By 2030, their combined purchasing power is five times greater than that of the US today.

  Rather than compete, Indian and Chinese technology vendors take advantage of governmental cooperation, building on the March 2005 agreement by the prime ministers of India and China to establish a strategic science and technology alliance between their countries.[7] By tapping each other's specialized invention and innovation capabilities, Indian and Chinese Innovation Networks become the high-tech version of the Silk Road, the collaborative trading network that initially linked Indian and Chinese firms nearly 2,000 years ago. By integrating their invention, transformation, brokering, and financing capabilities, Indo-China-based Innovation

[6] By 2010, India's population will reach 1.2 billion and China's population will reach 1.4 billion. Source: US Library of Congress (http://countrystudies.us/india/33.htm).

[7] Chinese Prime Minister Wen Jiabao paid a state visit to India from April 9 to 12, 2005, and held talks with India's Prime Minister Dr. Manmohan Singh and President Dr. A.P.J. Abdul Kalam. During the history-making talks, India and China signed nearly 30 agreements to promote political, technological, economic, and cultural ties. Source: Wired.com (http://www.wired.com/news/business/0, 1367,67181,00.html).

Networks create a massive market and talent supply base for both US vendors and local players to tap into, leading to competition among US and Indo-Chinese vendors.

Placing Safe Bets on the New Tech World Order: A Risk-Adjusted Projection

Because each of the three scenarios described above is plausible, it's hard to pick the "winning" scenario for the global Innovation Network era that is coming. Yet, irrespective of which scenario pans out, Forrester has identified five factors that will most likely characterize global technology Innovation Networks in the next two decades:

1. Sustained US-India tech relationships. The US and India are bound by shared cultural and societal values - rule of law, entrepreneurial mindset, use of English, and democracy - that will sustain US-India economic linkages in global technology Innovation Networks. Though the breadth and depth of these relationships could vary from scenario to scenario, they have a stronger foundation than those between the democratic US and a communist China. The growing US-China relationships are mostly economic in nature, making Sino-US links in global technology Innovation Networks vulnerable to diverging geopolitical and societal values, as described in the Cold War II scenario.

2. Influential Taiwanese and Korean technology vendors. Taiwanese technology firms have already invested heavily in mainland China, and Samsung has eclipsed Sony as the most valued global brand in consumer electronics. Expect Taiwan and Korea to join Japan as either Financiers in the Pax Indo-China scenario, or global Inventors and Transformers in the Chinese Mirage scenario. Even in the Cold War II scenario, both countries will continue to play a significant role, although Taiwanese vendors will do so as part of the China-led Innovation Network, whereas Korean players will put their innovation capabilities in play in the US-led Innovation Network.

3. Technology market growth in Latin America, Russia, and Eastern Europe. Geographic proximity and/or cultural affinity has already led US and Western European technology firms like Flextronics and Intel to move Invention activities like software development to talent-rich Russia, and technology manufacturing to Mexico, Brazil, and Poland. The Chinese Mirage scenario will accelerate this trend. Even the Indian and Chinese technology vendors in the Pax Indo-China scenario will do this in order to tap those countries' vast domestic markets, as well as to cost-effectively and flexibly meet finicky innovation demand in US and Europe.

4. Economic interdependence between India and China. In coming decades, India and China will become more economically interdependent, as both countries collaboratively invent and transform technology products and services, not only in the Pax Indo-China scenario but also in the Chinese Mirage crisis. "Demography is destiny". With its working population poised to peak in 2015 and then steadily decline, China will look for outside

help. And India will be just the place to go, as its population - 50% of which today is below the age of 25 - is poised to account for 18% of the global workforce by 2030.[8]

5. Co-evolution of US nationalism and global technology cooperation. While the US government approved the sale of IBM's PC unit to China's Lenovo, it blocked the sale of Applied Materials' chip-making equipment to Chinese foundry SMIC. Expect such American political ambivalence to force US technology vendors to hone their tango skills as their cooperation with Indo-Chinese partners evolves two steps forward, one step backward - even in the Pax Indo-China scenario.

[8] According to the United Nations, India's working age population will increase from 16% to 18% of the world's total worker pool over the next 50 years.

The Rise of Asia in IT Manufacturing

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The story of the rise of Asia in IT manufacturing is not a story of innovation, at least not breakthrough innovations. It is more a story of technology diffusion, success at adaptation and incremental improvements, which has enabled Asia to effectively compete in the manufacturing of IT equipment and more recently the production of IT software and services. There have, of course, been numerous innovations in manufacturing processes, but these are not the innovations that lead to major new directions in current industries or give rise to whole new industries.

Asia's successes in manufacturing have been spectacular and are not all due to low labor costs. An increasing supply of talented scientists and engineers, and increasing sophistication on the part of business leaders, have been significant contributors.

In the high technology leadership interviews recently done by Stanford as part of a Greater China Networks study, it became clear that there is currently little incentive to commercialize "breakthrough innovations". At this stage of its development the payoffs are too small and there is much greater opportunity in executing well on tried business models and established technologies. Of course there are adaptations and new designs, but these are not revolutionary. The major successes we see reported are adaptations of applications that have succeeded elsewhere. In this sense, China behaves like venture capitalists who prefer to invest in companies that can gain a position in a fast growing market, rather than in risky new technologies. As one VC said, "Why go for risky innovations when there is so much low hanging fruit".

Asia's successes in manufacturing, however, have been dramatic. Stanford University's Project on Regions of Innovation and Entrepreneurship (SPRIE) recently led an international collaboration of teams of experts in six Asian countries - Japan, Korea, mainland China, Taiwan, Singapore, and India - and a Stanford team, which focused on the paths these countries took in developing their IT industries. Although the format for reporting and the method of analysis differed in each country, the framework for thinking about IT developments was provided by an earlier SPRIE book, The Silicon Valley Edge (Stanford University Press, 2000). A new book based on the studies of these six countries, "Making IT", will be published by the Stanford University in 2006.

The principal process at work in Asia over the last three decades has been technology diffusion from the US, Europe, and Japan. In the last few years there has also been diffusion of technology to mainland China from Korea and Taiwan. The timing, rate of development, and effect of these diffusions differed substantially from country to country, depending on both internal and external conditions.

Each of these six countries has developed a significant position in the IT industry. Their governments have adopted strategies that are similar in some cases and different in others. Japan developed first, Korea, Taiwan, and Singapore next, with China and India developing relatively recently. We generally mark China as opening in 1978, whereas India did not embrace openness until about 1990.

Countries have followed similar development paths in a number of areas:

(1) Eventually, all six pursued export-oriented growth strategies.
(2) Early on, all got their start by acquiring technologies from the US and Europe. Japan, having started earlier, subsequently became a source of technology for the others, and more recently Korea and Taiwan have also become sources of technology.
(3) All six saw the IT industry as significant for their economic development and actively promoted it.
(4) All of these countries embraced globalism and developed varying degrees of openness in attracting foreign direct investment, welcoming the presence of multinational corporations, and immigration. Japan, and to a lesser degree Korea, were to some extent exceptions.
(5) Financial systems evolved. There was a shift from loans as a source of development capital to equity investments, and the beginnings of a venture capital system. Compared to the US and Europe, however, stock markets and venture capital are still underdeveloped.
(6) Universities have rarely been a source of technology.
(7) All of these countries had extensive linkages to the US, through immigrants to Silicon Valley, students who studied in the US and stayed on to gain industrial experience, and through technology licensing, the exchange of goods and services, and direct investment.

Policies and mechanisms for developing IT varied:

(1) Legal rules, inherited or newly established, were reasonably effective in all countries except for mainland China. Because such rules limit the ability of those with political power to extort resources from private parties, and provide predictable processes for making and enforcing contracts, they encourage investment.
(2) Japan, Korea and India long held off foreign direct investment, while Singapore, Taiwan and mainland China selectively welcomed it.
(3) Japan, Korea and Taiwan became major acquirers of technology through licensing.
(4) Flows abroad of students, many of whom then stayed overseas to work, and the return-migration of people skilled in technology and management, were important for Taiwan, India, Singapore and the Mainland but much less so for Japan and Korea.
(5) Promotion of their IT industries was done in different ways, some effectively and some less so. A wide array of instruments was used: the training of computer scientists and engineers; trade protection; inviting MNCs or, on the contrary, using other instruments such as licensing; government spending on R&D; tax incentives for private R&D; creation of dedicated research institutes; recruiting of experts with foreign experience; supplying cheap real estate to favored companies, tax breaks and more.

(6) Although all had strong links with the U.S., the mix varied: these included trade, foreign direct investment, licensing, and movements of people. There were also extensive connections between Japan and East Asia. Dense business connections have been established more recently between Taiwan and the Mainland.
(7) Some regions benefited from active entrepreneurship expressed through the formation of new firms (Taiwan, India, mainland China) while little entrepreneurship was evident in others. Singapore, Japan and Korea have been making legal and policy changes to encourage entrepreneurship, so far with modest results.
(8) Only Japan among the six displayed technical innovation throughout the period. Taiwan, Korea and Singapore, especially, began to develop it during the 1990s (measured, for instance, by U.S. patents). There are good reasons to expect an increase in innovation from these counties in the years ahead.
(9) Regional clusters became prominent in all these countries except Japan. These were mostly government-created, except for Teheran Valley in Korea, the Indian clusters, and the nascent IC cluster in Fukuoka, Japan.
(10) Except for Japan and Korea, all had mobile labor markets, and those governments have now taken actions to encourage labor mobility. A question that has arisen is whether the mobility of professionals is too high in places like Shanghai and Beijing, where "job-hopping" is alleged to be a problem. If it is, the market will sort it out.
(11) Financial systems evolved during this period, but only Taiwan had a well-developed venture capital system by 2000. A recent phenomenon is the marked rise of interest among U.S. venture capitalists in investing in China and India. Such investments might become substantial in the years ahead.
(12) Research institutes specializing in IT became ubiquitous, but their significance varied. They were significant sources of funding for new companies in Taiwan and mainland China but not in the other countries.

Asia's future IT development will be shaped by several factors:

Looking ahead there are three factors that will be most significant in shaping the future IT industry: (1) the growing importance of Asian demand for IT products; (2) the further development of venture capital; and (3) the prospect of Asia becoming a creator of technology.

Asia's Growing Market for IT Products. Its role as a supplier has long been prominent, but it is now becoming clear that Asia will also be a large consumer. Japan, with total economic output one-half that of the U.S., is already a major IT consumer, but the economic development of China and India will transform the world market for these goods. With plausible projections that China's total output in purchasing parity will overtake that of the United States by around 2015, and that India will do the same perhaps 20 years later, an enormous demand for products is on the horizon. The large markets will not be limited to Japan, China and India. Indonesia, for example, also has the potential to become a large consumer.

Their rise on the demand side is beginning to have a significant effect on the supply side. Even in an age in which telecommunications costs have plummeted, distance can matter. Producers of many products want to be close to their customers and, increasingly, these customers will be in Asia. To cite a recent case, the Wyse Corporation, a maker of computer terminals, is expanding into the mobile telecommunications market and, at the same time, is moving sixty percent of its jobs from Silicon Valley to India and China. Those remaining here will perform headquarters and research functions. It is making this move to be closer to customers and because engineers are cheaper there than in Silicon Valley. Management forecasts a five-fold expansion in sales by 2010. This is not necessarily a zero-sum game, however. If Wyse succeeds, by 2010 it might have more – and higher level – workers in Silicon Valley than it does today.

Development of Venture Capital. Venture capital, as it is has developed in the U.S., is a very productive but complex system that turns out not to be easily transferred to other economic systems. It depends, among other things, on having a cadre of experienced participants, and it takes time to develop them. Venture Capital has been successfully transferred to some nations, particularly Israel and Taiwan. In their chapter in *Making IT,* Kenney et al point out that the Asian economies most successful in creating a venture capital industry are those with the closest human ties to the United States, Taiwan and Singapore. Their governments have adopted policies to encourage it, and because India and China have strong ties to the U.S., Kenney et al suggest that a Silicon Valley-like venture capital industry will evolve there. They expect China to become a "successful hotbed for venture capital innovation." They also point out that investors there are subject to the vagaries of the Chinese legal and political system, that its long term profitability is not yet proven, and that a more stable system is needed.

Advances in Higher Education, Science and Technology. There is a growing belief in scientific and technical circles that Asia is not only a place for making things but also a place where important technologies will be created – perhaps soon. All of the countries that have not already done so are establishing the requisites for this. They have able, well-trained people, have or are developing needed institutions, and have researchers with personal experience and connections in productive research establishments around the world.

The American experience supports the view that the core requirement for having innovative science-based industries is having excellent universities. Dr. Morris Chang, Chairman of Taiwan Semiconductor Manufacturing Company, has commented "I wish Taiwan had a world-class university." Taiwan is not alone. According to a recent survey of the world's top 500 universities by Shanghai's Jiao Tong University, Asia has none in the top 100 outside of Japan. The Times Higher Education Supplement rates Asian universities rather higher, with eight in its top 100 outside of Japan: Beijing (#17), National University of Singapore (#18), Hong Kong University (#39), Indian Institute of Technology (#41), Hong Kong University of Science and Technology (#42), Nanyang University (#50), Tsinghua University in Beijing (#62), and the Chinese University of Hong Kong (#84). This is not very many for a region with 40 percent of the world's people.

The problem is not with the quality of the students. Rather it is with the quality of faculties and the research support they get. Many talented students have gone abroad for graduate studies and stayed there; many first-rate academics from Asia are found in American and European universities; others have moved to careers in business; and governments have tended to allocate research funds preferentially to research institutes rather than universities. Given the importance of graduate students in advancing science, this is a dubious allocation of resources. This is changing as Asian universities work to improve their quality. One indicator is the large and growing numbers of scientists and engineers with advanced degrees. The number of PhD's granted in Korea from 1986 to 1999 increased four times, in Taiwan by five times and in China by about 50 times (from 100-200 to over 7,000). There is increased spending on research and development, growth in scientific publications, and in their quality as measured by citations.

On the commercial side, there is a high and rising level of patent generation in Japan, Korea and Taiwan, the beginning of international patenting from China, and a shift towards net zero in the balance of royalty and license payments with the US. Singapore has recruited a stellar group of biologists from around the world and many foreign firms have set up R&D centers in China – reportedly over 600 in number. There is some question about what activities are actually taking place in these centers; many seem to be designing products for the domestic market rather than doing research or leap-ahead development, but this will likely change.

China has great ambitions in science and technology and given its accomplishments they are likely to be realized – although the timing is uncertain. Between 1995 and 2000, its spending on R&D more than doubled. It still was only one percent of GDP, but was growing at ten percent a year and the government says it wants to increase that share. By 2000, China ranked eighth in the world in scientific papers contributed by Chinese authors (three percent of the world total), compared with 15th five years earlier. This does not mean that China's capacities are up to those of the industrialized countries, which is not likely happen soon. But it is on the move.

China's progress in nanoscale science is one indicator of progress. From publishing no articles in this field in 1984-87, in 2003 Chinese scholars produced about 12 percent of the nanotechnology articles published in the world, and nearly half the number produced in the leading country, the U.S. This was more than was published by scientists in Japan. However, China was still short on high impact articles (judging by citations), with about 15 percent as many as the U.S. (in 2001-03).

A creative Asia will have mixed implications for others. The generation of new ideas can benefit everyone. It also gives their creator an industrial advantage – as Silicon Valley has demonstrated. What should not be in doubt is that the U.S. and every one else will face a large challenge coping with the rise of an innovative Asia.

Services Innovation as a Competitive Response to Globalization

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The articles in this volume are about the future, specifically what Americans—as individuals, private organizations, and government—should do to prosper in the new, more competitive global economy. Of course, no one can predict the future precisely. It is possible, however, to see its outlines by considering four factors:

1) Demographics: the people who can produce, consume, procreate, and compete
2) Technology: the objects and processes people use to produce value
3) Economics: the results of people applying technology in pursuit of their goals
4) Culture: shared beliefs and social norms—and one of the reasons that groups with similar physical resources produce markedly different economic results (a story elaborated in Jared Diamond's *Guns, Germs, and Steel*)

Tracking secular trends in these factors—not simply short-term perturbations—reveals the most likely scenarios. What do these exercises tell Americans—and Bay Area residents in particular? The good times may be over, unless we radically change our ways to become more competitive. Unbridled competition with Asia (China and India in particular) is inevitable. Innovation is the key if we are to maintain our position in the world.

That Was Then, This Is Now

As a group, American households have enjoyed a steadily growing standard of living for more than 30 years based on personal disposable income (Bureau of Economic Analysis, 2006). The benefits have been large and distributed widely. For example, in 1959, 22.4 percent of Americans were living below the poverty line; by 2004, that figure was just 12.7 percent (U.S. Census Bureau, 2005). Admittedly, much of the household gains reflect a simple fact: households are putting more labor in the market. The number of women (age 20 and over) employed outside the home, for example, rose from 35.1 percent in 1959 to 57.6 percent in 2005 (U.S. Department of Labor, 2006).

After World War II, the United States enjoyed almost unchallenged economic opportunity while the former world powers rebuilt. The "extra" gains accrued during that period of relatively weak international competition were invested wisely in public universities and schools, transportation infrastructure, telecommunications, television, and the electrification of the last few isolated farms and hamlets. Investments in the so-called "military-industrial complex" (a term used by Dwight Eisenhower during his 1961 presidential farewell address), driven by Cold War demands, fueled research and development innovations that spilled over to civilian applications. The Internet, envisioned in 1970 to provide communications resilience in the event of thermonuclear war, was a product of this era (although it was not until 1995, when the easy-to-use browser and Worldwide Web appeared, that the Internet reached the masses).

Despite some ups and downs, since World War II Americans have enjoyed a level of prosperity heretofore unknown in human history. Now, however, storm clouds loom large on the horizon. Competition has arrived from many sources, and it is not going away. Sean Randolph's article in this volume provides a pithy summary of the forces at work, and Thomas Friedman's book on global competition has captured public attention. Its title—*The World is Flat*—has become the answer to every economic question. "Should I be worried that my medical and financial records are exposed somewhere in an outsourcer's offshore operations?" Answer: "The world is flat." In other words, it's inevitable; get over it.

Some might summarize the current trends as "manufacturing to China, and software and business-process outsourcing to India," but that ignores the truly global scale of the value migration. The rise of India and China cannot be disputed. From 2001 to 2005, India and China posted real GDP compound average growth rates of 6.8 percent and 9 percent, respectively (Global Insight, 2006). But mindless, straight-line extrapolation of growth projections is dangerous. We learned this in the 1980s, when Japanese industrial prowess—based largely on production techniques imported from American innovators like Dr. W. Edwards Deming—dominated Western manufacturers. The Japanese enjoyed what were, at the time, record-breaking trade surpluses with the United States.

Two things happened to change this trajectory. First, the world went to school on the Japanese production methods, and Western productivity improved dramatically. Turnaround stories from this period have become modern business legends. Harley-Davidson, maker of the iconic American motorcycle, almost went out of business when a tsunami of innovative, high-quality, low-cost Japanese products flooded the market. By making radical improvements in product designs, production processes, and labor arrangements, however, Harley-Davidson not only survived, it thrived.

Second, the Japanese, flush with the world's cash, overinvested in some sectors (notably real estate), aided by banks that assumed continuing boom times. The result was predictable: a classic bubble, which burst in 1991, followed by a deep economic malaise.

The message is plain: assume a *competitive reaction*. It may not be adequate to reverse the tide, but often it is sufficient to change the competitive trajectory. For instance, when the Worldwide Web appeared, e-commerce promised to "blow to bits" Old Economy brick-and-mortar businesses, to quote the then popular book by Philip Evans and Thomas Wurster. Web-based e-commerce operations like Amazon.com were going to eliminate bookstores, but it did not turn out that way because the book distribution business responded with more efficient supply chain logistics and consolidation, which permitted more competitive prices. Barnes & Noble, which operates 824 brick-and-mortar bookstores and also sells via the Web, sold approximately $5 billion in media—books, movie DVDs, and music CDs—last year, while Amazon's media sales were $6.3 billion. Dot-com-era forecasters failed to see the growth of harmonized, multichannel distribution, which is now the norm in most industries. Retail banks, for instance, serve customers through a combination of branches ("stores" in banking parlance), ATM networks, websites, and call centers.

The lesson here is that we should not underestimate competitive responses. Others' comparative advantages in cheap labor can be balanced by technology innovation.

What Is the Solution? More Innovation

The word *innovate*—"to make changes, to do something in a new way"—stems from the Latin, *innovatus*; but the first use of the transitive verb form in English was in 1548, in the midst of the Renaissance, arguably the most radically innovative period in human history. That innovation is back on our agenda is a sure sign the economy has rebounded from the collapse of 2001. Enter "innovation" in a Google search and more than 721 *million* items appear. Amazon.com offers no fewer than 11,583 books with "innovation" in the title.

Innovation, stripped down to the basics, involves three steps: *invention*, *adoption*, and *implementation*. Interestingly, most of the innovation literature emphasizes the first element: invention, or new ways of doing things. "Innovation" is closely related to "creativity"—doing things in a completely novel manner. We remember and glorify those who had the "Eureka!" moment. The more unexpected and novel the approach, the greater our admiration.

Adoption is not the hard part; seeing the potential of an idea is not difficult. The hard part is *implementation*—making a new idea real, profitable, and a standard for the way we do things. Which innovation phase will we nurture? Is it breakthrough invention, which creates new value through disruptive technologies and processes? Or is it improved implementation—a society that is quick to discard traditions, change restrictive laws, and adopt new ideas?

Services Innovation

Services, as a proportion of gross domestic product (GDP), have grown for almost a century and now account for the lion's share of U.S. GDP—78.5 percent in 2004 (Bureau of Economic Analysis). This does not mean that manufacturing is less important. We have more "things" than ever before, but we are consuming relatively fewer resources to produce these manufactured goods, so prices have risen slowly and performance has risen exponentially. Many businesses in Silicon Valley live by some variant of Moore's Law: price-performance doubles roughly every 24 months in the semiconductor industry, 18 months for storage, and 12 months for networks.

Productivity trends vary widely across different industries. It is important to understand why this is true because the answer highlights opportunities for innovators. Indexing productivity in 1997 to 100, we see that by 2003, productivity was 219 in manufacturing; 141 in grocery retailing, wholesaling, and general merchandise stores; and 102 in commercial banking (BLS, 2006). The gap between manufacturing productivity and services productivity pinpoints an opportunity for innovative thinking.

Two kinds of services innovation in particular will accelerate. One will improve *services productivity,* making it feasible to deliver more services to more people at lower prices. The second will create value through *new service models.* Both strategies depend heavily on technology, especially information technology.

Improved Services Productivity

The solution to services productivity is either to eliminate labor through automation or to make labor more efficient. A few of the IT-based innovations that companies are pursuing to deliver more efficient service transactions include self-service, interactive voice response, automatic provisioning, distribution channel convergence, and wireless applications.

1) Self-service is a growing trend. One way to cut labor is to ask the customer to "do it yourself." Airlines invite passengers to step out of long lines and use automated kiosks to check in. Typically, these kiosks allow 2.6 agents to do the work of four, a 35 percent labor saving. Similarly, retail stores have installed self-checkout systems, which are seeing rapid adoption: according to the Food Marketing Institute, almost half of U.S. supermarket chains now use self-checkout—up from only 6 percent in 1999 (*Sacramento Business Journal,* May 13, 2002; *The Philadelphia Inquirer,* April 30, 2006). These labor savings can be applied two different ways: (a) to cut expenses and, in theory, the prices customers pay, or (b) to redeploy the labor to new value-creation activities.

2) Interactive voice response (IVR) technology has become so common in call centers that it's difficult, and sometimes impossible, to reach a live agent. Websites like gethuman.com, which reveal workaround codes to reach a live agent, reflect the frustration many users feel. Some companies are making IVR more palatable through "brand personification"—attributing a personality to the voice on the line. Bell Canada, for instance, has created a character—"Emily"—to answer questions on IVR systems (310-BELL) and the customer service Website. Emily handled more than 35 million of the 85 million calls Bell Canada received last year.

3) Automatic provisioning: Automating the elements of services promises to boost productivity the same way automation revolutionized manufacturing. Check into a wireless network in a hotel, airport, or Starbucks, and you experience firsthand the automation of self-provisioning. It is all machine-to-machine.

4) Converged networks: Before buying a car, 60 percent of American auto buyers spend almost five hours consulting Internet information sources, visiting an average of seven sites (J.D. Power and Associates, 2005). Often, buyers need to talk to a human being about what they are seeing. That requires a converged network, which allows the prospect and a call center agent to co-navigate Web pages and view unique content that is "pushed" to the customer. When call centers and Websites work on the same Internet Protocol standards, this collaboration is feasible.

5) Wireless communications: Most of the 109 million houses in the United States have utility meters, which record how much gas, water, and electricity the household uses—information essential for calculating utility bills. Most of these meters are "read" by a meter reader — an expensive labor investment that adds no value to the household and often creates inaccurate bills. Once it was a necessary evil, but today wireless, automatic meter-reading technologies (and other methods) can reduce the labor required. Another example of the myriad ways wireless communications are improving efficiency is the "line buster"—a mobile cashier who checks out customers during peak hours at many retail stores or checks in returning customers at a car rental site.

All of these technologies are examples of innovations aimed at improving the *efficiency* of services production, but the biggest value gains will come from entirely new services.

New Service Models

The second form of innovation focuses on creating new services or delivering services in new places. There are opportunities for remote delivery of complex services, more service-enhanced products, and coproduction of value through collaboration.

1) Remote delivery of services: Healthcare spending consumes 15 percent of U.S. GDP, and the trends are ever upward. "Telemedicine" makes it feasible for specialists to deliver their expertise to patients located far away. For example, M.D. "intensivists" in central eICU control rooms can monitor patients in intensive care units spread over a wide geography (Sentara Healthcare, Norfolk, VA, 2006). Rural hospitals that have no staff radiologist can deliver first-class care by having images read remotely by certified radiologists in Australia (*Medical Imaging* magazine, February 2005). And a physician in Canada has used hospital-to-hospital telerobotics procedures to complete successfully almost two dozen laparoscopic surgeries on patients located more than 400 kilometers away in rural communities (*Virtual Medical Worlds*, 2003).

2) Service-enhanced products: As products commoditize—just about everyone is offering the same features at roughly the same prices—manufacturers are adding services to extract better margins. American auto companies make almost 70 percent of their net profits from services they sell, rather than from the vehicle itself. The service revenues come from financing, extended warranties, and monthly fees for services such as OnStar communications, cell phone services, and satellite radio. For these manufacturers, it is a "razor and blade" business—they will give away the car in order to create a platform for more profitable services.

3) Coproduction of value: Globally, government spending equals 30 percent of total world GDP, or $11 trillion. The classic view of government is that taxpayers provide the money and government gives citizens services. Coproduction of value is a new way of creating value for citizens. For example, chaos reigned when Hurricane Katrina destroyed parts of the Louisiana, Mississippi, and Alabama coastlines in 2005, and government at every level was unable to answer refugees' questions about what happened to their property. But private citizens used their own computers and time to provide that information (*The New York Times*, September 5, 2005). They used pre-storm satellite images, provided by free sites like Google Earth, and post-storm fly-over photographs, provided by the U.S. National Oceanic and Atmospheric Administration (NOAA), to create composite "overlays" that showed the condition of specific properties. As a result, they provided a service that government could not produce alone. There are many other possible applications of coproduction principles, including monitoring of pollution, land-use compliance, and health status (now done by sampling "sentinel" hospitals).

From Transactions to Interactions

The greatest source of new value in services comes from converting mere transaction exchanges into *interaction* exchanges—creating more valued experiences based on knowledge about the customer. These personalized experiences engender greater loyalty from customers. In his popular book *The Loyalty Effect*, Frederick Reichheld showed that loyal customers generate higher profits because they give a larger share of their budget to their favorite brands, increase spending as they move through the lifecycle, pay a price premium, and refer others, which reduces new-customer acquisition costs. To enable deep, personalized interactions with customers, companies must be able to capture information about customers and apply this learning in future exchanges.

In the distant past, the corner shopkeeper knew customers' individual wants and needs quite accurately because he or she dealt with them often. Stores also sold on credit, so shopkeepers had an incentive to know their customers' credit worthiness and financial condition (see Susan Strasser, *Satisfaction Guaranteed*). Today, in a 24/7 environment with high employee turnover, it is difficult to establish those ongoing relationships. Increasingly, however, technology is providing a solution.

"Auto-segmentation" is a way to customize interactions in the absence of deep, personal information about a customer. For example, Netflix—a company that rents DVDs, which are ordered online and distributed via postal delivery—created a recommendation engine called Cinematch. If a customer gives permission, his or her friends can review that customer's past movie choices. "Birds of a feather flock together," as the old saw says, so it is not surprising that 60 percent of the DVDs that Netflix customers choose after consulting Cinematch are not on their original purchase list. Netflix is using customer relationships and technology to deliver a new and valued service. One measure of Netflix's innovativeness is the 170 percent increase in its stock price over the last 12 months (*FastCompany*, October 2005; Variety.com, October 2005).

To enable interactions across a large customer base, companies must invest in technologies that facilitate the four steps of the interaction sequence: Capture, Analyze, Store, Act (CASA):

Capture: Airlines' frequent-flyer programs illustrate a simple capture scenario: when you fly, you identify yourself and your account number in order to claim your mileage reward. Similarly, every sale at Wal-Mart ends up in a database as it is scanned. As a result, stores are able to adjust stocking levels based on the velocity of products moving through the scanners.

Radio frequency identification (RFID) tags are automating data capture and changing supply chain economics. An RFID tag is a tiny circuit, with memory, logic, and an antenna. A reader connected to a network can capture information from each RFID chip. RFID tags have two advantages over bar codes: (a) bar codes identify only the category of an item, whereas the information in RFID tags can include a product-specific identifier; and (b) bar codes must be read in a straight line of sight, while RFID tags broadcast their contents. Technologies like RFID provide a low-cost way to capture large amounts of information about products, people, and their environments. When properly analyzed, these data show what needs to be done to deliver a compelling customer experience. This ease of data capture, however, has also raised privacy concerns about "spychips."

Analyze: The objective is to reach a policy decision to guide action. "Given these facts about the customer, we will do X." Business intelligence applications inform those who make the policy rules, and a steady stream of customer interactions provides feedback about the effectiveness of these policies in the real world.

Store means that we remember what we decided to do the next time we encounter a particular customer. In the past, this information might have been stored in a massive data warehouse. Now, the data can be distributed across many systems spread around the world and brought together automatically in a single view of the customer, where and when needed.

Act refers to applying the policy rules to create value for the customer. Consider this scenario: your flight is delayed en route by weather and you miss a connecting flight. The airline's computers detect the event, examine your status—based on your financial value to the airline (customer lifetime value)—and apply appropriate rules to book a seat (of the kind you prefer) on the next available flight. You receive a confirmation on your mobile phone, and e-mail messages are sent to your office, family, and the car service that was scheduled to pick you up at the airport.

The noteworthy fact about the combination of technologies described here—the CASA model—is that every element exists today. Technology costs have fallen sufficiently to make it feasible to deploy these innovations at scale. The question is: who will do it?

The Path Forward

To establish an effective framework for services innovation, we must first identify interests that represent the best opportunities for building profitable services industries. Only then can we begin to foster the conditions needed for success. The path forward includes the following steps:

1) Improve services productivity through reengineering and intelligent application of technology. Out-tasking and outsourcing will also be part of the productivity equation. These efficiencies will generate the savings needed for investment in advanced services.

2) Redeploy redundant labor into higher value-add tasks. If a company achieves productivity gains but cannot reapply the saved labor, some employees are redundant and must leave. Schemes to soften this personal hardship have been tried, particularly in Europe, with some success. Upskilling is critical.

3) Improve educational effectiveness, particularly in K-12 schooling. Occupations—what workers do—have shifted toward tasks that require (a) expert knowledge and (b) advanced communications skills. That trend is accelerating, as Levy and Murnane demonstrated in *The New Division of Labor*. Education, from preschool to university, must recognize these demands and align the curriculum, teaching methods, and metrics accordingly.

4) Foster broadband to home and small businesses because this infrastructure is essential to services innovation and delivery. In the 1800s, it was the canal system that opened up new regions and changed American economics. Later, the railroads accelerated these trends. Then it was electricity, petroleum, and the highway system. Now, the Internet is the key infrastructure investment. The United States invented the Internet and had an early lead in adoption, but it now ranks well down in the international rankings. Korea and Japan, for example, offer far higher bandwidth at much lower prices than are available to U.S. consumers and small businesses.

5) Maintain the United States as the center of science, technology, and innovation. The United States dominates science right now, but this concentration of influence will erode as other regions invest in the invention element of the innovation equation. The United States, however, can still play a leading role by providing the best support services, technology financing, and science education.

6) Protect our intellectual property effectively. If invention, the first stage in innovation, is going to be a U.S. comparative advantage, investors must have confidence that their risks will be rewarded. Many of the newest sources of service value, however, come from combining existing inventions, and strict patent rules inhibit those new aggregations. A more nuanced approach to copyright and patent regulation is required.

7) Control global service certification standards, so that service delivery is consistent with American mores and educational and business conventions.

8) Develop the legal and social conventions that foster customer trust. Many innovative services depend on customer information to create and deliver new value to customers, and this raises privacy concerns. It is imperative that individuals feel secure about opting in to permit use of their personal information. Transparency is essential—customers must be able to control data capture, sharing, and use. And, of course, security is a fundamental requirement.

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How Should the Bay Area Respond to the Global Innovation Challenge?

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No region has been more closely associated with emergence of new technologies than the Bay Area. Recently the National Academies of Science and Engineering published a landmark report "Rising above the Gathering Storm" that calls for urgent national action if the United States wishes to retain its technological and economic leadership. Where is the Bay Area in this discussion and what should it be doing to lead a response?

The region competes in the global market as a knowledge-based economy powered by its wealth of research capacity, technology, entrepreneurship and innovation. It is the venture capital "capital" of the world, receiving 35 percent of all venture capital invested in the United States. With that capital, local companies can obtain capital and move ideas and products into the marketplace faster than anywhere else.

Silicon Valley is known for IT, but the Bay Area's leadership in bioscience is just as significant. In 1976 a University of California San Francisco biochemist Herbert Bower, and venture capitalist Robert Swanson, formed the first biotech company in South San Francisco – Genentech. Today this is the leading bioscience region in the world, with 600 bioscience companies and a total of 820 life science companies. A new life science company is created in the Bay Area on average every 10 – 14 days. Since 2003, and in the biomedical field alone, there have been 315 spin-off companies from our five research universities.

The Bay Area has a much higher concentration of knowledge-based occupations – especially professional and executive positions – than the nation as a whole, and its percentage of computer, math and engineering jobs is twice the national average. 37% of its residents have at least a bachelor's degree, compared to 24% nationwide, and one in six has a graduate or professional degree. More than 10% of all the nation's patents are generated in Silicon Valley – patents per capita have more than tripled, from 114 to 377 per 100,000 residents between 1994 and 2004.

A Sputnik Moment or a False Alarm?

However, the Gathering Storm report sounds an alarm bell. Citing an array of global challenges, it concludes that "the United States must compete by optimizing its knowledge-based resources, particularly in science and technology, and by sustaining the most fertile environment for new and revitalized industries and the well-paying jobs they bring." Will this be a "Sputnik moment" in US history, or a false alarm? There are dueling statistics being ventured on both sides of the argument, with both dire predictions and assertions that job losses are minimal and that the US is still leading in technology.

Some, citing the current doom and gloom, say that we are losing our skilled workforce and should come down hard on "disloyal" American executives who are exporting jobs. Yet many companies are now global organizations that derive revenue just as globally as they source labor. It is only natural that they will use labor and deliver their value wherever economics dictates that they should. And on the other end of the spectrum, there are the comparative advantage *laissez faire* advocates who believe that "everything will be OK". Analytical international economists will tell you that it could go either way: we can either have a win/win or a win/lose endgame.

One of the principal causes of decrease in profitability of a business is the commoditization of its products or services. If industries commoditize, we can fight it out on costs such as labor rates, but in this flattening world the more expensive regions will lose, at least until costs equilibrate (e.g., labor rates sink to meet the rising labor rates abroad). With respect to jobs, this is not something any of us want to see. There are only three ways to fight commoditization: (a) exit, (b) de-commoditize, and (c) accept commodity product pricing and innovate on the supply side. Let's look at these one by one.

To exit (option a), you must have a replacement product; in other words you must innovate to develop new products or you will end up with smaller output and the win/lose endgame. De-commoditizing (option b) is fundamentally about changing the character of your products/services to be more innovative in what you deliver. For option c to work (accepting commodity product pricing and competing instead on the supply side), success stories again demonstrate that the biggest lever is innovation. So the net message is that whether or not we can make globalization a win/win proposition is a function of whether our products and services stagnate or innovate.

The second element in parsing the problem concerns jobs, and the concern that young people don't want to go into physical science or engineering any more. We hear from universities that they are being forced to drop their GPA thresholds for incoming classes in science and engineering (especially computer science), and that international applications at graduate schools are down. Actual acceptances may not be down as much, if standards are lowered. The implication of this is that while science and technology educational output may remain the same, quality may well be lower. What is causing this? For international students, part of the problem stems from the difficulty in obtaining visas to the U.S. since 9/11. Part stems from higher U.S. costs, and part from stiffening competition from other regions. For American students, one explanation is that students have heard that "all the programming and engineering jobs are going to India and China", or may know a friend whose father's job has been "offshored."

If our workforce fails to excel, and we try to compete for low-end engineering jobs, the road ahead is going to be very difficult. Educational institutions abroad are first class and they are producing top talent that can be hired for a fraction of the price that prevails here. But our winning play has always been that we change the game. Look closely at our key technology industries and you will see that they are undergoing fundamental change. For example in IT, the cost of hardware and software accounts for a decreasing portion of total cost – the majority of the cost is in labor and services. For example, it costs less than a dollar to buy a gigabyte of raw data storage. Adding the needed surrounding systems and software might cost you $10, but the cost of services (labor plus technology) to make that gigabyte secure, reliably backed up and resilient to disaster or attack typically costs hundreds of dollars per year. Does an increase in services mean an increase in labor content and therefore an ever greater problem as labor is sourced globally? Not necessarily. It means that there is both an opportunity and an imperative to innovate. And indeed there is plenty of evidence that the need for services is increasingly providing a fresh set of opportunities to innovate with new technology-based services.

The Gathering Storm report calls for increased federal investment in physical sciences, engineering, mathematics and information sciences. So, to that we must add "the science of services". Over 70% of the US economy is now services-related, and services are rapidly growing in other economies around the world. The most commonly given example of this rapid rise in a services economy is of course India, but China is just as determined to participate. Mr. Guanhua Xu, the Chinese Minister of Science and Technology, recently observed at the First China Modern Services Forum that "facing the global services transformation environment, we should view services as being at least as important as manufacturing, and that Government should bias towards supporting the modern services industry." He then proceeded to outline how China would do just that, by building supply chain services and by expanding into technology services.

Services are a U.S. product that in many cases can be easily sourced anywhere, and whether we continue to have a viable services economy will directly influence whether we stagnate or grow. Fortunately, we still have an extraordinary base for services science in some of the world's most advanced information, mathematical and social science, which can be applied in new ways to a new class of problems. For example, IBM tends to be thought of as a product company, but today over half of its revenue comes from services – and not surprisingly it is heavily engaged in using and promoting services science and technologies.

What will be these opportunities for fundamental change (and the non-commoditized jobs that go with them) in the 21st century be, and where will the sources of future innovation will be? Some of the most promising areas include:

a. Highly innovative services: frequently based on technological and business innovation;
b. Nanotechnology: commodity electronics may be offshored, but we are hitting fundamental limits to scaling in microelectronics. The answer to these limitations will come through innovation in nanotechnology;
c. Technology to help the US become more self-sufficient in energy;
d. Personalized medicine: using genomics or other techniques to understand which therapies will work on whom.

These four areas are already the focus of major work in the Bay Area. In the field of services, for example, both San Jose State and UC Berkeley have recently launched formal diploma-granting programs in Services Science Management and Engineering; there are numerous research programs underway in nanotechnology, and the beginnings of nano-level production; Lawrence Berkeley Laboratory (LBL) and other Bay Area laboratories are conducting breakthrough energy research; and both our universities and biotech companies are investing heavily in personalized medicine.

There are also specific tie-ins between the major recommendations in the National Academies' "Gathering Storm" report and programs at BASIC, the Bay Area Science and Innovation Consortium.

National Academies recommendation: "Increase America's talent pool by vastly improving K-12 mathematics and science education."

Somewhere right now there is a student who is deciding whether to go into an area that may have him intrigued him or her, but is wondering whether to take a "safer" path and do "something that is not currently being talked about in the same sentence as offshoring." We will succeed if we can reach those students, intrigue them to take the right path, and then deliver the programs and courses to help them succeed. Bruce Alberts at UCSF has argued that we need to teach science as an activity, not a form of history. San Francisco has a nationally recognized Science Education Project (SEP) that he started more than 10 years ago as a collaboration between UCSF, the City of San Francisco, and the San Francisco Unified School District, with scientists and educators working together to support quality science education for K-12 students.

National laboratories are also playing a role. At the NASA-Ames Research Center, the Ames Exploration Encounter uses real-world locations --like wind tunnels and space station labs --and specialized equipment to provide 4th through 6th grade students and their educators with immersive, interactive experiences in Earth and life science and engineering, space technology, aeronautics research, and the "feel" of living and working in space. More than 100,000 students and 3,000 teachers have expanded their horizons in this decidedly non-classroom setting over the past 15 years.

SRI International is collaborating with Girls Inc. of Alameda County to create and implement "Build IT", an after-school and summer youth-based curriculum for low-income middle school girls, to develop information technology fluency, interest in mathematics, and knowledge of IT careers. In the corporate sector, HP for the past 13 years has been participating in the National Science Resources Center, working with 70 U.S. school districts and impacting more than one million students. There are many other programs like this, including IBM's EXCITE program for middle school girls. The latter program found a remarkable difference in the answers to the question "are you interested in a career in science or engineering?" when asked at the beginning and end of the course.

National Academies Recommendation: "Sustain and strengthen the nation's traditional commitment to the long-term basic research that has the potential to be transformational, to maintain the flow of new ideas that fuel the economy, provide security, and enhance the quality of life."

Once we have captured the heart and mind of that student and he or she has decided on a career in science and technology, how do we provide the sustaining resources needed to maintain our world-class capability? We've sold the student a "bill of goods" if we don't ensure that our industries are on a path of world class innovation.

Both the Bay Area and the State of California have long and rich histories of bringing together government, university and a diverse high technology industry to establish world-class, collaborative research capabilities. Notable recent examples include the four California Institutes for Science and Innovation (CISI) – unprecedented partnerships between the State, the University of California, and California industry. These institutes were conceived as a catalytic partnership between university research interests and private industry, with the goal of expanding California's economy into new industries and markets and accelerate the delivery of scientific innovation to the end user.

The two Institutes based in the Bay Area are:

- QB3 – the California Institute for Quantitative Biomedical Research (UC Berkeley, Davis and Santa Cruz). Research at QB3 involves the application of computational tools in mathematics, engineering and physics to tackle the complex biological problems essential for many medical advances.
- CITRIS, or the Center for Information Technology Research in the Interest of Society (UC Berkeley, Davis, Santa Cruz and Merced). Major projects are being conducted in the fields of transportation, health care, education, environmental monitoring, energy efficiency, and emergency response/homeland defense. These projects are all based on the role that information technology can play in addressing large-scale societal problems.

The state's stem cell research program, the California Institute on Regenerative Medicine (CIRM) stem cell research program, which will invest $3 billion over 10 years, is also based in the Bay Area.

The fact that we have the world's highest concentration of research universities, national laboratories, biotech, IT and other corporate laboratories offers unprecedented opportunities for innovative collaboration.

National Academies Recommendation: "Make the United States the most attractive setting in which to study"

Foreign students and scientific colleagues have always been a key ingredient of innovation in the U.S., and in the Bay Area in particular. They have added a significant component to our sources of talent, as students or visitors and sometimes as immigrants. Last year, a BASIC report on visas for higher education and scientific exchanges stated that "A high proportion of the foreign nationals now working in Bay Area companies first came to the region as students, earned advanced degrees and remained to make major contributions to the economy. Surveys show that nearly 80% of mainland Chinese, nearly 80% of Taiwanese, and almost 55% of Indians working in Silicon Valley attended school in the United States." As markets in developing countries explode, that interchange has become even more critical to our success, but we are no longer the only game in town when it comes to attracting the most promising talent. Security concerns have increased since 9/11, resulting in tighter procedures for foreign students and scientists coming to the United States. While the need for measured improvements in security is clear, we need to re-evaluate our risk acceptance posture, to make sure that unnecessary measures do not damage our ability to attract the world's best minds, or to compete as a region and a nation.

On a more personal note, having come to the United States as an exchange student, and later having been welcomed as an immigrant, the United States was a beacon for scientific and technological leadership. That beacon will dim if we discourage and exclude students, scientists and technologists from overseas, who now have more choices than ever in where and how to conduct leading edge research and development. We must prudently balance the need for security with our need to remain leaders in science and technology, and increasingly, in the business and competitiveness that goes with it.   The perception has developed that it is more difficult now to become part of our business and academic network. We have to change that.

National Academies Recommendation: "Ensure that the United States is the premier place in the world to innovate"

Innovation isn't just about invention, but about the translation of this creativity into impact. Historically, one of the Bay Area's key recipes for success has been the effective collaboration between our academic and commercial institutions. But this has been increasingly threatened by Intellectual Property (IP) disputes. One of BASIC's most exciting projects has been its BASIC IP project, which is working to break down the barriers that have been hindering university and industry collaboration. We have outlined new principles to guide how we work together, and are already seeing the benefits in accelerating the joint study agreements between our members. We have national partnerships with GUIRR (the National Academies-sponsored Government-University-Industry Research Roundtable), as well as the Open Collaboration Principles for Software Research (sponsored by the Kauffman Foundation). These efforts have been publicly supported by more than a dozen leading research institutions.

Not so long ago it was thought that the way for the federal government to promote innovation was to simply increase R&D budgets. It is becoming increasingly clear, however, that in addition to greater capital investment we also need to create an environment in which innovation will flourish. In this context, we need to determine how to protect the rewards of intellectual property, while at the same time encourage the proliferation of open standards. Intellectual property rights and legal judgments should not get in the way of innovative partnerships between private industry and academia, or stifle innovative commerce.

The challenge we face is increasingly clear, and so is the need for action. Some steps we should consider to assure that the Bay Area, California and the United States remain global hotbeds of innovation are:

1. Build public-private support for Congressional legislation, and for state and regional action in California, that responds to the National Academies report, such as the PACE Acts and the National Innovation Act.
2. Address the issue of visas and green cards for foreign students studying in high priority disciplines.
3. Consider a California R&D tax credit or other tax incentives to encourage private investment.
4. Provide operational funding for the California's Institutes of Science and Innovation.
5. Encourage the more rapid deployment of broadband networks.
6. Develop strategies to attract the best researchers to California.
7. Develop strategies to increase the number of trained math and science teachers in California, and the number of bachelor's level graduates in math, science and engineering.
8. Consider the creation of a position on the Governor's senior staff to coordinate with the science and technology community.
9. Encourage the State Legislature to create standing committees to deal with science and technology issues.

In the end, it doesn't really matter whether the threats to US jobs from globalization are real or being exaggerated. We should continually re-examine ourselves, not take our leadership for granted, and recognize that now more than ever innovation is the best source of regional and national advantage. Our baseline capabilities to respond are strong but we must act now to focus them on this new set of challenges.

This essay is based on a presentation given on February 27, 2006 to the National Academies Committee on Science, Engineering, and Public Policy (COSEPUP), which sponsored the report "Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future (2006)"

APPENDICES

Appendix I

Contributors Biographies

R. Sean Randolph
Sean Randolph is President & CEO of the Bay Area Economic Forum. He previously served as director of international trade for the State of California, and as International Director General of the Pacific Basin Economic Council, a 15-nation, international organization of leading U.S., Asian and Latin American corporations. His professional career includes extensive experience in the U.S. Government, including Congressional staff, and the White House staff. From 1981-85 he served in the U.S. State Department on the Policy Planning Staff, as Special Adviser for Policy in the Bureau of East Asian and Pacific Affairs, and as Deputy/Ambassador-at Large for Pacific Basin affairs. From 1985–88 he served in the U.S. Department of Energy as Deputy Assistant Secretary for International Affairs, where he managed nuclear non-proliferation, scientific research, and global oil and gas issues.

Dr. Randolph holds a JD from the Georgetown University Law Center, a Ph.D. from the Fletcher School of Law and Diplomacy (Tufts University), a B.S.F.S. from Georgetown's School of Foreign Service, and studied at the London School of Economics. He currently serves as chairman of the San Francisco Bay Conservation and Development Commission (BCDC), is a member of the District of Columbia Bar Association, the Council on Foreign Relations, and the Pacific Council on International Policy, and serves on the Board of Directors of the Bay Area World Trade Center and the University of San Francisco Center for the Pacific Rim.

Diana Farrell
Diana Farrell is Director of the McKinsey Global Institute (MGI), McKinsey & Company's economics think tank, and a McKinsey director. MGI's independent research combines McKinsey & Company's microeconomic understanding of companies and industries with the rigor of leading economic thinking to derive perspectives and publish reports on important global economic issues. MGI is widely acclaimed as a key contributor to economic debates, and its research has been prominently featured in international publications. To date, MGI has published reports on more than 15 countries across nearly 30 industry sectors. Under Ms. Farrell's leadership, MGI's research agenda has spanned related topics including foreign direct investment, offshoring, capital markets, the integration of China and India into the global economy, and the relationship between IT and productivity.

Ms. Farrell was previously a McKinsey partner in the Washington, D.C. office and a leader of McKinsey's Global Financial Institutions and Global Strategy practices. She has served clients around the world in a variety of capacities. Ms. Farrell has a B.A. from Wesleyan University in Economics and in the College of Social Studies. She also holds an M.B.A. from Harvard Business School. Prior to joining McKinsey, Ms. Farrell worked with Goldman, Sachs & Company in New York. She is a member of Council on Foreign Relations and the Bretton Woods Committee, a trustee for the Committee for Economic

Development, a member of the Pacific Council on International Policy, a Senior Advisor to the American Assembly's Next Generation Project, and a regular participant in major US and global forums.

Navi Radjou

Navi Radjou is a vice president on the IT Management team at Forrester Research. He investigates how globalized innovation — with the rise of India and China as both a source and market for tech innovations — is driving new market structures and business processes, which Forrester designates as "Global Innovation Networks." He advises senior executives — including CIOs/CTOs — worldwide on new organizational designs and business processes their firms must adopt to sustain global competitiveness through technology-enabled innovation.

During his six years at Forrester, Radjou has advised senior executives around the world on issues related to innovation, supply chain, and customer service. He was named by Supply & Demand Chain Executive magazine as one of the "Pros to Know," honoring an elite group of professionals who have excelled in the innovative use of supply chain technologies and practices within user companies. Prior to joining Forrester, he was a technology consultant in Asia – working with both private and public-sector companies -- and a development analyst at IBM's Toronto Software Lab. He earned his M.S. degree in information systems at Ecole Centrale Paris. Trilingual, he also attended the Yale School of Management.

William F. Miller

Dr. William F. Miller has spent half of his professional life in business and half in academia. Dr. Miller was the last faculty member recruited to Stanford University by the legendary Frederick Terman who was then Vice President and Provost. .Miller, himself, later became Vice President and Provost of Stanford.

In 1968 Dr. Miller played a role in the founding of the first Mayfield Fund (venture capital) as a special limited partner and advisor to the general partners. As President and CEO of SRI International (1979-1990) Miller opened SRI to the Pacific Region, established the spin-out and commercialization program at SRI, and established the David Sarnoff Research Center (now the Sarnoff Corporation) as a for-profit subsidiary of SRI. He later became the Chairman and CEO. In 1982 Dr. Miller was appointed to the National Science Board .He has served on the board of directors of major companies such as Signetics, Firemans Fund Insurance, First Interstate Bank (and later)Wells Fargo Bank, Pacific Gas and Electric Company, Varian Associates, WhoWhere? Inc. (Chairman), and Borland Software Corp. (Chairman). He co-founded SmartValley, Inc., aided the formation of CommerceNet and serves on its board of directors. Dr. Miller was a founding director of the Center for Excellence in Non-profits. He currently serves as Chairman of the Board of Sentius Corporation and is a Founder and Chairman of Nanostellar, Inc.

Dr. Miller is a Life Member of the National Academy of Engineering, a Fellow of the American Academy of Arts and Science, Fellow of the American Association for the Advancement of Science, Life Fellow of IEEE, and Member of the Silicon Valley Engineering Hall of Fame.

Gary Bridge
Gary Bridge is senior vice president of the Cisco Internet Business Solutions Group (IBSG). IBSG works with many of the world's leading companies and governments to help them become more effective through changed business processes and intelligent technology deployment.

Bridge brings deep industry knowledge and broad experience to the organization. Prior to joining Cisco, he was corporate vice president of IBM's Worldwide Marketing Management and Market Intelligence. He was instrumental in the development of IBM's e-business strategy and was responsible for marketing management, brand strategy, and worldwide customer information. Prior to IBM, he led his own strategy-consulting firm for 10 years, serving multinational clients in the IT, industry, finance, and publishing industries.

He graduated from the University of California, Los Angeles with a bachelor's degree in economics and a master's degree and doctorate in psychology. A former professor at Columbia University, Bridge has had associations with a number of prestigious think tanks, including the RAND Corporation, Battelle Memorial Institute, and the Defense Advanced Research Projects Agency (Department of Defense).

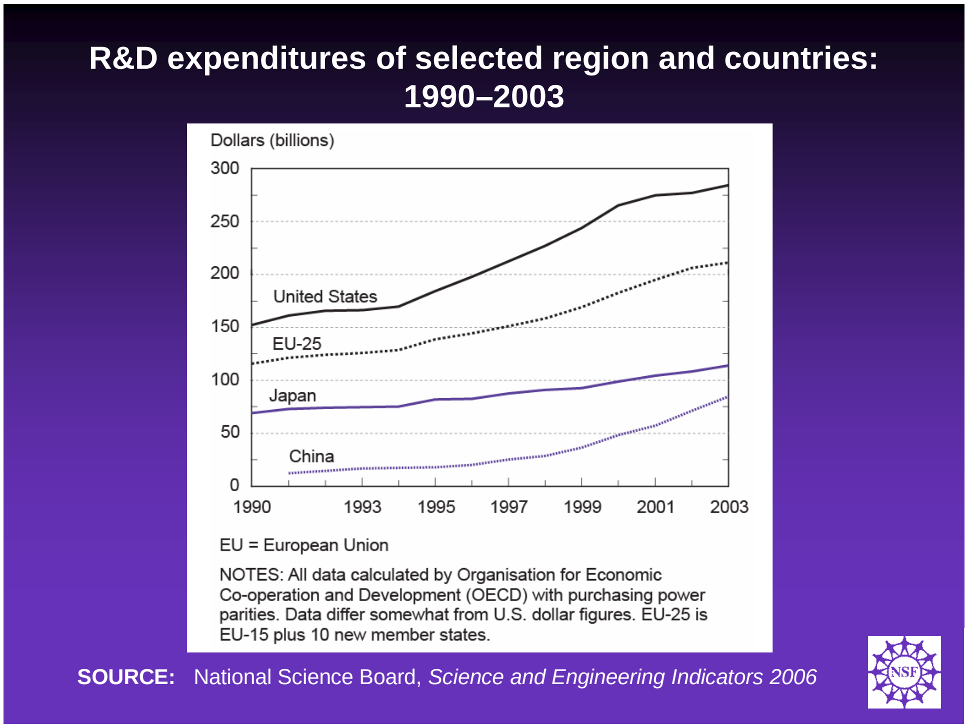
Robert J. T. Morris
Dr. Robert Morris is Vice President for Assets Innovation at IBM. In this position his mission is to drive innovation in IBM's services through four main activities: the creation and commercialization of intellectual assets (typically technology) that can be used to improve service effectiveness; the creation and management of services methods and tools; knowledge management tools; and talent (professions, communities, etc).

From 1999 to 2004, Dr. Morris was the director of the IBM Almaden Research Center in San Jose, where he oversaw scientists and engineers doing exploratory and applied research in hardware and software areas such as nanotechnology, materials science, storage systems, data management, web technologies and user interfaces. He was also vice president for personal systems and storage research, managing this worldwide research work within IBM. Previously, he was a director at the IBM T.J. Watson Research Lab in New York, where he led teams in personal systems research and was the executive responsible for the Deep Blue chess machine. Originally from Australia, he began his career at Bell Laboratories where he was involved in developing a number of networking and computing technologies.

Dr. Morris was named chairman of the Bay Area Science and Innovation Consortium in 2002, an organization consisting of the heads of major research institutions in Silicon Valley and the San Francisco Bay Area. He now serves as Chairman Emeritus. He has published more than fifty articles in computer science, electrical engineering, and mathematics literature and has received eleven patents. He holds a Ph.D. in computer science from the University of California at Los Angeles and is a member of the IBM Academy of Technology and a Fellow of the IEEE. He was an Editor of the IEEE Transactions on Computers from 1986-1991 and is on a variety of advisory boards for leading universities.

Appendix II

Tables and Graphs



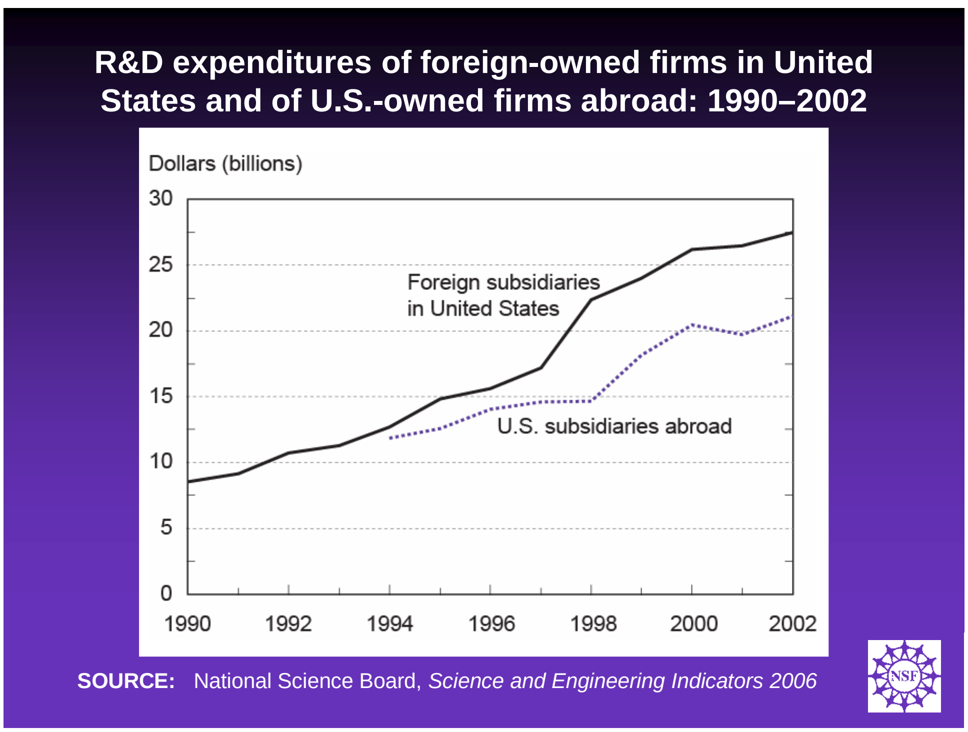
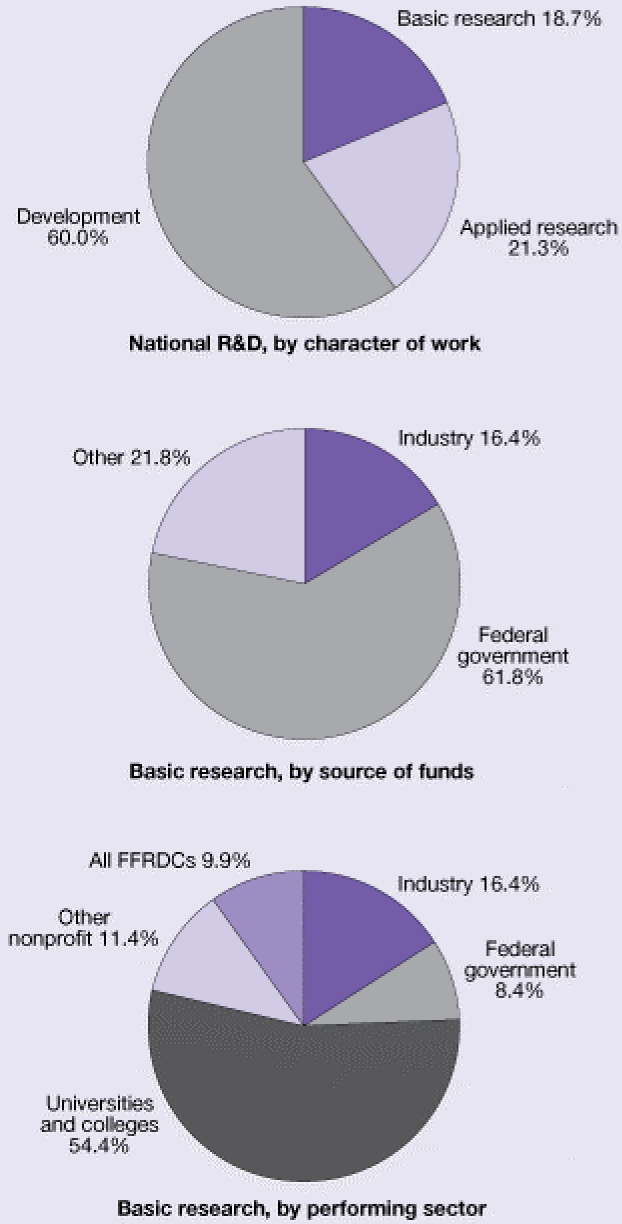


Figure 4-4
National R&D by character of work, basic research by source of funds, and basic research by performing sector: 2004



FFRDC = federally funded research and development center

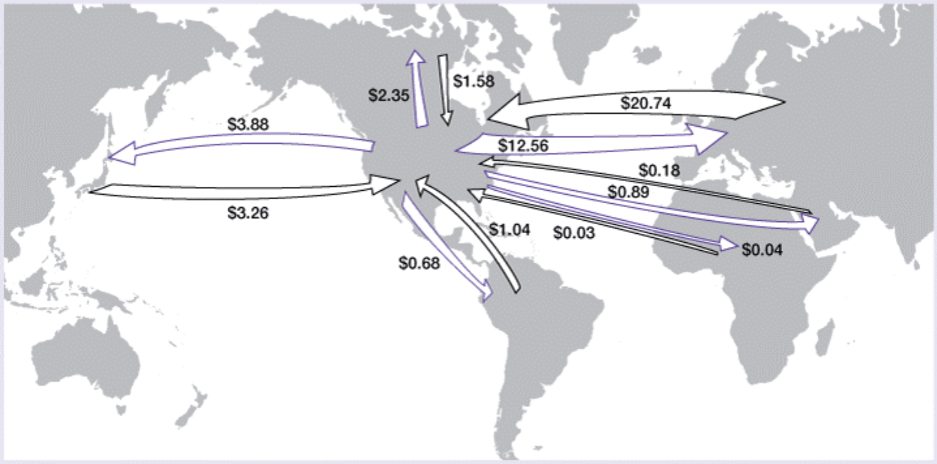
NOTES: Figures rounded to nearest whole number. National R&D expenditures estimated at $313 billion in 2004.

SOURCE: National Science Foundation, Division of Science Resources Statistics, *National Patterns of R&D Resources* (annual series). See appendix tables 4-3, 4-7, 4-11, and 4-15.

Science and Engineering Indicators 2006

Figure 4-47
R&D performed by U.S. affiliates of foreign companies in U.S. by investing region and by foreign affiliates of U.S. multinational corporations by host region: 2002 or latest year

(Billions of current dollars)

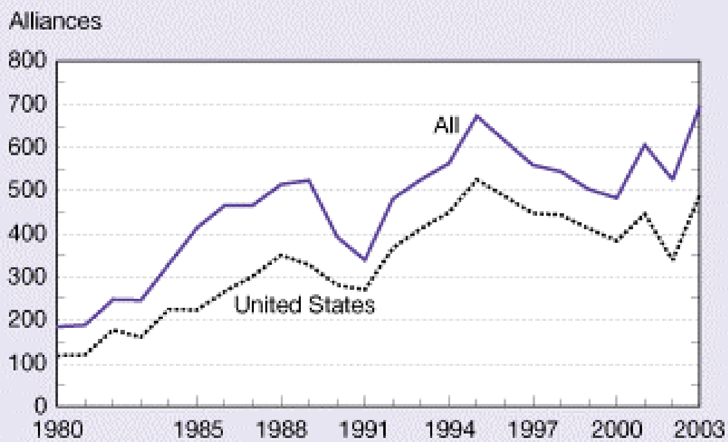


NOTES: Preliminary estimates for 2002. Regional totals for foreign affiliates of U.S. multinational corporations located in Europe and in Latin America and other Western Hemisphere are sums computed by National Science Foundation based on available country data for those regions. Data for foreign affiliates located in Africa and for U.S. affiliates of foreign companies from Middle East are for 2001.

SOURCES: U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Foreign Direct Investment in the United States; and Survey of U.S. Direct Investment Abroad. See appendix tables 4-48 and 4-51.

Science and Engineering Indicators 2006

Figure 4-19
Worldwide industrial technology alliances and those with at least one U.S.-owned company: 1980–2003



NOTE: Data are annual counts of new alliances.

SOURCE: Maastricht Economic Research Institute on Innovation and Technology, Cooperative Agreements and Technology Indicators (CATI-MERIT) database, special tabulations. See appendix table 4-37.

Science and Engineering Indicators 2006

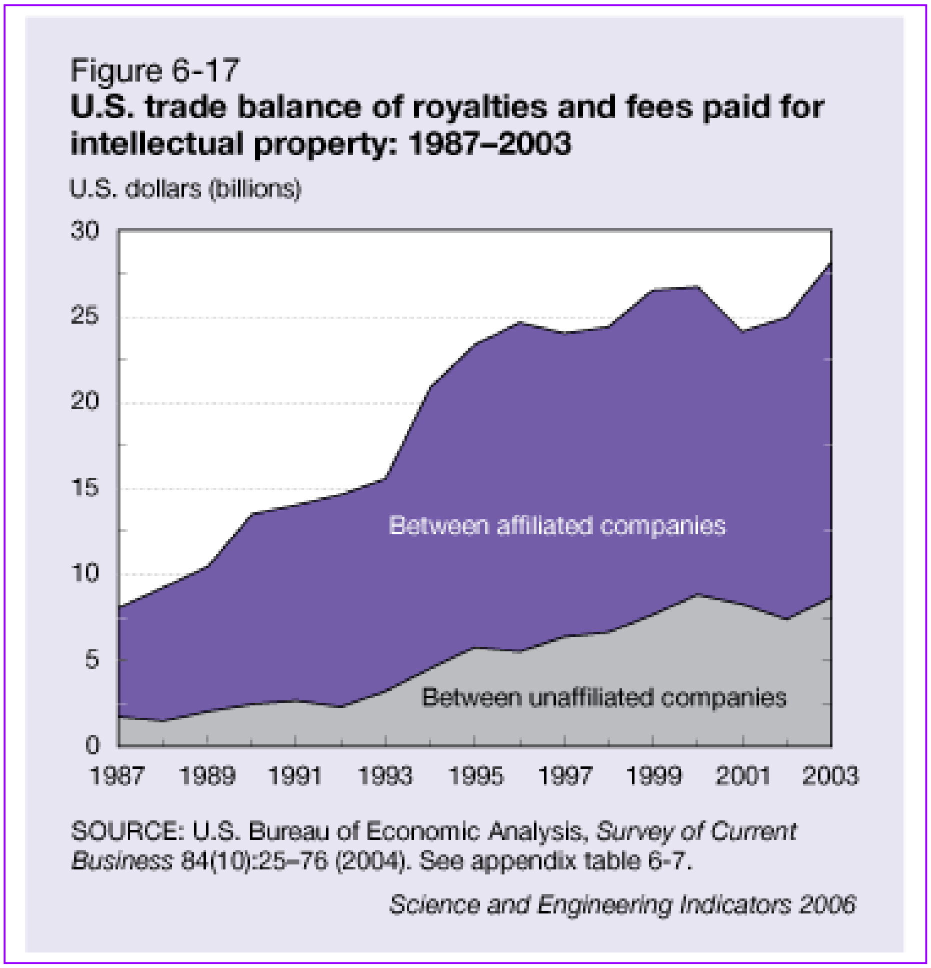
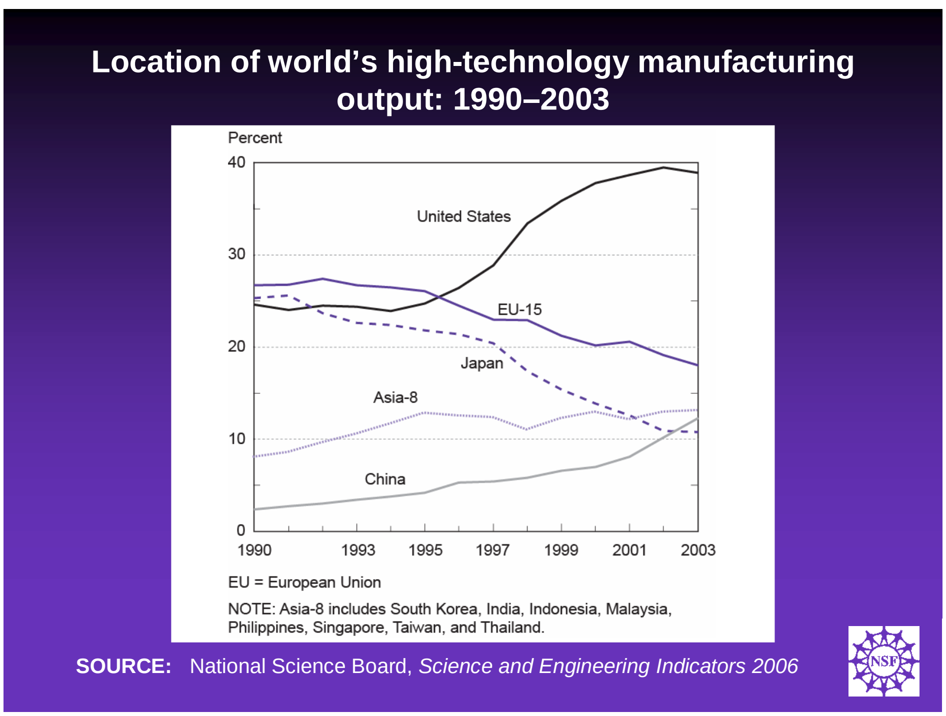
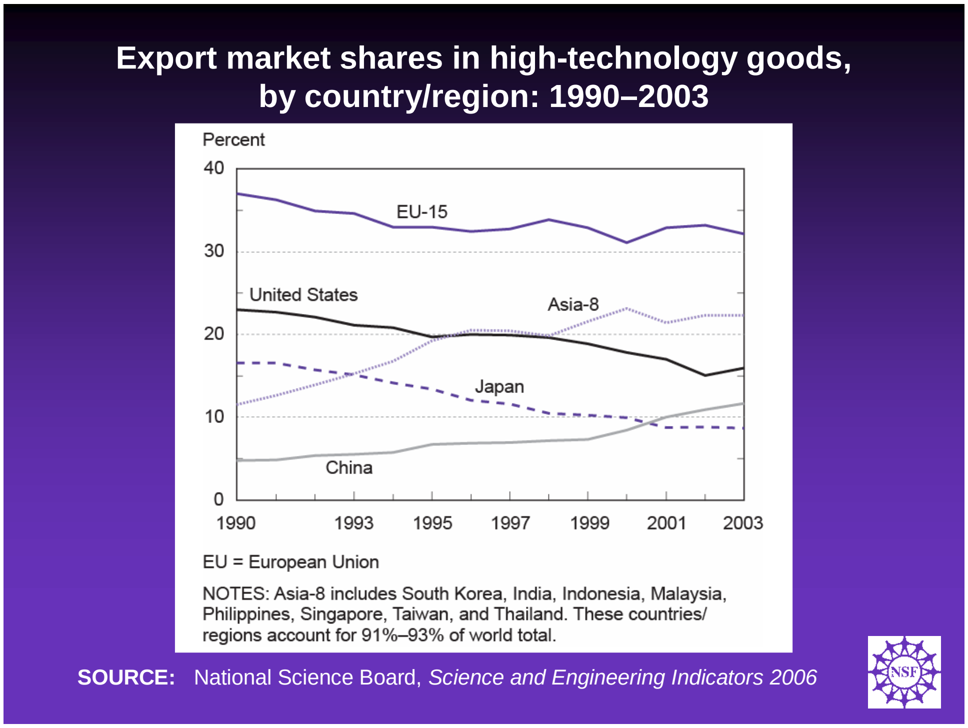


Figure 6-17
U.S. trade balance of royalties and fees paid for intellectual property: 1987–2003
U.S. dollars (billions)
30
25
20
15
10
5
0
1987
1989
1991
1993
1995
1997
1999
2001
2003
Between affiliated companies
Between unaffiliated companies
SOURCE: U.S. Bureau of Economic Analysis, Survey of Current Business 84(10):25–76 (2004). See appendix table 6-7.
Science and Engineering Indicators 2006


Location of world's high-technology manufacturing output: 1990–2003
Percent
40
30
20
10
0
1990
1993
1995
1997
1999
2001
2003
United States
EU-15
Japan
Asia-8
China
EU = European Union
NOTE: Asia-8 includes South Korea, India, Indonesia, Malaysia, Philippines, Singapore, Taiwan, and Thailand.
SOURCE: National Science Board, Science and Engineering Indicators 2006


Export market shares in high-technology goods, by country/region: 1990–2003
Percent
40
30
20
10
0
EU-15
United States
Asia-8
Japan
China
1990
1993
1995
1997
1999
2001
2003
EU = European Union
NOTES: Asia-8 includes South Korea, India, Indonesia, Malaysia, Philippines, Singapore, Taiwan, and Thailand. These countries/regions account for 91%–93% of world total.
SOURCE: National Science Board, *Science and Engineering Indicators 2006*

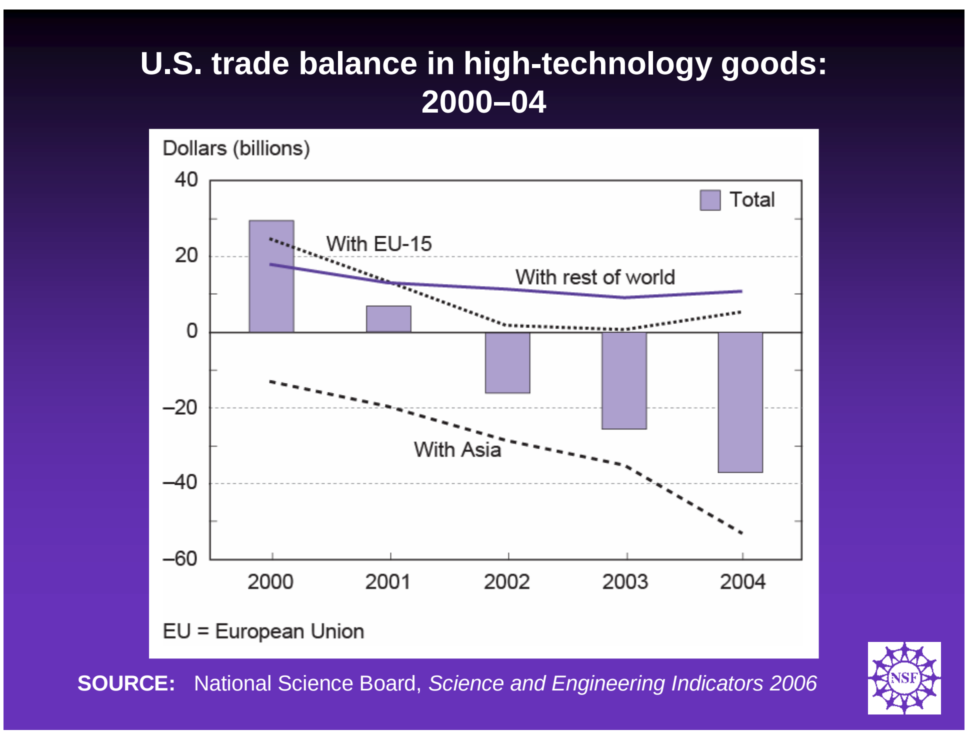
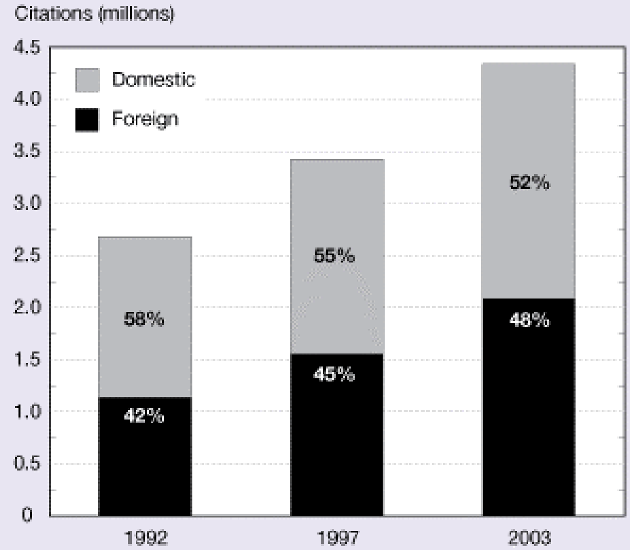

U.S. trade balance in high-technology goods: 2000–04
Dollars (billions)
40
20
0
–20
–40
–60
Total
With EU-15
With rest of world
With Asia
2000
2001
2002
2003
2004
EU = European Union
SOURCE: National Science Board, *Science and Engineering Indicators 2006*

Figure 5-53
Worldwide citations of S&E literature: 1992, 1997, and 2003

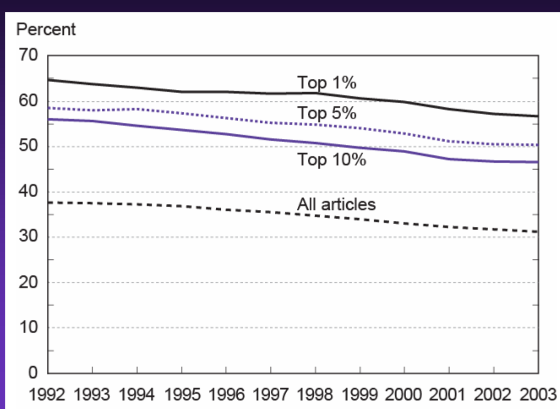


NOTES: Citations are references to articles, notes, and reviews in journals covered by *Science Citation Index* (SCI) and *Social Sciences Citation Index* (SSCI). Citation counts based on a 3-year window with 2-year lag; e.g., citations for 2001 are references made in articles published in 2001 to articles published in 1997–99. Numbers refer to share of citations to foreign S&E literature. Foreign citations are references originating outside author's country. Domestic citations are references that originate from same country as article author.

SOURCES: Thomson ISI, SCI and SSCI, http://www.isinet.com/products/citation/; ipIQ, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations. See appendix table 5-61.

Science and Engineering Indicators 2006

Share of U.S. articles among most-cited articles, total S&E: 1992–2003

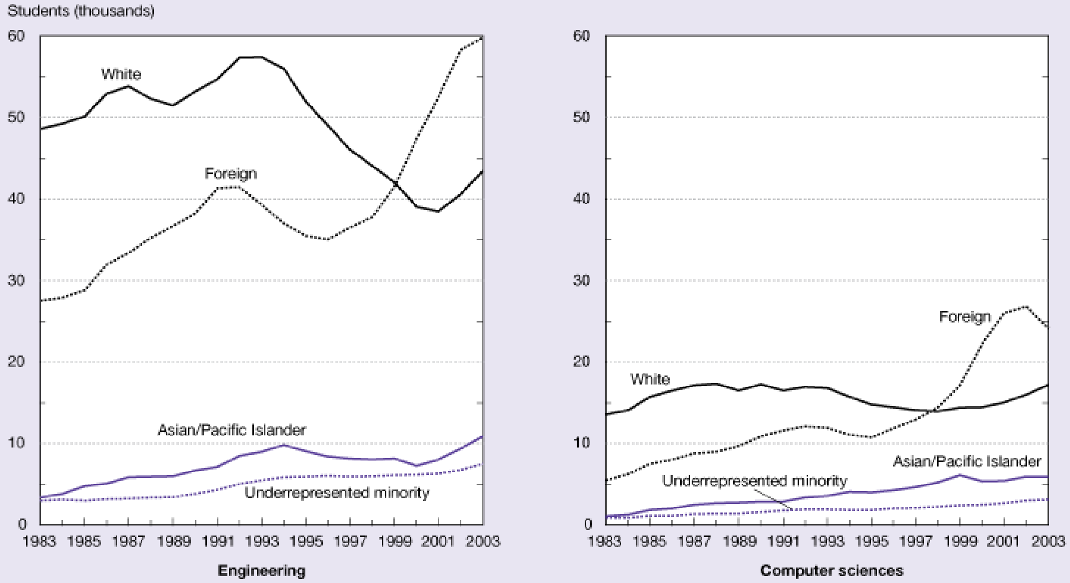


NOTE: Three years of article citations, lagged by 2 years.

SOURCE: National Science Board, *Science and Engineering Indicators 2006*

Figure 2-5

Graduate enrollment in computer sciences and in engineering, by citizenship and race/ethnicity: 1983–2003



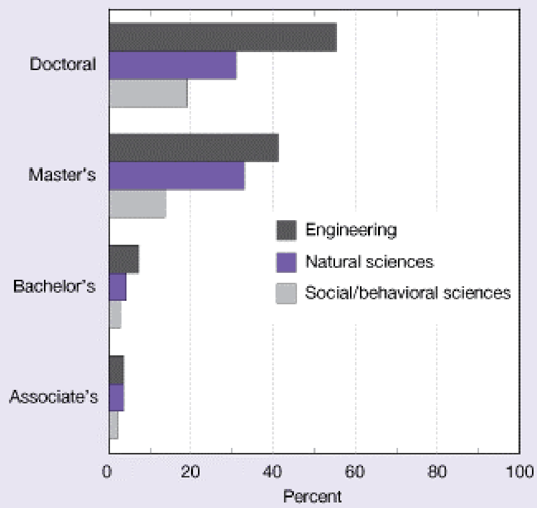
NOTES: Foreign includes temporary residents only. Race/ethnicity includes U.S. citizens and permanent residents. Underrepresented minority includes black, Hispanic, and American Indian/Alaska Native.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering, WebCASPAR database, http://webcaspar.nsf.gov. See appendix table 2-15.

Science and Engineering Indicators 2006

Figure 2-20

Foreign share of U.S. S&E degrees, by degree and field: 2002 or 2003

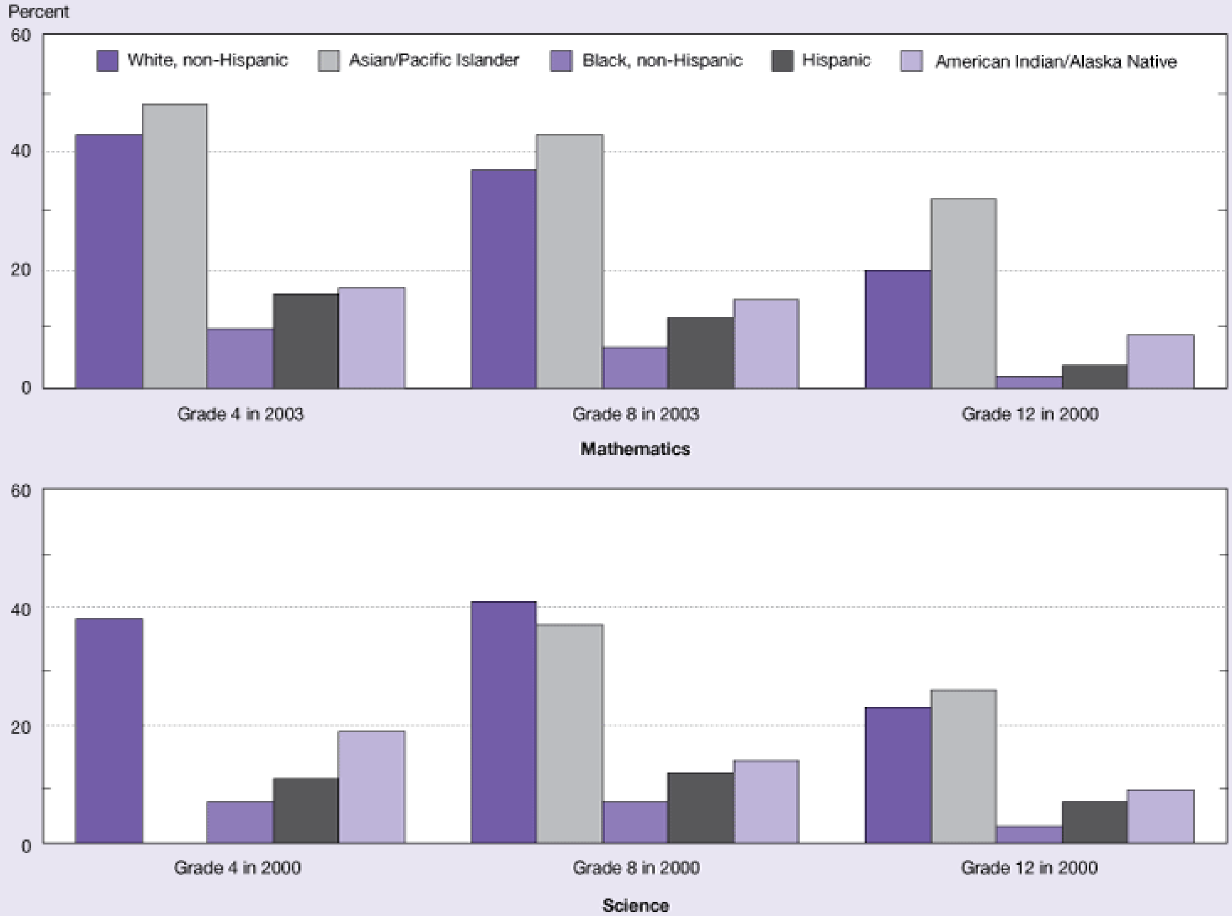


NOTES: Doctoral degree data are for 2003; other data are for 2002. Foreign includes temporary residents only. Natural sciences include physical, biological, agricultural, computer, earth, atmospheric, and ocean sciences and mathematics.

SOURCES: U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates, WebCASPAR database, http://webcaspar.nsf.gov. See appendix tables 2-25, 2-27, 2-29, and 2-31.

Science and Engineering Indicators 2006

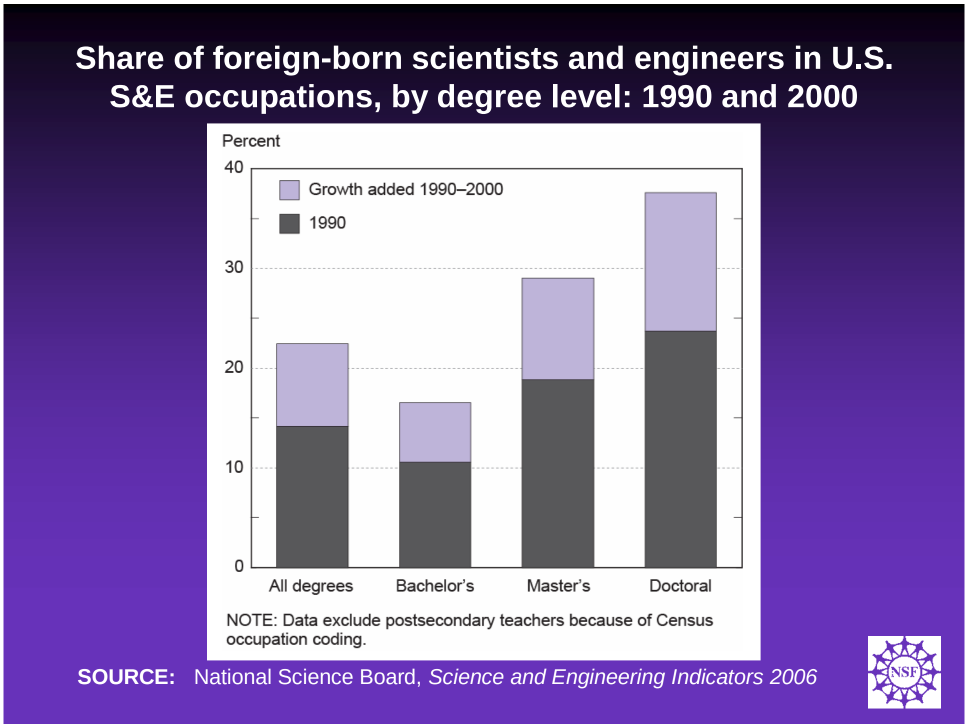
Figure 1-7
Students performing at or above proficient level for their grade, by race/ethnicity: 2000 and 2003



NOTE: National Center for Education Statistics (NCES) did not publish 2000 science scores for fourth grade Asian/Pacific Islander students because of accuracy and precision concerns.

SOURCES: U.S. Department of Education, NCES, *The Nation's Report Card: Mathematics Highlights 2003* (2003); *The Nation's Report Card: Mathematics 2000* (2001); and *The Nation's Report Card: Science Highlights 2000* (2001). See appendix tables 1-6 and 1-8.

Science and Engineering Indicators 2006


Share of foreign-born scientists and engineers in U.S. S&E occupations, by degree level: 1990 and 2000
Percent
40
30
20
10
0
Growth added 1990–2000
1990
All degrees
Bachelor's
Master's
Doctoral
NOTE: Data exclude postsecondary teachers because of Census occupation coding.
SOURCE: National Science Board, Science and Engineering Indicators 2006
NSF

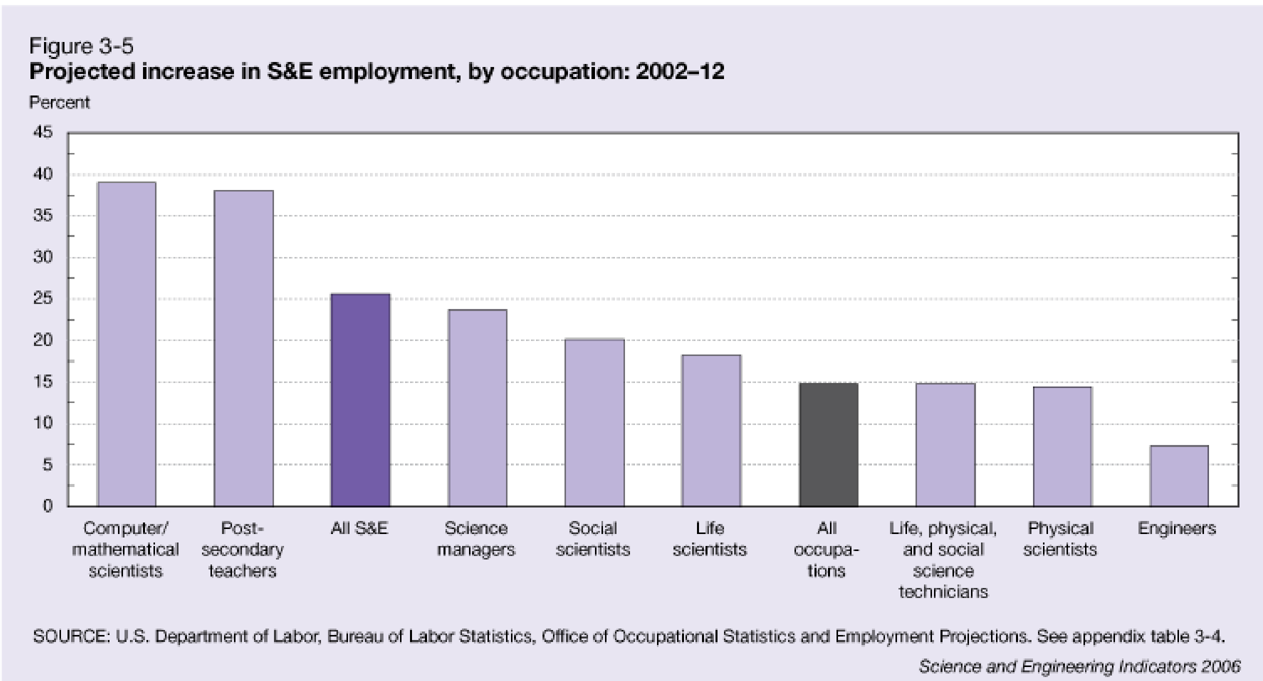
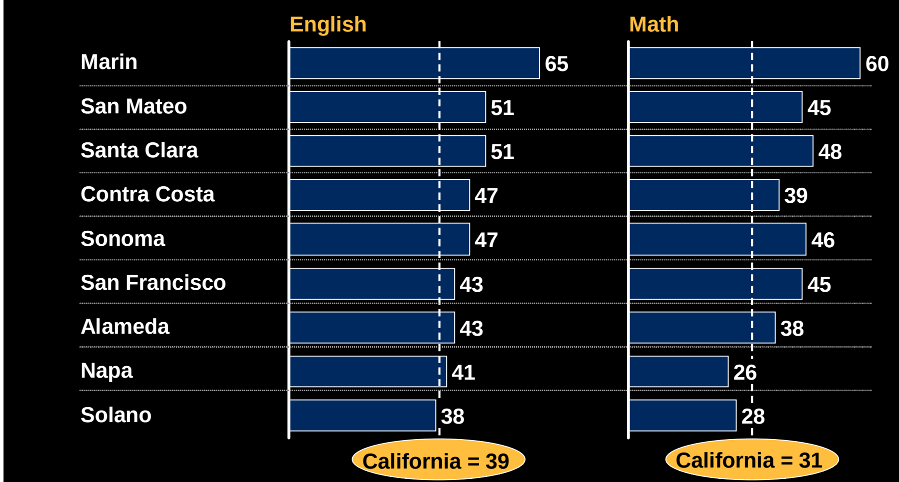


Figure 3-5
Projected increase in S&E employment, by occupation: 2002–12
Percent
45
40
35
30
25
20
15
10
5
0
Computer/ mathematical scientists
Post-secondary teachers
All S&E
Science managers
Social scientists
Life scientists
All occupa-tions
Life, physical, and social science technicians
Physical scientists
Engineers
SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Office of Occupational Statistics and Employment Projections. See appendix table 3-4.
Science and Engineering Indicators 2006

BAY AREA STUDENTS OUTPERFORM THE STATE AVERAGE ON EIGHTH GRADE PROFICIENCY TESTS

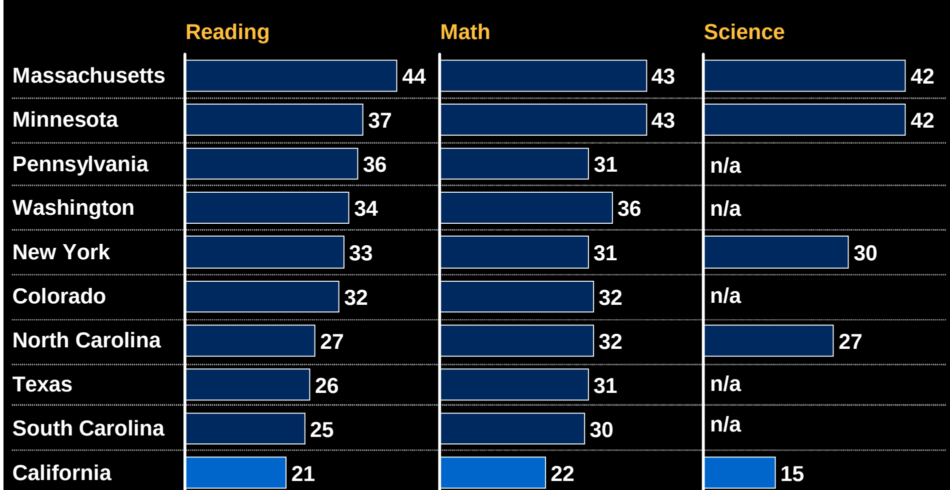
STAR Achievement, 2005
Percent of students testing proficient or above



Source: California Department of Education; McKinsey analysis

HOWEVER, CALIFORNIA LAGS COMPARABLE STATES IN EDUCATION PROFICIENCY

Percent of 8th-grade students at or above the proficient level for public schools, 2005



Source: National Assessment of Educational Progress

Appendix III

References

Key Resource Documents

Innovate America: Thriving in a World of Challenge and Change, Council on Competitiveness, 2004 (www.compete.org)

Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine of the National Academies, 2005 (www.national-academies.org).

Thinking Big about Thinking Small: An Action Agenda for California, Blue Ribbon Task Force on Nanotechnology, 2005 (www.blueribbonnano.org).

Key Initiatives (2006)

White House: *American Competitiveness Initiative* (ACI)
http://www.whitehouse.gov/state of the union/2006/ACI

House Democrats: *Innovation Agenda: A Commitment to Competitiveness*
http://www.democraticleader.house.gov/pdf/HDIA.pdf

Workforce Innovations in Regional Economic Development (WIRED):
California Innovation Corridor, http://www.californiaspaceauthority.org/html/wired/

Key Legislation (2006)

National Innovation Act (NIA)

Protect America's Competitive Edge (PACE) Education Act, Bill # S.2198
Protect America's Competitive Edge (PACE) Energy Act, Bill # S.2197
Protect America's Competitive Edge (PACE) Finance Act, Bill #S.2199

Innovation and Competitiveness Act, H.R. 4845

Other reports on innovation and competitiveness, and detailed information on federal initiatives and legislation, can be found at www.innovateamerica.org.

BAY AREA COUNCIL

BAY AREA ECONOMIC FORUM

A Partnership of the Association of Bay Area Governments and the Bay Area Council

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