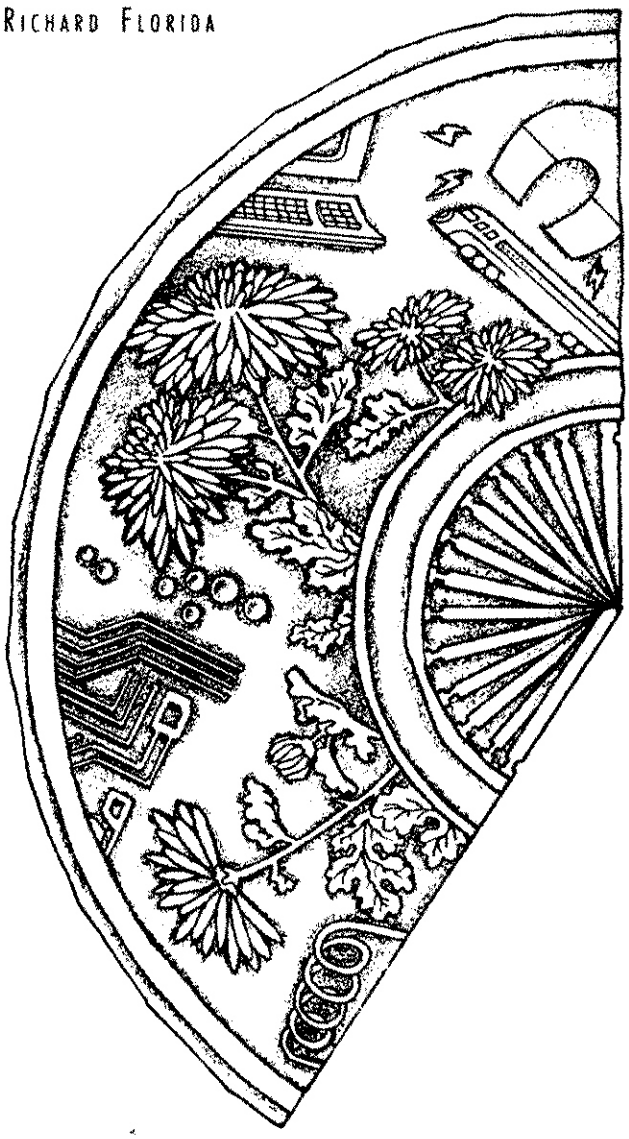
COMMENTARY

U.S. BREAKTHROUGHS BESTED BY JAPAN FOLLOW-THROUGH

BY MARTIN KENNEY AND RICHARD FLORIDA

Our strength in basic science, high-end R&D and other aspects of breakthrough technology has not been enough to hold off foreign, especially Japanese, competitors.



IN 1986, two IBM scientists working in a Zurich laboratory made an important new discovery. Working with highly advanced ceramic materials, they discovered a new form of electrical superconductor that no longer required extremely low temperatures but could work in real-world conditions. The commercial implications of this revolutionary breakthrough quickly became apparent. The door was now open for major advances in microchip technology, wires, switches, motors, sensors, bearings, lasers, computers, high-powered magnets and motors, and even new forms of transportation. The race to commercialize superconductivity was on.

In the United States, IBM led the way. Other large corporations, including American Telephone & Telegraph, DuPont, General Electric, and Westinghouse, quickly followed suit. In 1987 a bevy of entrepreneurial start-ups with names like American Superconductor Corp., Conductus, Ceracon, American Magnetics and Superconductive Components Inc. stepped forward to capitalize on this new technology.

But in the corporate offices and research and development (R&D) labs of Tokyo, a different approach took shape. Although they lacked the scientific capabilities of American corporate R&D labs, universities and spin-off companies, Japanese corporations aimed to capitalize on unique advantages—well-honed capabilities in ceramics and new materials, existing programs in low-temperature superconductivity and a tremendous capacity to turn technological innovations into products. The Japanese government helped make this a "collective" effort; in 1988, 46 Japanese companies joined a government-sponsored consortium. By mid-1988 Japanese firms had homed in on a number of product applications: superconducting films, wires, magnets, computer components and even advanced applications like "mag-lev" trains, which use magnetic levitation to ride above the rails at very high speeds.

As Japan's effort grew, American enthusiasm faded. For large U.S. corporations, the payoffs from superconductor research were slower than anticipated; actual applications were a long way off. By late 1988 reports from the National Science Foundation and the Office of Technology Assessment made the new reality painfully clear: in just three short years, the United States had fallen far behind Japan in the race to develop superconductor products.

The story of the U.S. superconductor effort is not unique. In semiconductors,

computers and now even biotechnology, much the same thing has occurred. Our strength in basic science, high-end R&D and other aspects of breakthrough technology has not been enough to hold off foreign, especially Japanese, competitors.

What caused this dramatic turnabout in our technological and industrial fortunes?

The explanation lies in the emergence of a model of technological innovation and development we call the "breakthrough economy." The breakthrough economy has a remarkable capacity to make major new technological breakthroughs, but it neglects the more mundane product and process innovations that are needed to improve new technology, use it effectively, turn it into products, and generate the wealth and economic growth that come from doing so.

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The breakthrough economy is premised on the comforting myth that innovation is synonymous with technological breakthrough—a myth in which most Americans continue to believe. Even though the majority of us are keenly aware of the U.S. decline in automobiles, consumer electronics and even some older high-tech fields like semiconductors, we take comfort in America's seemingly limitless ability to generate new technological marvels that will keep us well ahead of our major competitors.

In this regard, history seems to be on our side. The legacy of America's ability to develop and, more importantly, commercialize breakthroughs is indeed impressive in the areas of mass-produced automobiles, radio and television and more recently in high technology. A comforting image indeed: the United States makes the breakthroughs and forges ahead, leaving older "hand-me-down" industries to other countries.

But reality is far more complex than the comforting images. Even though many important breakthrough innovations have been made here, the high-technology end products, along with the jobs and wealth they create, are being produced elsewhere—mainly in Japan and Korea, Taiwan, Singapore and Hong Kong.

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Many have attempted to explain the reasons for America's alarming decline in high technology. One popular explanation suggests that we "gave it away" by selling off technology, promoting free trade even though it hurt key industries, and failing to respond to foreign, mainly Japanese, efforts to subsidize, protect and enhance key high-tech industries. Of course, the sale of technology and shortsighted technology and trade policies have contributed to our problems.

But the real problem lies in the failure of U.S. firms to overcome their long legacy of "functional specialization" by developing new functionally integrated ways of organizing R&D and shop-floor production, and connecting them together to tap the full capabilities of all workers. Even the most advanced manufacturing plants will not amount to much if shop-floor workers are not allowed to contribute their knowledge or if such plants are not connected to the innovations that come from R&D labs. Cutting-edge R&D and product development will mean little if they are not connected to manufacturing facilities that can turn innovations into products.

Organizational failures take many forms: corporate R&D labs that are located far from factories, and the lack of communication between high-paid white-collar think-workers who work in the gleaming office parks and R&D campuses and low-paid factory workers in the United States and increasingly in the Third World. And it is rooted in a long legacy of American organizational practices that separate "brains" and "hands"—managers and R&D scientists, on the one hand, and factory workers, on the other. The lack of integration across the R&D-manufacturing spectrum is the main reason the United States is increasingly unable to follow through on the innovations it makes. And it may eventually cost us much of the ability to invent as well.

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New visions, new passions, are needed to reawaken us from the current malaise, transform outmoded institutions and re-establish a sense of purpose in our economy and society.

Even the most well-meaning commissions made up of corporate executives, elected officials and labor union leaders cannot galvanize the broad grass-roots effort that is required. And such an effort will never be mobilized by cynical politicians who support democracy in Eastern Europe while assisting in the repression of workers in the United States and by business leaders who ask for a worker's involvement in the firm while preparing for mass layoffs. When vision is mistaken for turning a profit on the next quarterly report or a blip in the opinion polls, little can be expected from common citizens.

The energy of workers and citizens is needed to transform our system and build new institutional structures. The past provides certain grounds for optimism. Our nation has so much diversity, so much potential that can be released to overturn the present apathy and cynicism and once again fashion new development trajectories.

We can move forward or we can stagnate. To follow our current path will mean a slow, steady decline punctuated by more radical drops associated with the business cycle. As this occurs, the United States will become a second-rate economy that cannot deliver economic opportunities for the vast majority of its people or the social welfare of Western European countries. But if we can break with the assumptions of both the old follow-through economy and the breakthrough economy, we may achieve a new synthesis that can develop new technologies and harness them in ways that will improve the living standards, not only of the privileged, but especially of those who have been denied the benefits by our system.

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Kenney and Florida are currently working on their second book together, discussing the transfer of the Japanese production system to the United States, for Oxford University Press.

America's "Breakthrough Illusion" Threatens Its Future Competitiveness in Biotechnology

By Martin Kenney, Ph.D., and Richard Florida, Ph.D.

Why is the United States, the nation that once dominated world markets, no longer able to follow through with products based on its own technological breakthroughs in biotechnology, semiconductors and computers?

America's "breakthrough illusion" is the belief held by scientists, policymakers, business and government officials, as well as the average American, that major scientific and technological breakthroughs will continue to advance the American economy above and beyond its competitors.

point of view

Unfortunately, this concept does not conform to global reality. Major competitors, especially the Japanese, are proving that what matters today is the ability to harness and implement new technology—not just to invent it. Technology must be used effectively to produce new and better products and to improve manufacturing processes. This requires workers with the necessary knowledge and skills.

The root of the American problem lies in the separation of R&D from production. Also at fault is an outmoded and increasingly anticompetitive form of corporate organization that treats workers (sometimes including engineers) as a necessary nuisance. Critical product and process innovations that can make production more efficient are neglected.

A New System

The breakthrough economy is made up of entrepreneurial start-ups and venture capital that arose in response to the limits of the older follow-through economy which is composed of large bureaucratic firms. The small start-ups provided highly interactive environments, in which there was intense information exchange and cross-disciplinary interaction.

Yet, although there are many benefits that flow from the breakthrough model of organizing high-tech industry, this model is beset by serious problems, particularly the ability of high-tech workers to move around, change jobs and form new businesses. We call this underlying condition the "hypermobility of high-tech labor." Hypermobility is rooted in the organizational incentives of the breakthrough economy that allow high-tech think-workers to derive tremendous financial benefit by changing companies and jobs. The reality of rapid breakthrough innovation, four- and five-year vesting schedules, and the lure of more stock from a new company, make it rational for high-tech think-workers to move from start-up to start-up in a constant quest to hit it big.

But, what's good for individuals may not be good for American high technology. The hypermobility of high-tech labor enhances short-term individual gain, not long-term social benefit. And, increasingly, actions that ensure individual financial gain are different from those necessary to build successful high-tech firms and industries. Hypermobility results in disrupted research teams, inefficient use of resources, and burned-out employees.

Most significantly, hypermobility has made it increasingly difficult for established companies to benefit from and internalize the innovations they make. Rather than building stable competitive companies, we develop one-shot, breakthrough firms. Hypermobility is a fundamental dilemma of the breakthrough economy—one for which there is no easy resolution.

Misguided Solutions

For the better part of a century, the U.S. has shown an uncanny ability to solve many, if not most, of the technological and economic problems it has come up against. But now, for the first time, it seems unable to generate the kinds of solutions needed to put the country back on track. In field after field, the U.S. seems to get an important head start only to have competitors rapidly catch up as new products are commercialized.

A highly touted solution involves

Many Americans believe that major scientific and technological breakthroughs will continue to advance the American economy above and beyond its competitors. But the U.S.'s main economic rivals, especially the Japanese, are proving that what really matters is the ability to harness and implement new technology—not just to invent it.

companies abruptly cancelling their joint venture agreements with start-ups after they have managed to appropriate the start-ups' technology, thereby disrupting research and, at times, even bankrupting their small ally. The alliance route is often less a marriage of true partners than a distrustful relationship to be broken at the earliest possible convenience.

There is a final fatal flaw in the logic of those who see linkages between large and small firms as the key to a U.S. comeback in high technology. The flaw is, quite simply, that foreign companies can and are playing the same game. For example, Hoffmann-La Roche has absorbed Genentech. Japanese firms have purchased a number of smaller firms and nearly all the start-ups have agreements with foreign partners.

Despite all the controversy, it is difficult to block foreign access to U.S.-developed breakthrough technologies. The reason for this is simple. The U.S. high-tech system produces wave after wave of start-ups that need capital to survive. The problem is especially acute for companies that have exhausted their venture capital.

Role of Universities

Universities have also been drafted in the drive for competitiveness. The university has long played a role in society as a trainer of scientists, engineers and other employees with advanced skills. During the late 20th century, the university's role has increasingly shifted to one of basic research. In the years following World War II, the U.S. government became a primary funder of basic research.

With the decline in American competitiveness during the late 1970s and 1980s, concern grew that advances in basic university research were not being exploited by industry. The university came to be viewed as yet another weapon in the battle for competitiveness. In the 1970s, the National Science Foundation established a landmark program to create university-industry centers. In 1980 Harvard University president Derek Bok announced that the university was going to have to ally itself more closely with private industry in an effort to resuscitate the American economy.

an important role in the development of commercial technologies, critics contend that the university is selling out to industry.

The university is the institution that produces (and reproduces) the fundamental scientific and technological skills that are so critical for producing new innovations. The excessive emphasis on commercialization and profitable research has already partially eroded this institutional space. Once the commons is destroyed, it will be impossible to replace.

The real tragedy of the situation is that the root problems of the breakthrough economy have nothing to do with the university but lie in U.S. corporations that cannot turn their innovations into products. A hundred, a thousand or a million new university innovations will not solve this. It is ill-considered to push the university to undertake the social functions of the industrial corporation.

Beyond the Breakthrough Economy

The common prescription for these problems is to make more venture capital available, lower taxes on capital gains, weaken antitrust law, create quotas and involve the universities more in industrial activities. These policies are exactly the ones that were implemented during the 1980s—a period which will be remembered as the fastest relative drop of a premier economic power in all of human history. To turn the economy around in the 1990s will require a far more fundamental rethinking of the social, political and economic arrangements of this country.

First, the U.S. must radically cut military spending, and these monies must immediately be redirected into education starting at the kindergarten level and job training programs. Second, employees must be recognized as the most important stakeholders in the firm and simultaneously they must be encouraged to contribute to the firm's success. However, true commitment to the firm can only occur if they have very strong tenure guarantees. In effect, the entire economy must be redirected toward a long-term orientation and that begins by making a long-term commitment to the company's em-

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