
Decades of outsourcing manufacturing has left U.S. industry without the means to invent the next generation of high-tech products that are key to rebuilding its economy.

Restoring American Competitiveness

by Gary P. Pisano and Willy C. Shih

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Restoring American Competitiveness

The Idea in Brief

- Thanks to destructive outsourcing and faltering investment in research, the U.S. has lost or is on the verge of losing its ability to develop and manufacture a slew of high-tech products.
- To address this crisis, government and business must work together to rebuild the country's *industrial commons*—the collective R&D, engineering, and manufacturing capabilities that sustain innovation. Both must step up their funding of research and encourage collaborative R&D initiatives to tackle society's big problems. And companies must overhaul the management practices and governance structures that have caused them to make destructive outsourcing decisions.
- Only by rejuvenating its high-tech sector can the U.S. hope to return to the path of sustained growth needed to pay down its huge deficits and raise its citizens' standard of living.

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As the United States strives to recover from the current economic crisis, it's going to discover an unpleasant fact: The competitiveness problem of the 1980s and early 1990s didn't really go away. It was just hidden during the bubble years behind a mirage of prosperity, and all the while the country's industrial base continued to erode.

Now, the U.S. will finally have to take the problem seriously. Rebuilding its wealth-generating machine—that is, restoring the ability of enterprises to develop and manufacture high-technology products in America—is the only way the country can hope to pay down its enormous deficits and maintain, let alone raise, its citizens' standard of living. Reversing the decline in competitiveness will require two drastic changes:

The government must alter the way it supports both basic and applied scientific research to promote the kind of broad collaboration of business, academia, and government needed to tackle society's big problems.

Corporate management must overhaul its

practices and governance structures so they no longer exaggerate the payoffs and discount the dangers of outsourcing production and cutting investments in R&D.

The Competitiveness Problem

For much of the past two decades, the stunning growth of the U.S. economy was widely hailed in academic, business, and government circles as evidence that America's competitiveness problem was as obsolete as leg warmers and Jazzercise. The data suggest otherwise. Beginning in 2000, the country's trade balance in high-technology products—historically a bastion of U.S. strength—began to decrease. By 2002, it turned negative for the first time and continued to decline through 2007. (See the exhibit "A Sign of Trouble.")

Even more worrisome, average real weekly wages have essentially remained flat since 1980, meaning that the U.S. economy has been unable to provide a rising standard of living for the majority of its people. This undoubtedly is one reason Americans have attempted to bor-

row their way to prosperity, a strategy that clearly is no longer tenable.

What, then, was actually happening when it seemed things were going so well? Companies operating in the U.S. were steadily outsourcing development and manufacturing work to specialists abroad and cutting their spending on basic research. In making their decisions to outsource, executives were heeding the advice du jour of business gurus and Wall Street: Focus on your core competencies, off-load your low-value-added activities, and redeploy the savings to innovation, the true source of your competitive advantage. But in reality, the outsourcing has not stopped with low-value tasks like simple assembly or circuit-board stuffing. Sophisticated engineering and manufacturing capabilities that underpin innovation in a wide range of products have been rapidly leaving too. As a result, the U.S. has lost or is in the process of losing the knowledge, skilled people, and supplier infrastructure needed to manufacture many of the cutting-edge products it invented.

Among these are such critical components as light-emitting diodes for the next generation of energy-efficient illumination; advanced displays for mobile phones and new consumer electronics products like Amazon's Kindle e-reader; the batteries that power electric and hybrid cars; flat-panel displays for TVs, computers, and handheld devices; and many of the carbon fiber components for Boeing's new 787 Dreamliner.

A similar trend is undermining the U.S. software industry. Initially, companies outsourced only relatively mundane code-writing projects to Indian firms to lower software-development costs. Over time, as Indian companies have developed their own software-engineering capabilities, they have been able to win more complex work, like developing architectural specifications and writing sophisticated firmware and device drivers.

Equally alarming is the U.S.'s diminished capacity to *create* new high-tech products. For example, nearly every U.S. brand of notebook computer, except Apple, is now designed in Asia, and the same is true for most cell phones and many other handheld electronic devices.

We have heard managers rationalize outsourcing decisions by saying that they can always reverse course if the quality of the work isn't good enough, if the anticipated cost sav-

ings prove ephemeral, if supply-chain complexities or risks are too great, or if the work turns out to be more strategic than they originally thought. But this logic overlooks the lasting damage that outsourcing inflicts not only on a firm's own capabilities but also on those of other companies that serve its industry, including suppliers of advanced materials, tools, production equipment, and components. We call these collective capabilities the *industrial commons*.

The World Is Not Flat

Centuries ago, "the commons" referred to the land where animals belonging to people in the community would graze. As the name implies, the commons did not belong to any one farmer. All were better off for having access to it. Industries also have commons. A foundation for innovation and competitiveness, a commons can include R&D know-how, advanced process development and engineering skills, and manufacturing competencies related to a specific technology.

Such resources may be embedded in a large number of companies and universities. Software knowledge and skills, for instance, are vital to an extremely wide range of industries (machine tools, medical devices, earth-moving equipment, automobiles, aircraft, computers, consumer electronics, defense). Similarly, capabilities related to thin-film deposition processes are crucial to sophisticated optics; to such electronic products as semiconductors and disk drives; and to industrial tools, packaging, solar panels, and advanced displays. The knowledge, skills, and equipment related to the development and production of advanced materials are a commons for such diverse industries as aerospace, automobiles, medical devices, and consumer products. Biotechnology is a commons not just for drugs but also for agriculture and the emerging alternative-fuels industry.

More often than not, a particular industrial commons will be geographically rooted. For instance, northern Italy is home to a design commons that feeds, and is fed by, several design-intensive businesses, including automobiles, furniture, apparel, and household products. The mechanical-engineering commons in Germany is tightly coupled to the country's automobile and machine tool industries. The geographic character of industrial commons helps to explain why companies in certain industries

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tend to cluster in particular regions—a phenomenon noted by Michael Porter and other scholars. Being geographically close to the commons is a source of competitive advantage.

What about the popular notion that distance and location no longer matter, or, as Thomas Friedman put it, “The world is flat”? While we agree with the general idea that geographic boundaries to trade are falling and that the global economy is more intertwined than ever, the evidence suggests that when it comes to knowledge, distance does matter. Detailed empirical work on knowledge flows among inventors by our HBS colleague Lee Fleming shows that proximity is crucial. An engineer in Silicon Valley, for instance, is more likely to exchange ideas with other engineers in Silicon Valley than with engineers in Boston. When you think about it, this is not surprising, given that much technical knowledge, even in hard sciences, is highly tacit and therefore far more effectively transmitted face-to-face. Other studies show that the main way knowledge spreads from company to company is when people switch jobs. And even in America’s relatively mobile society, it turns out that the vast majority of job hopping is local.

This helps to explain why commons persist in specific locations in an era when huge amounts of scientific data can be accessed easily from anywhere. For example, even though virtually all the raw data from the Human Genome Project, the decade-plus effort to map the human genome, is available electronically all over the world, the drug research it has generated is heavily concentrated in the Boston, San Diego, and San Francisco areas.

Once an industrial commons has taken root in a region, a powerful virtuous cycle feeds its growth. Experts flock there because that’s where the jobs and knowledge networks are. Firms do the same to tap the talent pool, stay abreast of advances, and be near suppliers and potential partners. The Swiss pharmaceutical giant Novartis, for instance, chose to move its research headquarters from Basel, Switzerland, to Cambridge, Massachusetts, to be close to universities and research institutes that are global leaders in biosciences and the hundreds of biotech firms already in the area. And its presence, in turn, has increased the Boston area’s pull on yet more firms and individuals. These dynamics make it difficult for other regions that do not yet have a vibrant biotech-

nology commons to attract biotech companies, even with generous incentives.

Our research on the semiconductor, electronics, pharmaceutical, and biotech industries has found that commons are even more important to countries’ and companies’ prosperity than is generally believed. That’s because innovation in one business can spawn whole new industries.

A historical example is the birth of the modern pharmaceutical industry. It began in the late 1800s in Switzerland and Germany because the earliest drugs were based on synthetic dye chemistry and the two countries were home to large chemical companies with strong research labs and deep technical expertise in synthetic dye production.

A current example is the solar panel industry, which is booming in Asian countries such as India, Japan, Taiwan, Korea, and especially China. India owes its position to Moser Baer, a leading manufacturer of optical storage media, which used its capabilities in thin-film coating and manufacturing to move into solar panels. China’s, Japan’s, Taiwan’s and Korea’s successes stem, at least in part, from their deep expertise in processing ultrapure crystalline silicon into wafers and applying thin films of silicon onto large glass sheets—capabilities developed by their semiconductor foundries and their manufacturers of flat-panel displays. (China has another advantage: It is the production base for the mundane components like power semiconductors, controllers, and housings that are needed to produce full panels.)

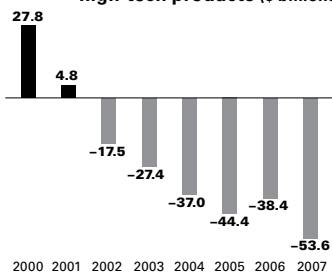
Although the U.S. still produces about 14% of the world’s photovoltaic cells, it no longer is a significant player in crystalline silicon-based solar panels, the prevailing technology. Some U.S. manufacturers such as Tempe, Arizona-based First Solar are trying to become players in thin-film solar, the newest technology. But the decline of the domestic infrastructure in thin-film deposition and electronics manufacturing puts them at a big disadvantage.

Erosion of the Commons

When a major player in an industry outsources an activity, cuts funding for long-term research, and gains a short-term cost advantage, competitive pressure often forces rivals to follow suit. As potential employment opportunities shrink, experienced people change jobs, moving out of the region, and students shy away from enter-

A Sign of Trouble

The U.S. trade deficit in high-tech products (\$ billions)

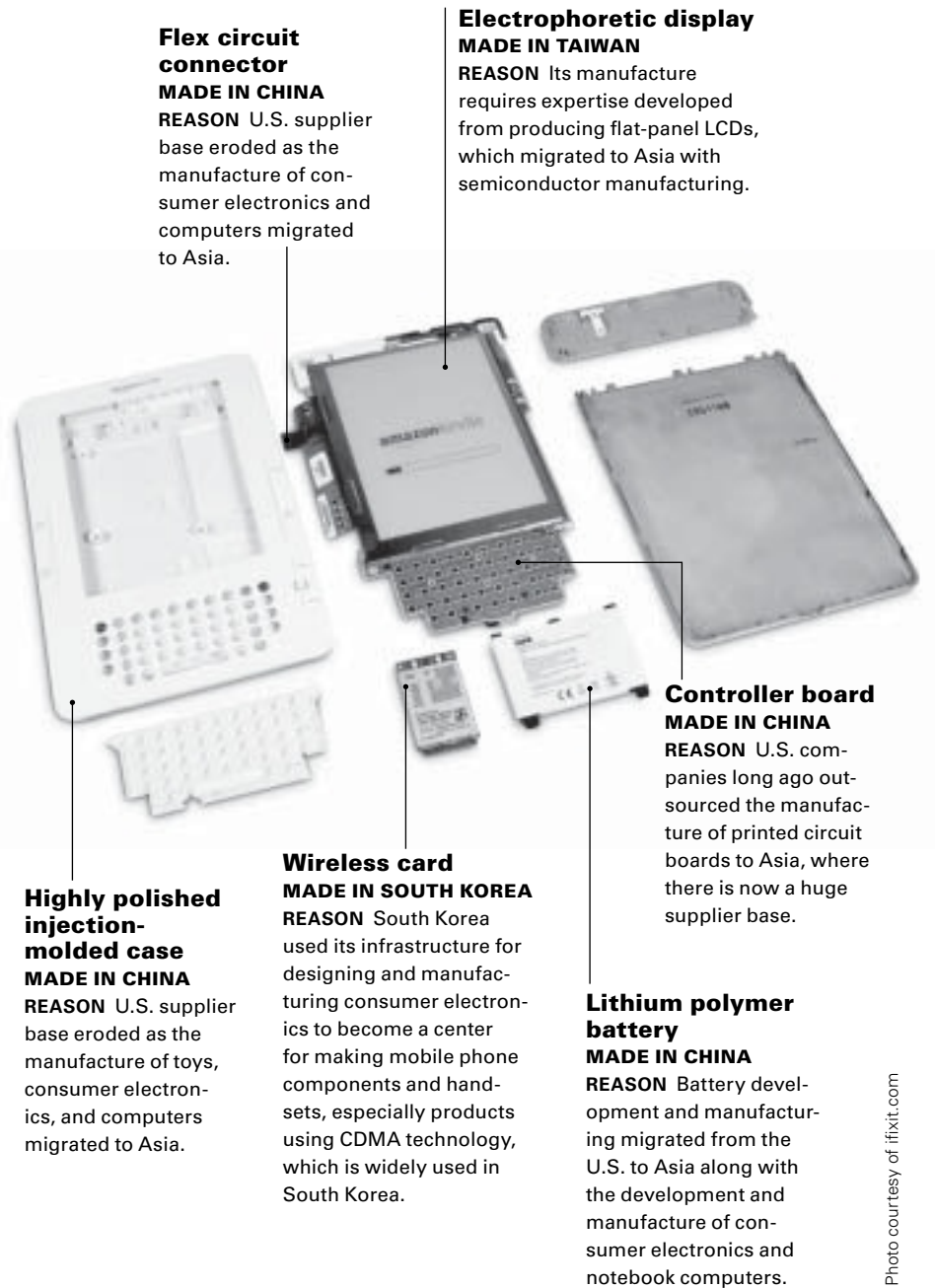


Note: Sectors included are: biotechnology, life sciences, optoelectronics, information and communications, electronics, flexible manufacturing, advanced materials, aerospace, weapons, nuclear technology, and computer software.

Source: National Science Board, “Science and Engineering Indicators 2008”

Why Amazon's Kindle 2 Can't Be Made in the U.S.

The Kindle 2 e-reader was designed by Amazon's Lab126 unit in California. The vast majority of its components are made in China, Taiwan, and South Korea, and it is assembled in China, a center for such work.



Flex circuit connector
MADE IN CHINA
REASON U.S. supplier base eroded as the manufacture of consumer electronics and computers migrated to Asia.

Electrophoretic display
MADE IN TAIWAN
REASON Its manufacture requires expertise developed from producing flat-panel LCDs, which migrated to Asia with semiconductor manufacturing.

Highly polished injection-molded case
MADE IN CHINA
REASON U.S. supplier base eroded as the manufacture of toys, consumer electronics, and computers migrated to Asia.

Wireless card
MADE IN SOUTH KOREA
REASON South Korea used its infrastructure for designing and manufacturing consumer electronics to become a center for making mobile phone components and handsets, especially products using CDMA technology, which is widely used in South Korea.

Controller board
MADE IN CHINA
REASON U.S. companies long ago outsourced the manufacture of printed circuit boards to Asia, where there is now a huge supplier base.

Lithium polymer battery
MADE IN CHINA
REASON Battery development and manufacturing migrated from the U.S. to Asia along with the development and manufacture of consumer electronics and notebook computers.

Photo courtesy of ifixit.com

ing the field. Eventually, the commons loses a critical mass of work, skills, and scientific knowledge and can no longer support providers of upstream and downstream activities, which are, in their turn, forced to move away as well. This is what happened to the industrial commons serving a number of high-tech sectors in the United States.

Consider the commons supporting the personal computer industry in the United States. In the late 1980s, original equipment manufacturers in the United States initially began to outsource the assembly of printed circuit boards to specialist contractors in South Korea, Taiwan, and China. These specialists offered significant cost savings, partly because of their

location in low-wage countries and partly because of the economies of scale they achieved by serving lots of OEMs. The OEMs understandably didn't see the move as strategically risky because they held the critical intellectual property and design skills (they provided the contractors with detailed specifications) and because manufacturing the boards wasn't a source of competitive advantage.

Ferocious competition and razor-thin margins, however, prompted many of the contractors, particularly those in Taiwan, to seek higher-value-added work. They persuaded the OEMs to allow them to assemble a greater share of the overall product, and from there they moved into complete product assembly.

Going...Going...Gone

Many high-tech products can no longer be manufactured in the United States because critical knowledge, skills, and suppliers of advanced materials, tools, production equipment, and components have been lost through outsourcing. Many other products are on the verge of the same fate.

Semiconductors

Already Lost

"Fabless" chips

At Risk

DRAMs

Flash memory chips

Lighting

Already Lost

Compact fluorescent lighting

At Risk

LEDs for solid-state lighting, signs, indicators, and backlights

Electronic displays

Already Lost

LCDs for monitors, TVs, and handheld devices like mobile phones

Electrophoretic displays for Amazon's Kindle e-reader and electronic signs

At Risk

Next-generation "electronic paper" displays for portable devices like e-readers, retail signs, and advertising displays

Energy storage and green energy production

Already Lost

Lithium-ion, lithium polymer, and NiMH batteries for cell phones, portable consumer electronics, laptops, and power tools

Advanced rechargeable batteries (NiMH, Li-ion) for hybrid vehicles

Crystalline and polycrystalline silicon solar cells, inverters, and power semiconductors for solar panels

At Risk

Thin-film solar cells (the newest solar-power technology)

Computing and communications

Already Lost

Desktop, notebook, and netbook PCs

Low-end servers

Hard disk drives

Consumer-networking gear such as routers, access points, and home set-top boxes

At Risk

Blade servers, midrange servers

Mobile handsets

Optical-communication components

Core network equipment

Advanced materials

Already Lost

Advanced composites used in sporting goods and other consumer gear

Advanced ceramics

Integrated circuit packaging

At Risk

Carbon composite components for aerospace and wind energy applications

Given that many of the components were also sourced from Asia, a logical next step was to take over the management of the supply chain from their American customers.

Then came design. Initially, these firms took over design-engineering tasks on a contract basis. The OEM typically would still provide the high-level conceptual design and specifications, contracting with the Asian supplier to do the detailed engineering. Eventually, though, the suppliers took over those activities as well for products like notebooks, which require designers to interact frequently with manufacturing. The result: These “original design manufacturers,” as they describe themselves, ended up designing and manufacturing virtually all Windows notebook PCs.

The standout exception is Apple, whose design capability in the U.S. for both notebook computers and consumer electronics has been critical to its success. Although Apple has outsourced the manufacture of its notebooks, iPod, and iPhone, it has been able to preserve a first-rate design capability in the States so far by remaining deeply involved in the selection of components, in industrial design, in software development, and in the articulation of the concept of its products and how they address users’ needs. But for how long can it continue to do so? Given the perennially ruthless competition Apple faces and the continuing migration of design capabilities away from the U.S. to Asia, Apple’s challenges promise to increase.

After a contractor has evolved into an ODM, there’s little to prevent it from launching its own brand and becoming a competitor to its OEM customers. That’s exactly what happened in consumer electronics, where U.S. pioneers like RCA and Sylvania in television manufacturing ultimately became nothing more than brands that were traded like playing cards among Asian manufacturers. Most U.S. companies in the notebook PC business now seem headed for the same fate.

The electronics-outsourcing story exposes several pieces of conventional wisdom as myths. One is the popular belief that an advanced economy like the United States no longer needs to manufacture and can thrive exclusively as a hub for high-value-added design and innovation. In reality, there are relatively few high-tech industries where the manufacturing process is not a factor in developing

new—especially, radically new—products.

That’s because in most of these industries product and process innovation are intertwined. So the decline of manufacturing in a region sets off a chain reaction. Once manufacturing is outsourced, process-engineering expertise can’t be maintained, since it depends on daily interactions with manufacturing. Without process-engineering capabilities, companies find it increasingly difficult to conduct advanced research on next-generation process technologies. Without the ability to develop such new processes, they find they can no longer develop new products. In the long term, then, an economy that lacks an infrastructure for advanced process engineering and manufacturing will lose its ability to innovate.

Another myth is the prevailing view that the migration of mature manufacturing industries away from developed countries like the United States is just part of a healthy, natural process of economic evolution that allows resources to be redeployed to new, higher-potential businesses. We certainly agree that a dynamic global economy leads to shifting patterns of production and trade. We also agree that shedding certain activities that no longer provide opportunities for innovation and redeploying resources to others can spur economic growth and raise living standards. If that hadn’t occurred in the U.S., its economy would still be largely agrarian and probably quite poor. But this logic has been taken to a dangerous extreme.

It ignores the fact that new cutting-edge high-tech products often depend in some critical way on the commons of a mature industry. Lose that commons, and you lose the opportunity to be the home of the hot new businesses of tomorrow. We mentioned one example earlier: The migration of semiconductor foundries to Asia, which caused a sharp decline in silicon-processing and thin-film-deposition capabilities in the U.S., greatly reducing, if not eliminating, its chances of becoming a major player in solar panels.

Another example is batteries for hybrid and electric vehicles like GM’s forthcoming Chevy Volt. The Volt’s lithium-ion battery—the highest-value-added component in the car—will be manufactured in South Korea. GM had no choice but to look abroad. Rechargeable-battery manufacturing left the U.S. long ago. Why? Most innovation in batteries in recent decades has been driven by the increasing de-

Nearly every U.S. brand of laptop and cell phone is not only manufactured but designed in Asia.

mands of consumer electronics products for more and more power in smaller and smaller packages. When U.S. companies largely abandoned the “mature” consumer electronics business, the locus of R&D and manufacturing—not just for the laptops, cell phones, and such but also for the batteries that power them—shifted to Asia. Yes, there are some efforts (including one by General Electric–backed A123Systems) to resurrect rechargeable-battery manufacturing in the United States. But given the state of the U.S. commons relative to Asia’s, players like A123 face an uphill battle.

So do U.S. automakers. Japan’s and South Korea’s strong battery and car industries give them an advantage over U.S. companies in developing electric and hybrid cars. And, as the *New York Times* reported in April, China’s leaders want to make their country one of the world’s top producers of hybrid and all-electric cars within three years. Chinese battery maker BYD has announced plans to begin selling hybrid and electric cars in the United States and Europe in 2011.

Restoring the Commons

During the 1980s and early 1990s, when outsourcing by U.S. firms and inroads by Japanese companies last raised concerns about U.S. competitiveness, there was heated debate about the remedies. Some called for Washington to follow the lead of Japan’s Ministry of International Trade and Industry and provide special support for important industries. Others exhorted American companies to stop outsourcing for patriotic reasons. Neither of these recommendations is a realistic way to preserve U.S. competitiveness and jobs.

As Robert Reich astutely pointed out nearly 20 years ago in his provocative article “Who Is Us?” (*HBR*, January–February 1990), the national identities of large corporations have become meaningless. Given the realities of global competition and capital market pressures, it is too much to expect executives to demonstrate an allegiance to a particular location merely because it is their company’s nation of origin. Nor does it make sense for Washington to favor multinationals that happen to be headquartered in the United States and discriminate against foreign-based corporations that run large operations in the country; both sets of companies are important contributors to

the American economy.

That said, it is in the interests of Washington and all companies that operate in the U.S. to work together to reinvigorate the country’s industrial commons. Washington’s interest is obvious: to revitalize the all-important high-tech sector. Why should companies care? America is an important market. If a company, regardless of its nationality, is a player there, building or sustaining local capabilities is in its interest. Beyond that, a commons, regardless of where in the world it’s located, can be a source of long-term competitive advantage for all its members. So whether you’re the U.S. firm IBM with a major research laboratory in Switzerland or the Swiss company Novartis operating in the biotech commons in the Boston area, sacrificing such a commons for short-term cost benefits is a risky proposition.

We don’t claim to have an elaborate master plan for repairing the U.S. commons. But especially at a time when Washington’s efforts to save the banks and the U.S. auto industry are reigniting the industrial policy debate, we think it would be helpful to challenge some widely held perceptions about government involvement, suggest ways to learn from programs that worked in the past, and offer some ideas on what management needs to do.

What Government Should Do

All too often, the debate about what role Washington should play in supporting innovation degenerates into a battle between two extremes: the laissez-faire camp and advocates of centralized industrial policy. Listening to them, you’d think there could be no middle ground.

History says otherwise. While the U.S. has perhaps the most market-oriented economy in the world, federal and, to a lesser extent, state governments have long played a central role in supporting technological innovation. In the early twentieth century, the agricultural experiment stations created by state governments were instrumental in spawning innovations like hybrid corn that enormously boosted agricultural productivity. In the 1950s and 1960s, the Department of Defense spurred innovation in semiconductors through procurement and targeted research programs. In the 1960s through the 1980s, DOD- and NASA-sponsored research contributed heavily to building American science and engineering capabilities in chip de-

sign, aeronautics, and satellite communications.

Not all government programs have been successful, of course. The supersonic transport program of the 1960s and the thermal solar and synthetic fuels initiatives in the late 1970s and 1980s are examples of failures. In general, government has been effective in its support for innovation when it has acted as a customer seeking a solution to a concrete, compelling need or when it has been a patron of basic or applied research that has the potential for broad application. Conversely, its support of innovation has generally failed when it has not had a user's stake in the outcome or when it has bet on unproven technical solutions that required extensive knowledge of commercial applications or market realities that it lacked. With this in mind, we offer three broad suggestions for what Washington should do to rebuild the industrial commons:

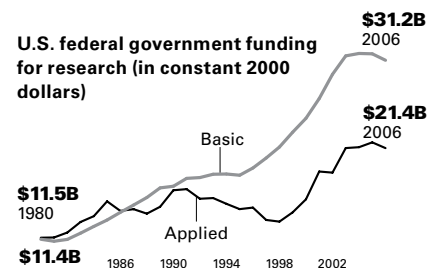
Reverse the slide in the funding of basic and applied science. Innovative activities can be grouped into three broad categories, whose boundaries are admittedly a bit blurry. *Basic scientific research* seeks to deepen our understanding of first principles, such as the genetic mechanisms that regulate how cells grow and divide. *Applied research* seeks to extend that knowledge to answer more specific questions about real-world problems, like which particular genes are involved in cancer. And *commercial R&D* focuses on finding marketable solutions—for example, discovering, developing, and testing a drug to treat a certain type of cancer. We can think of applied research as the bridge between basic research and commercial R&D.

Washington has long been the main supporter of basic research in the U.S. and a major provider of funding for applied research. No country, in fact, has invested more in basic research since the end of World War II than the United States, and three-quarters of the funding has come from the federal government. Through such agencies as the National Science Foundation and the National Institutes of Health, Washington has spent an inflation-adjusted total of \$1.2 trillion since 1953. By funding knowledge, supporting skilled scientists and technical personnel, and underwriting vibrant research universities that have acted as magnets for the laboratories of private enterprises, this support has been a vital stimulus for commercial innovation in the United

States. (We can't emphasize enough the importance of world-class universities in building a commons. Silicon Valley would never have become what it is without the presence of universities like Stanford and Berkeley.)

But while U.S. government funding for basic scientific research, adjusted for inflation, grew at a healthy pace through the 1990s, it began to drop in 2003 and has been flat or declining slightly since then. That's a worrisome trend.

Government funding for applied research has declined even more sharply. Historically, federal funding was split relatively evenly between basic and applied research, reflecting their equal importance. However, since around 1990, that has no longer been the case: Government funding for applied research declined 40% from 1990 to 1998. Even though it then rebounded, it's flattened in recent years and is still way behind funding for basic research (see the exhibit, "A Flagging Commitment to Scientific Research").



Source: National Science Board, "Science and Engineering Indicators 2008"

This is troubling because government support for applied research has been just as important to U.S. industrial competitiveness as its support of basic research. Government-sponsored endeavors that have made a huge difference in the past three decades include DARPA's VLSI chip development program and Strategic Computing Initiative; the DOD's and NASA's support of composite materials work; the NSF's funding of supercomputers and of NSFNET (an important contributor to the internet); and the DOD's support of the Global Positioning System, to mention a handful.

In most instances, these programs required a long-term commitment. Consider the internet, which sprang from a decades-long applied research effort that began in the late 1960s, when the federal government's Advanced Research Projects Agency, or

ARPA (later renamed DARPA when it became part of the Department of Defense), issued its first request for proposals to build a four-site computer network. Creating the internet involved little or no new basic science. It did, however, require significant investments in applied research on packet switching, communications protocols, and networking infrastructure—investments that the private sector probably would never have made because the time horizons were too long and the payoffs too difficult for any one company to capture. The way the project spurred collaboration among researchers in an array of companies and universities catalyzed the growth of basic networking-related capabilities, led to innovations such as the multiprotocol router, and resulted in the creation of a number of companies, including Cisco Systems, Juniper Networks, and Extreme Networks.

The U.S. cannot afford to be complacent. Governments in other countries like Singapore, China, Korea, and the United Arab Emirates are intent on fostering growth or building new world-class research universities. They are also investing heavily in applied science, hoping to replicate the success of Taiwan, whose Industrial Technology Research Institute built the foundations for that country's highly successful semiconductor industry.

Focus resources on solving “grand challenge problems.” Climate change, a dependence on expensive dirty hydrocarbons, a lack of potable water, the ravages of diseases—these are some of the grand problems plaguing the world that will require fundamental advances in knowledge to solve. Governments are often uniquely positioned to mobilize and coordinate the efforts of the numerous organizations needed to confront these huge challenges. At its peak, for instance, the ARPA networking initiative involved dozens of private companies and universities. Under the purview of the Department of Energy and the NIH, the Human Genome Project involved a similar number of laboratories from around the world.

Such government-sponsored collaborative efforts have two benefits. First, they leverage resources: A dollar spent on research goes much further when the fruits of that spending are shared broadly. Second, they help to create networks of collaborators that cut across aca-

demia and industry, which can provide a foundation for an industrial commons.

Unfortunately, the granting process for much of the scientific funding in the U.S. is biased toward lower-risk, incremental projects (“normal science”) that fit neatly into established academic fields and is weighted against higher-risk, high-return research that spans disciplines. To address this bias, the peer review process that such agencies as the NSF and NIH employ to award grants must be reformed. Currently, panels of academic scientists, each often composed of individuals from within a single discipline, make these decisions. Instead, groups comprising experts in a range of disciplines from the academic, business, and policy-making communities should be choosing the problems and deciding how best to structure basic and applied research programs to seek solutions. It is especially important for government policy makers involved in these decisions to have strong scientific backgrounds (as they do in Taiwan and Singapore).

Let ailing giants die. Throughout the world, governments have provided significant financial support to industrial companies struck by the economic crisis. As we were writing this article, Congress and the Obama administration were considering whether to give teetering GM more aid or let it go into bankruptcy proceedings. We oppose more support. There are rare instances when companies cannot be allowed to fail because of vital national interests (national security) or systemic effects (the impact that the failure of a big player like AIG or Citigroup would have on the interconnected financial system). Auto companies don't fall into either category.

Advocates of aid to the auto companies have argued that, in addition to preserving the huge number of jobs at those enterprises, a key reason to continue to prop them up is to preserve the supplier base. Lose these giants, they say, and you will lose feeder industries (machine tools, advanced metal fabrication, molding, and so on) crucial to the country's industrial base. We disagree and for two reasons believe that the potential impact on the U.S. commons has been exaggerated.

First, companies that are failing as a result of poor management or misguided strategy often suck the vitality out of the commons in which they participate, and government bailouts almost never succeed in restoring such compa-

Companies that are failing due to poor management or misguided strategy suck the vitality out of the commons.

nies to full health. Indeed, one cause of the U.S. automakers' current predicament is their failure to nurture a strong industrial commons. Several studies have documented a marked difference between the ways U.S. and Japanese companies have managed their supplier bases, for instance. Toyota has always understood the concept of industrial commons. It treats key suppliers as long-term partners, shares development work with them, and sticks with them over the long term. When a Toyota supplier is struggling, Toyota sends in its own people to help. In sharp contrast, U.S. auto companies have generally treated their suppliers as adversaries. They keep them on a tight leash. They offer them only short contracts. They all too often base their purchasing decisions largely on price. When a supplier has a problem, the U.S. auto company's typical response has been to terminate the contract.

Second, the bailout debate (in both the United States and Europe) completely ignores the global nature of the auto business and the contribution foreign-based companies make to the U.S. industrial commons. Not every player in the U.S. auto-manufacturing sector is a basket case. There are plenty of healthy factories. Most of them are owned and operated by foreign-based corporations like Toyota, Honda, Nissan, and BMW. These companies are contributing to the U.S. industrial commons.

If anything, Washington should encourage even more participation in the commons by foreign companies. An immediate case in point: the Fiat-Chrysler deal to save Chrysler. The Italian company has agreed to transfer its technology for producing highly efficient diesel engines to Chrysler in exchange for a substantial minority stake—contributing precisely the kind of clean technology that the Obama administration wants the U.S. to pursue. Ironically, some in Congress opposed the deal because they didn't want to use taxpayer money to benefit a "foreign" company. They just don't get it.

What Businesses Must Do

Government support of basic and applied research can fertilize the soil, but it takes private companies willing to make long-term investments in risky R&D to build a commons. The management challenge is a familiar one of balancing long-term and short-term performance. Here are six suggestions for striking

that balance:

Make capabilities the main pillar of your strategy. Companies pour enormous amounts of resources into marketing to build brands. But with the exception of a few industries like soft drinks, brands are only as good as the distinctive products they represent. Creating and making distinctive products requires an array of strong technical, design, and operational capabilities. Given how demanding and sophisticated customers throughout the world have become, marketing cannot cover up weak innovation for long. Apple, Intel, Corning, Amazon, and Applied Materials are companies that understand this. They realize that the only way to stay ahead of competition is to maintain an innovation advantage over the long term, and the only way they can do that is if they invest in new, differentiated capabilities.

Stop blaming Wall Street for short-term behavior. We've heard it over and over again from executives: "We'd love to build capabilities over the long term, but Wall Street, with its relentless pressure to produce ever-higher quarterly earnings, won't let us. We have no choice. We have to outsource." This devil-made-me-do-it defense does not hold up.

When companies promise to increase returns quarter after quarter, that's what Wall Street expects. But when they articulate a credible long-term strategy and demonstrate a capacity to execute that strategy, the capital markets have given them the necessary room to achieve it. In his first letter to the shareholders in the 1997 annual report, Amazon CEO and founder Jeff Bezos explained that his company would take a long-term perspective in its strategy and operating decisions. This message has been consistently reinforced in every subsequent letter. So short-term investors know Amazon is not the company for them. Sure, Amazon's stock has taken some hits now and then when the company has suffered a setback. But Bezos and his team have understood that the stock will rebound, and they have stayed the course.

Recognize the limits of financial tools. Most companies are wedded to highly analytical methods for evaluating investment opportunities. Still, it remains enormously hard to assess long-term R&D programs with quantitative techniques—even sophisticated ones like real-options valuation and Monte Carlo

simulations. Usually, the data, or even reasonable estimates, are simply not available. Nonetheless, all too often these tools become the ultimate arbiter of what gets funded and what does not. So short-term projects with more predictable outcomes beat out the long-term investments needed to replenish technical and operating capabilities. Managers would serve their companies more wisely by recognizing that informed judgment is a better guide to making such decisions than an analytical model loaded with arbitrary assumptions. There is no way to take the guesswork out of the process.

Reinvigorate basic and applied research. In the 1980s and 1990s, corporate research laboratories fell out of favor. They were deemed wasteful because many of their efforts could not be linked to the immediate business needs of their companies. Several—including Bell Labs and Xerox PARC, the birthplaces of many critical technologies that underpin important industrial commons—withered, disappeared, or were jettisoned by their corporate parents. Their resources were redeployed to business units.

It's true that laboratories like PARC generated many inventions that didn't serve the needs of their owners' core businesses. (It's widely known that Xerox was content to let other companies commercialize many of PARC's inventions, like the graphical user interface, Ethernet, and ball mouse.) But the fact that PARC's labs were generating inventions that Xerox's core copier business couldn't use should have told Xerox's executives something: that there were *huge* opportunities outside the core. Their inability to read and react to those signals was the fault of their flawed resource-allocation processes and strategies, not of PARC.

Of course, focused R&D that serves customers' needs is vitally important. But so is the capacity to explore. Recognizing this, a few companies, including IBM and Corning, have maintained strong corporate research capabilities and look to them to spur the next major wave of business opportunities.

Collaborate. While we want large companies to dedicate more resources to basic and applied research, we're not suggesting they return to the days when corporate labs were largely insular places. Rather, they should follow the lead of companies like Corning, IBM,

and Novartis, which recognize that their scientists needn't, and shouldn't, go it alone. They understand the value of the commons as a source of research capability.

IBM's leaders, for example, saw that the company could no longer afford on its own to make the investments required to stay on the cutting edge of semiconductor-manufacturing processes. Accordingly, over the past decade Big Blue has built what it calls a "radical collaboration" model in which it and a set of commercial partners share research capabilities and a common manufacturing platform, even though some of them compete downstream. IBM calculates the value of the benefits it receives from this relationship to be five to 10 times the amount it invests.

Create technology-savvy boards of directors. To effectively govern a company whose competitive advantage rests on science and technology, a board needs to have the same feel for technology as it has for finance and accounting. Boards—including those of many American high-tech corporations—are populated with plenty of lawyers, finance and accounting experts, and CEOs from other companies. Scientists are a very small minority. And while many corporations have scientific advisory groups, we have not yet come across one whose board has a science or technology committee. Regulations and good corporate governance call for audit, compensation, nominating, governance, finance, and executive committees. Shouldn't the boards of companies whose competitiveness heavily depends on science or technology also have a committee to ensure that all is well in this area?

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Alfred Chandler, the noted Harvard business historian, described how American companies like DuPont and General Motors gained prominence in the twentieth century by developing and integrating R&D, manufacturing, and marketing capabilities. These enterprises did not create these capacities to be good corporate citizens. They were pursuing competitive advantage, and they understood that these capabilities were essential to that goal. Today, the United States is at an analogous juncture, but the challenge is no longer to create capabilities to manage the large-scale, vertically integrated enterprise of the twentieth century; it is to build anew the technological operational capabilities needed to conceive and produce

Companies need to stop blaming Wall Street for their short-term focus. This devil-made-me-do-it defense does not hold up.

high-value goods and services. We must recognize that the capacity to undertake advanced process engineering and complex manufacturing is as important to continued innovation as are strong universities and a robust venture capital industry.

If major venture capital firms like Kleiner Perkins and Sequoia Capital announced they were leaving the U.S. to go to, say, India because they saw more profitable investment opportunities there, it would cause an uproar. Outsourcing by high-tech manufacturers

should do the same. It's unfortunate that the warning cries of the 1980s and early 1990s were ignored. Much has been lost since then, but it's not too late to rebuild the industrial commons. Only by rejuvenating its innovative capabilities can America return to a path of sustainable growth.

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