

AMERICA'S BREAKTHROUGH ILLUSION

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Wherever we look the story -- in semiconductors, computers and biotechnology -- the story is the same. The U.S. achieves a commanding lead in basic science, develops the start-up companies who pioneer cutting-edge new technologies, and then somehow fails to follow through leaving other nations like Japan to come up with the mass produced products the world wants. Why is the nation whose mass production once dominated world markets, so unable to follow through on its own technological breakthroughs.

The answer lies in America's "breakthrough illusion" -- the naive belief held by scientists, policy-makers, business officials and the average American that big new scientific and technological breakthroughs will continue to lift the American economy above and beyond its major competitors. Unfortunately, the breakthrough illusion does not conform to the new global reality. As our major competitors, especially the Japanese, are proving what matters now is the ability to harness and implement new technology -- not just to invent it -- to use it effectively to produce better products and improve manufacturing processes. The root of our problems lies in the glaring separation of R&D from production and an outmoded and increasingly un-competitive form of corporate organization which sees

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workers as a necessary nuisance and thus neglects the critical product and process innovations that shop-floor workers can provide.

How We Lost the Follow-through

It wasn't always this way. The key to America's growth as an industrial power lay in a powerful ability to follow-through on new technologies, frequently technology that was invented by our major European competitors, the British and the Germans. They may have had science and technology, but we had the world's greatest capacity to turn that technology into mass-produced products. We had the world's largest and most advanced factories. We had a huge industrial work-force of immigrant labor. We had the scientific management system of Frederick Taylor and the mass production assembly-line of Henry Ford. We could turn out mass produced products faster and better than anyone. And then we combined this with the industrial R&D laboratory, giving us a powerful new internal source of innovation. The industrial laboratory enabled large companies to integrate innovation with their already first-class manufacturing capabilities, propelling the U.S. economy to a position of world leadership in the earlier "high technology" industries. During the first half of the 20th century, we were especially good at transferring these innovations into products

But gradually, imperceptibly, the United States lost its follow-through capability. Somehow the same economic structures and institutions that once formed the heart of our advantage, could no longer deliver. In the R&D lab, a labyrinthine bureaucracy and complex managerial hierarchy grew up. It was exceedingly difficult to maneuver projects through a maze of sign-offs and approvals. R&D became a focal point for power plays,

information hoarding, and short-term political gain. Caught up in a byzantine maze of corporate bureaucracy and individual turf protection, projects could go through cycles of being designated as high priority, put on hold and then abandoned. R&D projects were constantly being "lost in the shuffle" of gigantic corporate bureaucracies.

Corporations responded to these problems in ways that only made the problems worse. New levels of managers were added, further expanding the R&D bureaucracy. Many of these new managers came straight from business school and had little expertise in or "feel" for technology. High rates of executive turnover and "job-hopping" made things even worse. Managers who were constantly on the move had little concern for long-term R&D projects that would incur costs now but yield returns after they had moved on.

In the factory, a strict division between shop-floor workers, on one side, and managers and engineers, on the other, was created. The employees were relegated to the position of hired hands paid to work not to think. A growing managerial bureaucracy was called upon to coordinate internal corporate transactions, manage shop-floor labor, keep things running smoothly, and plan for the future. The very model that the U.S. had developed to take it to new heights in productivity was predicated upon the conception that the vast majority of a firm's employees were nothing more than hands.

And, increasingly, corporations came to separate production from innovation as they moved their R&D facilities to suburban campuses and their factory production to low wage regions of the Sunbelt or the Third World.

A New System Emerges

A new system of innovation and production comprised of high-technology companies and venture capitalists grew up in the shadows of the traditional large enterprise. Although the details vary from technology-to-technology and industry-to-industry, the basic message remains the same: the large companies failed to move into new technological openings, leaving the door open for start-up companies and venture capitalists. A new breed of high technology industrialists saw the potential of these new technologies and stepped forward to create the new organizational structures needed to capture the new technological and industrial opportunities of the high technology age. These small start-ups overcame the organizational barriers among R&D labs, engineers and managements that had stymied innovations in the traditional large enterprise. They did so by creating highly interactive, team-based environments in which there was intense information exchange and cross-disciplinary interaction. Venture capitalists added the risk capital and the outside expertise needed to get new businesses started. And networks of related firms and support services emerged to accelerate this process of innovation through new business creation in places like Silicon Valley and Route 128.

But this new model soon generated problems of its own. Seeking "big bucks" and dismayed by the absence of corporate loyalty, engineers and scientists were encouraged to switch jobs often. A once virtuous circle of entrepreneurial business formation gradually turned into the vicious cycle of "chronic entrepreneurship." Venture capitalists at times raided established companies to staff new ones. The entire environment came to be distinguished by a "hyper-mobility" of high-tech labor -- where high-tech think-workers

derive tremendous financial benefit by changing companies and jobs as frequently as possible. 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 technology think-workers to move from start-up to start-up in a constant quest to hit it big.

And the problems multiplied. Disrupted research teams, wasted effort and burned-out workers became the casualties of America's new high-tech system. "Me-too start-ups" and copycat companies emerged to sap each others resources and markets as entrepreneurs and venture capitalists rushed to cash in on the latest technology fads. All of this 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. We now have hundreds, thousands, even tens of thousands of small semiconductor, computer, software and biotechnology companies. But their efforts often do not amount to much. And these companies are not only cut-off from one another, they are cut-off form the large traditional enterprises that comprise the bulk of our economy. This severe fragmentation and splintering of our high-technology capabilities makes it very difficult -- perhaps impossible -- to build stable companies and industries that can compete over the long haul.

Misguided Solutions

For the better part of a century, the United States 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, we are unable to generate the kinds of solutions needed to put

us back on track. In field after field the U.S. seems to get an important head-start only to have our competitors rapidly catch up when the new product is commercialized.

A highly touted solution involves combining the innovative capacity of our small start-ups with the manufacturing and marketing prowess of large industrial corporations through alliances and other forms of partnership. Unfortunately, the reality of strategic alliances falls far short of the hype. Competition and conflicting objectives make it hard to build true cooperation. For small companies, alliances are only a stepping stone, or worse yet a last resort, when they need capital or the access to manufacturing capabilities. And large companies just want access to new technology: once they get what they need, they have little incentive to continue the partnership. In biotechnology, for example, there has been a recurring pattern of large chemical and pharmaceutical companies abruptly canceling 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. The closer the large firm gets to the small firm, the more the small firm is suffocated. In the end, the small firm is usually devastated, while the large firm has not achieved its goals. Thus, the "perfect marriage" of innovative start-ups and the marketing and manufacturing prowess of our corporate giants too often ends up either in a painful divorce or a badly failing union that brings out the worst in both partners.

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, in biotechnology Ciba-

Geigy has absorbed Genentech, Japanese firms have purchased a number of smaller firms and nearly all the start-ups have agreements with foreign partners. There is growing concern that foreign alliances and takeovers "give away" important technologies to our competitors. But, despite all the controversy, it is difficult to block foreign access to our breakthrough technologies. The reason for this is simple. Our high-technology system produces wave after wave of start-ups who need capital to survive. The problem is especially acute for companies that have used up their venture capital. The impassioned attacks upon foreign companies developing liaisons with our small firms are understandable, but they fail to address the root causes of these relationships.

Universities are also being drafted in the drive for competitiveness. In the 1970s, the National Science Foundation established a landmark program to create university-industry centers. And, in a major address given 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 renew the American economy. By the mid-1980s and continuing into the 1990s, a host of new university-industry relations had been forged. These new arrangements are most noticeable in the new biotechnologies where multi-year, multimillion dollar contracts have been signed between large corporations and major research universities.

But, reconciling the university with the short-term profit motives of industry is difficult at best. While some believe that the university can play an important role in the development of commercial technologies, critics contend that the university is selling-out to industry. Many university scientists see the redirection from basic to more applied

research as misguided. Robert Park of the American Physical Society states that: "We're going to start shoving our universities into more applied and even more developmental work and I think that's a mistake. The potential for abuse is great and often perpetrated by the universities themselves. When university research comes to be viewed as a source of competitiveness, the norms developed to ensure excellence and reliability of research results are often left behind. The university is perhaps one of the last major American institutions that is respected and envied by the rest of the world. Its emphasis on the free interchange and flow of information has created an intellectual commons for which there is no equal. 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 our technological system but lie in U.S. corporations which 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. As an institution, the university is simply not equipped to play a significant role in bolstering our corporations' weakness in follow-through.

Another common prescription is to make more venture capital available, lower taxes on capital gains, weaken antitrust law, create quotas, involve the universities more in industrial activities. In effect, these policies are exactly the ones that have been followed 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.

A Strategy for the Future

It is now time to overcome the breakthrough illusion. To do this, requires breaking with outmoded ideas and old habits, adopting a new world view, and re-building many institutions from the ground up. It demands the hard work of many, deep public commitment, and the collective energy of workers and citizens.

There are three fundamental lines around which to start to organize an effort to rebuild our technological and industrial capabilities.

Stimulate the collective creativity and intelligence of the American work-force: Tapping the collective intelligence of all workers from R&D scientists to factory workers is absolutely essential for success in an age of rapid technological change and perpetual innovation. Today's most competitive firms -- in Japan, the U.S., Europe and elsewhere -- recognize that the key to success rests in the ideas and combined intelligence of their work-force. Konosuke Matsushita, the founder of Matsushita Electronics suggests that the essence of Japan's advantage over the U.S. "depends upon the continued mobilization of every ounce of intelligence." There can no longer be a one way flow of information from "all-knowing" scientists, engineers and managers to the "know-nothings" on the factory floor. Workers from different parts of the company must use their collective intelligence to fashion product and process improvements.

The shop-floor must become an extension of the R&D lab, and the R&D lab an extension of the shop-floor. The shop-floor is no longer a grimy factory, but rather has

become a semiconductor clean room or pharmaceutical production process. The reliability and intelligence of the employees working in these environments is crucial for success. Employees can no longer be treated as second-rate human beings whose only purpose is take orders from all-knowing managers and engineers. As the factory increasingly resembles the laboratory, sharing between engineers and factory floor workers is necessary. Every employee must become an innovator attempting to improve through both product and process innovation.

Provide Economic Security: American workers will resist, are resisting, and have every right to resist corporate efforts to tap into their "brains" if they are not given real guarantees that their jobs are safe. Invariably the most competitive firms and the most competitive nations provide the employment security it takes to ensure that workers are both smart and committed.

Move From a Military to a Civilian Economy: We must mobilize all the resources we can muster to build a more effective technology system and economy. This means dismantling the Cold War military burden and embarking on a comprehensive effort to rebuild our industrial plant and technological infrastructure. There are numerous bills in Congress that would start this necessary process of "reconversion" from a military to a civilian economy.

To do nothing may well result in our economy going the way of England, or worse yet, becoming "Brazil-ized" with declining industries, huge debt, falling living standards, and dependence upon foreign investment. But, if we can focus the collective energy of workers and citizens on re-building our key organizations and institutions, we may once again

provide sustained technological development, steady economic growth, and improved living standards.

The choice is ours.