ROOTS OF INNOVATION

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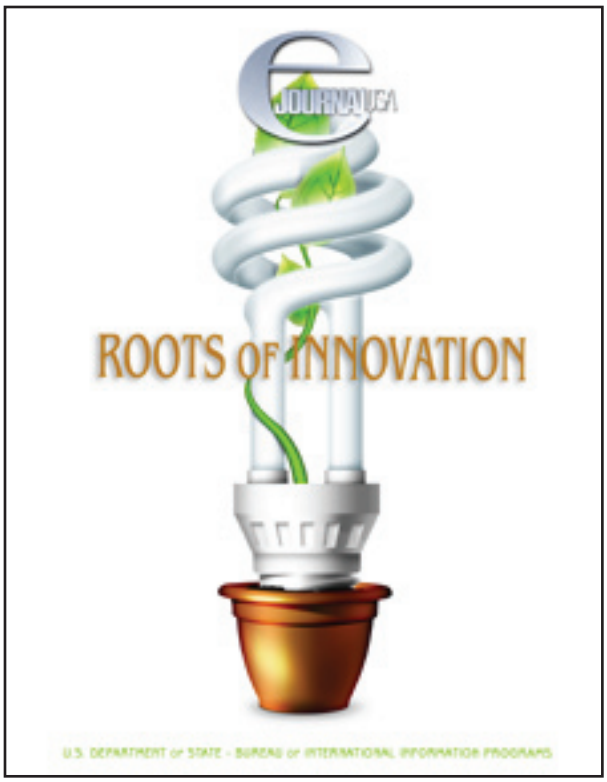
About This Issue



In 1943, the British academic and sinologist Joseph Needham (1900–1995) and his team of international collaborators began to produce a multi-volume work that ranks among the 20th century's most significant academic achievements. Entitled *Science and Civilisation in China,* it explored what became known as "The Needham Question": Why was China, home by many measures to the world's leading civilization, overtaken by the West in science and technology?

Scholars such as Dan Diner have asked similar questions about Islamic civilization, also a global pacesetter in one historical epoch but not today, as the Arab Human Development Reports document with regard to one predominately Muslim part of the world.

The present or impending decline of the United States is of course a hardy perennial in the world of ideas. We hardly lack for new books decrying American schoolchildren's relatively poor math and science test scores, and these titles often then condemn this nation to the fate of Rome, Great Britain, or really any major power whose influence declined over time.

This issue of *eJournal USA* explores one nexus of questions at the heart of these discussions: What is innovation? Can governments and societies encourage innovation? How do the emergence of semiconductor-powered computers and Internet-based communication technologies affect the equation?

Our contributors explore these questions from a number of angles, including the influence of culture, geography, and intellectual property rights on innovation. We also present profiles of successful innovators from the United States, Vietnam, Venezuela, South Africa, and Belgium.

We hope you will find these essays timely, informative, and even innovative!

— *The Editors*

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What Is Innovation?

David Nordfors

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More than half of the people in the world use cell phones; this boy in Mali charges his phone off an auto battery.

Innovation is invention plus introduction, and it is increasingly seen as crucial for economies and governments alike. Expanding economies no longer produce more of the same products, but rather ever more new products with additional value. David Nordfors is co-founder and executive director of the VINNOVA-Stanford Research Center of Innovation Journalism at Stanford University.

Innovation is today the most important driver of economic growth. It relies upon a social climate supporting entrepreneurship within a culture of economic and intellectual freedom. Wise policy makers understand the need to encourage this kind of "innovation ecosystem."

Invention creates something new. Innovation is more than that: It introduces something new. Innovation is invention plus introduction. It is not easy to introduce something new. Anybody who has had a bright idea about how to improve his or her workplace will know this. People say they want progress, but they resist change.

Communities and organizations are often more resistant than the people in them. Even if all individuals in an organization want a change, the organizational culture might not permit it.

Making innovation happen is a craft and an art; understanding how it happens is a science. Innovation is grounded as deeply in psychology and culture as in science and technology.

We are becoming better innovators, and the resulting products, services, and processes play a growing role in the lives of citizens across a growing swath of the globe. Large parts of the world have moved into the innovation economy; the rest are rapidly following.

In a traditional production-oriented economy, growth is driven by producing more of the same. Wealth has been

about growing more wheat and building more traditional houses and opening more traditional factories this year than last year. In the innovation economy, growth is about doing more new things this year than last year. That is a fundamental shift, one clearly visible to people around the world in their daily lives.

Targeting Short-Range Success

The rapid acceptance of the mobile phone illustrates how innovation works and how it changes our global culture. The first hand-held mobile phone call was made in April 1973. The first cell phone networks were rolled out in Sweden and Finland only a decade later. By the end of 2008, people had more than four billion cellular subscriptions, according to the International Telecommunication Union. That is more than half of the total world population! Compare that to literacy: The art of writing was invented many thousands of years ago, and it was only some decades ago that more than half the world population became literate. Cell phones have spread a hundred times faster than literacy!

How can change happen so fast? The key lies in focusing on innovation instead of focusing on producing more of the same.

If mobile phone business competitors were not constantly racing to take the lead with their next innovation, cell phones would have remained expensive, clunky, battery-draining contraptions only for rich people. Not many people would own them today.

Competition for the next big innovation is breaking down traditional corporate structures. No longer do successful companies separate research from business development. Companies under pressure want to avoid expensive research that is not buttressed by a business plan. Investing a lot of money to develop technology that does not contribute to revenues can bring a company to its knees. Technology development and business must be done together. Today the technology people and the marketing people work with each other. The traditional analytical thinking, where each group of experts thinks within its box and sends the result to the others in the form of a report, can be replaced by "design thinking," where different types of experts mix, combining empathy, creativity, and rationality to meet user needs and drive business success.

This is increasingly the case with information technology. Today's computer, mobile phone, or similar product is not expected to be on the market for more than a year or two before it is replaced. This is becoming true even for traditional products with longer lifetimes, as in the food and paper sectors. According to researchers at the McKinsey & Company consulting firm, product lifetimes are today a third of what they were 40 years ago. This too, reflects the shift from the "more-of-the-same" economy to the "introduction-of-something-new" economy.

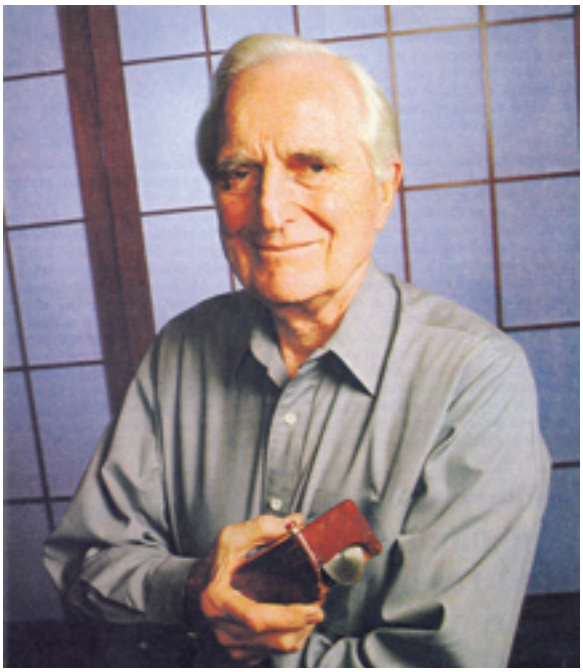
Vision to Reality

While the public imagination often links innovation to technological advance, innovative techniques have spurred improvements in such diverse fields as micro-loans, which enable people in developing economies to start new low-cost businesses, new ways of organizing companies, and new ways of learning.

The word "innovation" can refer to a novelty — a new gadget, for example — but it can also refer to the process that created the novelty. This might be primarily commercial — the "process of creating and delivering new customer value in the market," as suggested by Curtis Carlson and Bill Wilmot at the contract research institute SRI International — or driven in whole or in part by social needs. Social innovation and commercial innovation often drive each other. Micro-loans and open-source free software produced by nonprofit communities — for example the operating system Linux or the Firefox Internet browser — are good examples.

Many people link innovation to the world's wealthy economies, but today low-cost innovation is increasing, and this makes it possible for the innovation economy to expand to nearly every part of the globe. Little money is needed to create new innovative services on the Internet. Students at Stanford University started Yahoo! and Google with very little money. The big investments came after these companies were already up and running. The threshold for setting up innovative companies in certain fields, such as Internet services, is low. In principle, there is enough money in many places around the world to start such companies.

As the Internet is spreading and communication is improving, global markets are becoming more responsive as well. It has become easier in traditional societies to prompt people to replace traditional tools and methods with new ones. Innovative inexpensive water pumps, new cost-effective ways of improving traditional agriculture, new ways of organizing the care of ill people in villages:



Courtesy of SRI International

Doug Engelbart holds up his prototype computer mouse.

These are all important fields of innovation with great promise at potentially little cost.

Consider California's Silicon Valley — the most successful innovation ecosystem in our time, and one highly dependent upon the cross-pollination of ideas among its many technological and other innovations. There, in 1968, Doug Engelbart demonstrated the first prototype of a modern personal computer system. The demo featured the first computer mouse the public had seen. It introduced interactive text, videoconferencing, teleconferencing, e-mail, and hypertext. (The demo is available on YouTube; search for "the mother of all demos.")

Engelbart did not call the demo "a new personal computer system." Instead it had the peculiar title "a research center for augmenting human intellect." Engelbart's device was not about making smarter computers; it was about making smarter people. What is more, these personal computers were to be connected to each other so that people could work together on solving problems. They would form a collective intelligence that could solve much more difficult problems than people could solve without networking their computers. It was a wild idea at the time. Few people understood it. With the Internet, cell phones that are small personal computers, and social-network applications, the vision has today become reality.

The People Connection

We are coming to understand that innovation and collective intelligence are a pair. An intelligent, creative person can be inventive; collectively, intelligent communities can be innovative.

But connection alone does not suffice. The key is dissemination of information about how innovation happens. Journalists can play an important role here. If they convey to readers a sense of how innovation happens, our collective understanding of the process may increase. But if journalists do not themselves understand innovation, they will misrepresent it in the public discussion. One likely result would be to discourage innovators or else encourage them in unconstructive directions. The VINNOVA-Stanford Research Center of Innovation Journalism at Stanford University has invited journalists and researchers from several countries to come to Stanford to improve their expertise in covering innovation. This training will help journalists increase the collective intelligence around innovation ecosystems in their home countries.

Innovation requires entrepreneurs, and they in turn need a supportive environment: an innovation ecosystem of business and finance people, educators, and regulators who together create a climate within which new and established businesses can innovate and thrive. In good innovation systems, entrepreneurs with good ideas can find investors and partners, build their companies, and in some cases grow them from very small concerns to multinational corporations.

In Silicon Valley, this is everybody's dream. Innovation is the region's main industry. In Sweden, another leading innovation economy, there is even a government agency dedicated to developing good innovation systems. Tellingly, it focuses more on strengthening an innovation-friendly environment than on supporting any given innovation.

Hidden Dangers

In more-of-the-same economies — until now the norm in most societies — innovation, whether of products or ideas, is not a desirable vocation. The risk of failure is high. It is easy to get into trouble for trying something new. Many people would rather not try.

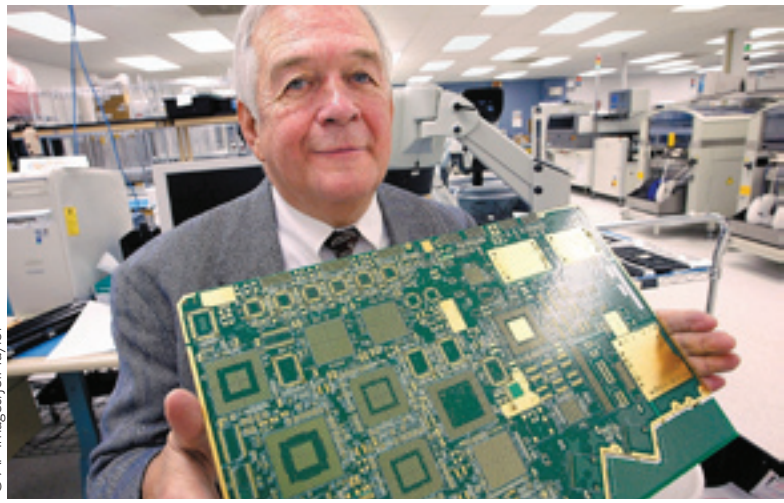
Dr. Ignaz Semmelweis, a Hungarian physician, discovered in 1847 that the occurrence of childbed fever

was drastically reduced if doctors delivering babies washed their hands. Semmelweis managed to all but eradicate childbed fever in clinics where previously more than 1 in 10 women had died during childbirth; he produced statistics proving beyond doubt that hand washing had saved their lives. But the medical community rejected his ideas; because this discovery came before Louis Pasteur proved the existence of germs, there were no theories supporting Semmelweis's results. Some doctors were offended to be told to wash their hands. Semmelweis managed to antagonize his colleagues, who ridiculed him. Semmelweis lost his job and social stature.

The danger of being an innovator in the more-of-the-same economy applies also to political leaders. In his 1513 book *The Prince,* Nicolo Machiavelli described methods that an aspiring prince can use to acquire the throne or an existing prince can use to maintain his reign. Here is what he had to say about innovators:

> We must bear in mind, then, that there is nothing more difficult and dangerous, or more doubtful of success, than an attempt to introduce a new order of things in any state. For the innovator has for enemies all those who derived advantages from the old order of things, whilst those who expect to be benefited by the new institutions will be but lukewarm defenders. This indifference arises in part from fear of their adversaries who were favored by the existing laws, and partly from the incredulity of men who have no faith in anything new that is not the result of well-established experience. Hence it is that, whenever the opponents of the new order of things have the opportunity to attack it, they will do it with the zeal of partisans, whilst the others defend it but feebly, so that it is dangerous to rely upon the latter.

Clinging to old norms and habits that stifle innovation is no longer a recipe for political or economic success. The society that censors the free flow of information or prevents people — men or women, old or young — from contributing fully to civic, social, and economic life is not using its full ability to compete in the global innovation economy. Better, many understand, to encourage cultures and systems that embrace and master innovation. South Korea, India, and Israel are among the growing number of economies that are succeeding with this strategy.



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Virginia inventor Joe T. May displays one of his innovations, a device that starts his auto's engine when his alarm clock goes off.

Mastering Change

Shifting from a traditional to an innovation economy requires real social change, openness to new best practices, and a commitment to developing the diverse skills required to produce a society of innovators.

In the past, schools have taught children how to solve known problems with known methods, a process that encourages them to reason in established ways. Now schools need instead to encourage children to master change, discover new problems, and devise new solutions.

Instead of encouraging uniformity, the innovation economy encourages diversity and creativity. Banks and investors must redefine risk to appraise more accurately the path-breaking, innovative project. Public decision makers who focus on regulating businesses producing more of the same need to refocus on how to reap greater benefits by letting the new continuously replace the old. It is all about looking at the next big thing instead of focusing on more of the same.

Improving innovation is about increasing our creative collective intelligence. It is a grand opportunity for all decision makers, be they individual entrepreneurs building businesses or political leaders running countries. ■

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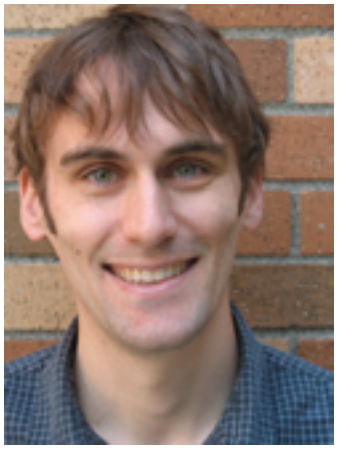
Jeff Bigham

A computer science researcher sees a way to make the Internet more available to the blind and visually impaired.


Courtesy of Jeff Bigham

Jeff Bigham

For the 38 million people around the world who have little or no vision, using the Internet is a near-impossible chore. The best option is a "screen reader" — software that reads aloud the text on the screen through a computer's audio speakers. But screen readers are expensive, and many public libraries and universities do not want to pay the more than $1,000 to have them installed. This means that most blind people miss out on the joys and opportunities of the Internet.

Jeff Bigham wants to change that. Bigham, now an assistant professor of computer science at the University of Rochester in New York State, has created a free, easy-to-install screen-reader application for the blind. A blind person logs onto Bigham's Web site — called WebAnywhere — and from that point forward all Web pages are read aloud. Users can tab through charts, select forms, or instruct the service to read a page from top to bottom.

The crucial part of Bigham's innovation is the quick load time between the moment a user requests to hear a certain page element and when the audio actually starts to play.

"The potential is there for big lag times between when the user presses a button and gets speech back," Bigham told MIT's *Technology Review* magazine. "Pretty much everyone thought that this latency problem would kill us." But it hasn't.

Bigham created an algorithm that predicts which elements of a page a user is most likely to want to hear. For example, after loading a news Web page such as nytimes.com, the system might predict that the user will read the top headline and news story. It would therefore preemptively load audio for that portion of the Web page. When the user eventually selects the top headline, the audio plays instantly. A seamless, swift Web-browsing experience for the blind replaces one that was choppy and full of delays.

Bigham wants to change the world; he doesn't care about profit. That's why he has kept his program open source, which means that anyone -– yes, anyone — can edit the application to fix bugs and make it better.

Thanks to Bigham's initial innovation and the subsequent contributions of others, it's not hard to see a bright Web-surfing future for the blind.

— *Ben Casnocha, author of* My Start-Up Life: What a (Very) Young CEO Learned on His Journey Through Silicon Valley

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Culture and Innovation

Rocco Leonard Martino

© AP Images/Kamran Jebreili

Visitors gather around a model of an artificial island for tourists in Dubai, one place in the Gulf region that extols innovation.

Those cultures that allow their people to dream, innovate, and produce will be the winners in the race for economic independence. Rocco Martino is founder and president of CyberFone Technologies and senior fellow at the Foreign Policy Research Institute in Philadelphia, Pennsylvania.

Until the Industrial Revolution, real income for individuals and nations was essentially flat. Over much of the globe, the living standard of, say, a farmer in 1750 would not differ greatly from that of his great-grandparent. Since the start of the 19th century, in some parts of the world this has changed. Growth and income for some nations has risen dramatically, but for others it is still flat. Why? One answer is that new technologies made possible the creation, accumulation, and dissemination of ever greater wealth. A deeper answer is that some cultures embraced knowledge and change, and thus emerged as the fertile soil in which innovators could take risks, pursue their dreams, and, not coincidentally, enrich their fellow citizens. Are the nations that lag bogged down by tradition, stultifying central control, or a culture of bureaucratic impediments?

The United States has long been a leader in both innovation and its application to wealth generation. One even might argue that the mindset was part of the nation's DNA. One of its founders, Benjamin Franklin, alone was responsible for inventing the lightning rod, the

© AP Images

Innovation took a leap in 1946 with creation of a computer, called the ENIAC, at the University of Pennsylvania.

Franklin stove, bifocal glasses, and the flexible urinary catheter. (Although Franklin chose not to patent these inventions, his many other entrepreneurial activities amply demonstrate his proclivity for making money!) In recent years, Pacific Rim economies including Hong Kong, Singapore, Taiwan, South Korea, and Japan have demonstrated similar skills, even as China and India develop significant earning capability and bid for roles as global economic leaders.

Member nations of the Organization of Petroleum Exporting Countries (OPEC) earn vast returns for their oil assets but mostly have neither displayed a great capacity for innovation nor participated greatly in the global economic expansion. Arguably these nations' significant oil-derived per capita income dampens incentive to invest in new ventures or to encourage innovation. Some regional governments seem aware of the problem, including Dubai, with its heavy investments in creating a financial and recreational infrastructure, and Saudi Arabia, whose King Saud University now has 70,000 students.

In Latin America, Brazil has emerged as a leader, making significant strides in applying modern innovative techniques internally and also for export.

The genius for innovation and its productive application to problem solving and wealth generation was not a U.S. invention, and its spread will continue far beyond the nations mentioned here. Everywhere, though, the emergence of innovation-friendly climates of opinion, habits, and ideas will be a challenge of culture, individual initiative, and government support for new ideas.

Affecting Culture

How does culture affect innovation, and vice versa?

Culture and innovation are linked. Innovation cannot occur in a culture that does not, cannot, or will not support it; but once created, an innovation affects the culture, and the two grow together. History is full of examples that demonstrate this. In today's Cyber Age of pervasive communication and information technology, this impact is pronounced.

The emergence of the smart phone — the handheld device coupling the cell phone with computing capabilities and Internet access — has created tools for modifying

public opinion, speeding trends and intensifying culture shifts. Reading habits have shifted from newspapers and books to short bursts of instant facts or opinions. Discussions and letters have been heavily replaced, initially by e-mail and now by Twitter and other micro-blogging sites. Cyber culture has dramatically shortened the time from knowledge to decision and shortened dramatically the cycle in which knowledge is recycled to create still more knowledge. Instant information, from anywhere to anyone, has now become a vehicle for instant impact on opinion and motivation — and a potential opening for manipulation. This acceleration of "knowing" can impact education, public opinion, entertainment, mores, and cultural development.

In much of the world, cultures originally developed among peoples dedicated primarily to feeding themselves, to the rhythms of agrarian life. Today culture often is shaped by the unique atmosphere, ways, mores, and traditions of a group of people connected in some fashion. That connection can be education level, religious beliefs, family linkages, ethnicity, geographic location, or nationality. And culture also is a driving force behind personal or group creativity.

Innovation is the art of creating something new, whether a poem, a writing, a flowering plant, a mathematical theorem, a medical advance, or an invention. Most recently there has been great focus on technology, especially information technology, as a major catalyst for innovation. This is due in large measure to the remarkable advances in global wealth in the past six decades tracing back to the creation of the general-purpose electronic computer in 1946. Linked with major advances in communication capability and in visualization techniques, the computer era has spawned a significant growth of wealth and made possible the birth of new industries, even in locations with no previous heavy-industry capability. Examples are the microchip industries of Singapore and Taiwan, and the software programming developments in Ireland and the Philippines. Similar developments have enlarged the economies of nations with existing heavy-industry capability, such as China, India, and Japan.

These developments built upon each other, each innovation leading logically to the next, and all depending upon a culture that embraced knowledge and change. Attempts have been made for centuries to find ways to compute more easily and quickly. Mechanical and electrical machines built within the industrial capabilities of their time preceded the computer. It was only the rise in electronic-tube stability and knowledge of its use that made it possible to conceive and build the first electronic computer. Computers made satellites possible, leading in turn to the communication revolution. And the same knowledge and use of circuits led to television and visualization techniques, mainly digital, that complete the information triad of power that has created today's Cyber Age.

© Reuters/Ali Jarekji

King Saud University seeks to foster a culture of innovation.

Nor was it a coincidence that so many of the events that led to the modern personal computer emerged in the United States in the 1940s and the following decades, with a concentration in California's Silicon Valley region. There, the prevailing culture brought together people with ideas and devices that could embody those ideas into a working product.

Today we live in what *New York Times* columnist Thomas Friedman calls a "flat world." If not yet completely flat, ours certainly is a flatter world, one where instant communication and availability of information brings innovation-friendly culture across national boundaries and empower ever larger numbers of world citizens to create and to innovate.

Fire in the Belly

Even in the Silicon Valley, India's Bangalore region, or any of the other world centers of innovation, not everyone is an innovator. Innovators are individuals with dreams and the strength of character to bring their dreams to fruition. This "fire in the belly" — a deep-seated personal drive and ambition to accomplish and achieve — cannot be created, but it can be nurtured, fostered, encouraged, whether in technology, medicine, the arts, or agriculture.

The major steps in building the cultural climate for innovation include expanding educational opportunities and facilities, providing financial support for innovators, eliminating bureaucratic impediments to recognition of an innovation, and spending money to publicize an innovative product.

Consider a musical composition. To assure its success there must be educational faculties available to train potential composers in music, financial support for a composer to create the piece, a legal infrastructure providing copyright protection against illegal copying, and funding to ensure performance of the music.

Another encouraging development is that many new technologies lower the barriers to further innovation, a virtuous circle that holds the promise of ushering in a more global culture of innovation. Before the emergence of cell phones and mobile smart phones, long-distance communication required extensive and expensive infrastructure, beyond the ability of many poor nations to afford. But cell phone towers are much simpler and cheaper to build than wired networks. As a result, millions of potential innovators who might otherwise have been isolated and bypassed are empowered to participate in the growing community of innovators.

The Internet

The emergence of the Internet, together with affordable cell phone or other access in a growing part of the world, is revolutionizing cultural development. This does not mean that Africans, Indians, or Chinese are becoming more like Europeans, Japanese, or Americans. It means that more global citizens can communicate and that one's location is gradually becoming a less important factor in one's ability to innovate.

The current cell phone population is more than half the world population, and closing in on the total figure. The cell phone is rapidly becoming the universal means of communication, entertainment, source of information, and even education. Data stored in countless systems and data banks around the world can be accessed and used anywhere, anytime, by anyone. This dramatic shift puts the resources of the world at everyone's fingertips.

While earlier technologies such as radio communicated across national boundaries — consider the Cold War battles between western shortwave broadcasters and Soviet jamming signals — the information flow is far greater today.

Attempts to control the Internet or cellular traffic can be only partially successful. Disclosure of information, sharing of ideas, impetus for creation, and successful innovation are bound to expand.

Nor should we link all innovation to technological advance. Pioneers in music, literature, and dance, for example, always will press the frontiers of their respective arts. But all can benefit from technology as well. Many is the composer who creates sound using special software on a personal computer. And technology aids immeasurably in the dissemination, use, and appreciation of their creations. No longer need a band rely upon a recording label to distribute its music when YouTube or the equivalent is but a click away.

Culture and innovation, then, feed upon each other and expand jointly together. On a global basis, there are no limits to what is possible, save one: An innovator must have the motivation, courage, and fortitude to prevail. Countries that encourage these individuals will advance both their culture and their innovation potential. Those that do not will lag behind.

Those nations that permit the individual to dream, innovate, and produce will gain stature and influence in the 21st century. Overcoming hidebound traditions (although certainly not all traditions), restrictive government, and unnecessary bureaucratic impediments will be major factors in this race. A culture rewarding ingenuity and success will catalyze a new and international wave of economic growth. Globally, a tsunami is building that will sweep the unprepared before it. ■

See also Richard Florida, "The Rise of the Creative Class," in the May 2008 eJournal USA, *"Venture Capital Meets Hi-Tech"* [http://www.america.gov/st/econ-english/2008/May/20080513101454jmnamdeirf0.6960718.html]

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Chi Huynh

A nicked pearl opens a treasure of innovation.

Courtesy of Chi Huynh

Chi Huynh

After the fall of Saigon in 1975, Chi Huynh had a dream: leave his homeland of Vietnam and create a new life in California. A few years later, he packed up his possessions and did it. The journey to California wasn't easy. A harrowing boat ride and a stint as a refugee in Thailand were just some of the travails. Finally reaching the shores of California marked a "spiritual turning point" for Huynh: Having seen much ugliness in his life, from that day forward he wanted to see and create beauty each and every day.

Jewelry making, a craft his father had mastered in Vietnam, seemed like the perfect way to live out this vision. Huynh called his jewelry enterprise Galetea and based it in Los Angeles County.

In early 2000, Huynh somewhat accidentally became an innovator. After nicking a traditional pearl during the carving process and exposing its mother-of-pearl center, "I thought to myself, 'What would happen if I grew a pearl using gemstone beads to let the color show through?'" he says. Doing just that would lead to his signature innovation — the Mercy Pearl, which is the name of the pearl cultured with a gemstone bead technique. It took time for Huynh to fully develop his carve-by-hand Mercy Pearl technique, but it is now considered one of the most significant variations in pearl farming since the early part of the 20th century, when pearls were first cultured in Japan. And he secured a patent on the Mercy Pearl.

In 2005, to grow his operation and reconnect with his roots, Huynh set up a pearl farm in his native Vietnam to harvest the Mercy Pearl in the country's coastal waters. The oysters are first enucleated with perfectly round gemstone beads such as turquoise, amethyst, garnet, citrine, and opal, then left to grow for almost a year to obtain a luxurious nacre, or exterior coating. His farm enables more production and therefore an ultimately wider dissemination of his innovative pearl technique.

Huynh's story shines with perseverance: from stranded child in war-torn Vietnam to successful American jeweler. He had a vision to bring more beauty into the world, and he has worked tirelessly to make it happen. His story also reveals the innovator's mindset. Instead of just making the last version of something a little bit better, Huynh believes true innovators blaze new trails: "No one will take you seriously unless you create your own ground. This is the difference between a good concept and a great one, between an OK design and one that is transcendent."

— *Ben Casnocha, author of* My Start-Up Life: What a (Very) Young CEO Learned on His Journey Through Silicon Valley

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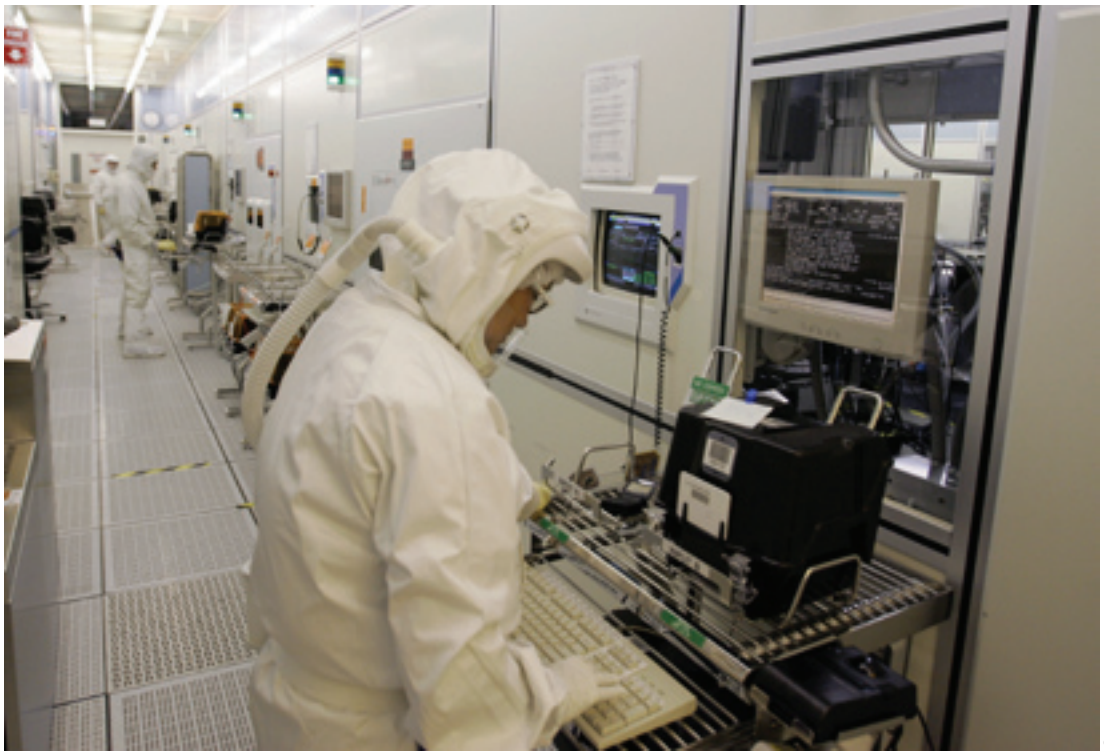
The Global Geography of Innovation

G. Pascal Zachary



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Chip maker Intel Corporation in Santa Clara, California, is one of the prominent players in the Silicon Valley cluster.

Silicon Valley and other geographic clusters of innovation emerge for practical reasons. G. Pascal Zachary is a journalist, author, and teacher who has published articles for the Wall Street Journal *and the* New York Times.

When a prominent financier in northern California raised an astonishing $1 billion in the summer of 2009 for investments in risky "green technologies," Silicon Valley reminded the world that, in the arena of innovation at least, geography is destiny.

Vinod Khosla, the venture capitalist who raised the money, embodies the critical role played by location in inventiveness and technological change. Thirty years ago, Khosla moved from his native India to attend Stanford University in California, where he studied business. On graduation in 1981, he helped found an influential computer manufacturer, Sun Microsystems. More recently, Khosla has embraced the search for alternative energy, applying the skills and connections of his adopted home to a new set of problems.

Certainly other parts of the world are pursuing innovations in alternative energy, ensuring that no one place will gain a monopoly over these emerging technologies. Yet the ability of Silicon Valley to expand into the development of visionary energy technologies is a reminder of the power of location: Innovations don't occur just anywhere, but arise most often from geographic clusters consisting of investors, major research universities, existing technology companies, and many engineers and scientists willing to try new things.

"The goal there is very much to take risks that nobody else will take," Khosla says of his new fund.

Risk taking and reinvention are central to Silicon Valley. For nearly a half century, the region has been in the forefront of innovation, first in computing and electronics, and then in software, the Internet, media, and communications. Every time Silicon Valley seemed ready to fade, surpassed by innovation centers elsewhere in the world, a fresh wave of breakthroughs helped the region maintain its top position globally.

In the 1990s, biotechnology blossomed in northern California, partly because of the role computers play in molecular engineering and pharmaceutical research. Early this decade, the rise of Google made the region the world leader in search engines. More recently, Silicon Valley spawned social-media companies such as Twitter and Facebook and open-source content movements such as Wikipedia. And the iPod and iPhone, designed and engineered by Apple in its Silicon Valley labs, have revolutionized consumer electronics worldwide.

The breakthroughs produced by innovators in northern California explain why the region receives as much as 40 percent of the risk capital invested in the entire United States. Include the Los Angeles and San Diego areas, and California receives nearly half of all venture capital some years. Getting all this money reinforces the supremacy of the region, partly because money acts as a magnet for talent from around the world.

Connecting Clusters

Even when the technical talent returns home, the pull of geography exerts a strong influence. AnnaLee Saxenian, an expert on regional innovation at the University of California, Berkeley, has shown that innovators can effectively shuttle back and forth between California and other innovation clusters, some as far away as India and Taiwan. What Saxenian calls the "new Argonauts" essentially take advantage of a geographic hierarchy connecting lower-cost production in Asia with higher-value activities in the United States and Europe.

Geographic clustering has a self-reinforcing logic. Gain an edge, and it is surprisingly hard to lose it. British historian Peter Hall has chronicled the rise of great cities in world history and attributes their persistence, in part, to the benefits of being the first to establish dominance and inward migration of talent. Just as Manchester United or Real Madrid keep assembling top football teams year after year, so can cities or regional clusters maintain an edge. Top talent wants to join a winner, after all, and by so doing, leading cities or organizations stay strong.

The implication is clear: Investors look at the address of an innovator as much as at his or her technology and résumé. A Brazilian with a better idea for electric-car batteries might be wise to include offices in Japan and Germany in his business plan. An Indian train designer should budget for frequent trips to Europe. A brilliant designer of a new microprocessor, who insists on living in Russia, is unlikely to get funding at all; if he moves to Silicon Valley, his cash register may quickly ring.

Fortunately for the people of the world, innovation clusters are fairly democratically distributed. France has important clusters in aviation, train technology, medicine, and nuclear power. Germany has been a world leader in automotive technology for 100 years. Bangalore, India, is a center for new software. Korea leads in design of "smart" electronic devices, from mobile phones to washing machines that sense the size of loads and the minimum amount of water to use. Brazil's engineers excel in designing commuter airplanes. Israel leads in security for computer networks.

Historical legacy sometimes explains why a certain geography commands a decisive advantage in a specific field. Nearly 20 years after the breakup of the Soviet Union and the end of the Cold War, Russia remains the world leader in launch technology for space travel and the center for the "space tourism" industry. Even the United States' National Aeronautics and Space Administration sometimes relies on Russian rockets to lift Americans into space.

Government also plays an important role in the innovation map. The French government has invested heavily in both train and nuclear-energy technology and, through centralized decisions, has reduced risks and removed uncertainties for innovators, improving their global competitiveness. U.S. spending on advanced electronics, often for military applications, spurred civilian innovators and partly explains why Intel has held for decades the No. 1 position among makers of microprocessors. And government policies that favored domestic producers created the environment for industrial innovations in India and aviation innovations in Brazil.

© AP Images

President Lee Myung-bak in Daejeon, South Korea, examines a prototype vehicle powered by electric power strips in the roadway.

Not Forever

While location confers important advantages to innovations, a favorable geography is no guarantee against failure. "What makes a particular city, at a particular time, suddenly become immensely creative, exceptionally innovative?" historian Hall asks in *Cities in Civilization,* his seminal study. "Why should this spirit flower for a few years, generally a decade or two at most, and then disappear as suddenly as it came?"

When a city or region loses its technological edge, the reasons may become clear only in retrospect. The decline of Detroit's automotive supremacy can be traced to technical, economic, and business decisions stretching back decades and even now poorly comprehended. Regaining lost supremacy can be very difficult, partly because new geographic centers of technological excellence can and do emerge on the world stage, seemingly out of nowhere.

Perhaps the most dramatic example in recent years is the rise of Helsinki, Finland, as a world center for mobile telephone technology. The success of a single company, Nokia, elevated Finland to the front ranks of the field and turned northern Europe, notably nearby Stockholm and Copenhagen, into a critical mobile cluster. In the 1990s, virtually every mobile innovator in the world opened offices in the cluster, drawing on local talent. The cluster also gave rise to important new telecommunications players such as Skype.

The success of Nokia — a very large innovative company in a very small country —- has inspired many other small countries and marginalized cities to dream of finding their own Nokias. Yet governments face difficulties in creating clusters from scratch. The cost of overtaking another region can be high because necessary universities are expensive to grow and essential risk capital may be unavailable.

In the 1970s and 1980s, dozens of cities around the world tried to grow their own Silicon Valleys. Most of these efforts ended up being exercises in industrial

© AFP/Getty Images

A man in Nairobi, Kenya, sends money through the innovative cell phone service M-PESA.

recruitment: enticing technology companies to locate factories or even research facilities in certain places.

Sometimes, recruitment can produce an innovation cluster over time. The island nation of Singapore, for instance, is today the world's leader in small-computer storage devices, after initially serving as a location for low-cost manufacturers of the devices. Yet Ireland, another island that attracted a large number of electronics manufacturers partly because Irish wages were low by European standards, hasn't given birth to an innovation.

Recycling Skills

Another role for government or civic associations is to take know-how and skills, which are often place specific, and apply them to new opportunities, setting the stage for a region to reinvent itself technologically. One of Silicon Valley's strengths, for instance, is finding ways to recycle older sets of technical skills or cultural norms: The electric car and sustainable energy industries are in Silicon Valley because people there have a lot of experience in battery design (because of the need for batteries in computers) and computer management of electricity grids.

The private sector remains crucial, even in places where the potential for achieving innovation leadership seems low. Consider the case of Kenya, which has given rise to one of the world's most innovative money-transfer technologies, called M-PESA. Created by the country's dominant mobile phone carrier, Safaricom, M-PESA combines the technology underlying text-messaging with the company's vast network of retailers who sell "units" to pay-as-you-go customers. Through M-PESA, people send electronic money using their phones; recipients collect actual cash from retailers who deduct units from the recipients' phone.

Partly because of the success of M-PESA, Nairobi is now home to a cluster of mobile innovators. Google, Microsoft, and Nokia employ researchers in the city, and new companies are forming around writing applications for mobile phones and the Internet.

Nairobi is not yet in the class of Bangalore or Shanghai, two cities of the developing world that support thriving communities of innovators. Yet the fact that innovation can occur even in Africa underscores a major shift toward what business consultant Henry Chesbrough calls "open innovation." Knowledge spreads more quickly than ever before, and the ability of also-ran regions to catch up to, or even leapfrog, traditional leaders surely has grown. Geography still matters greatly, but clearly not as much as before. ■

See also Ashlee Vance, "Not Just Semiconductors: Silicon Valley and the Culture of Innovation," in the May 2008 eJournal USA, *"Venture Capital Meets Hi-Tech"* [http://www.america.gov/st/econ-english/2008/May/200805121644 29jmnamdeirf0.4961206.html]

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Alicia Castillo Holley

Innovators with complementary skills can make things happen.

Courtesy of Alicia Castillo Holley

Alicia Castillo Holley

"If you want to go fast, go alone; if you want to go far, go with others," says an African proverb. If there's one thing many innovators have in common, it's that they teamed with others in order to achieve their dreams. Innovators seek help of all kinds: emotional, financial, and intellectual. They turn to partners, investors, and mentors to ask questions such as: What's the best way to make this product work? How can I raise money to further develop my idea? How do I balance my family needs with my research or entrepreneurship?

They turn to people like Alicia Castillo Holley. Born in Venezuela, Castillo Holley has spent her life co-founding nine companies and consulting with information technology and biotech companies in Latin America. As a consultant, she offers mentorship, early financing, and connections.

One early client, Directory Systems, demanded Castillo Holley's full range of innovation-advisory skills. Directory Systems was a company that matched companies holding an excess supply of mining parts and materials with companies in need of such materials. Real-time inventory tracking made this a valuable matchmaking service in the mining parts industry.

The idea was solid, but a good idea is not enough. The innovator needs a plan to execute it successfully. Directory Systems hired Castillo Holley to put in place a strategy, hire lawyers in Chile to expand the Latin America operation, and build a local prototype of the matchmaking product. She did all that and, eventually, Directory Systems was bought by a large American medical company.

"I estimate that my involvement saved the company [Directory Systems] two to four years of work and around half a million dollars," Castillo Holley says.

Castillo Holley succeeded because she complemented the founders' skill sets. They were passionate about the mining industry and supply chain databases. She was passionate about making certain business processes more efficient and brought to bear specific Latin America expertise the founders lacked.

To make an innovation work, oftentimes you have to recruit the help of outsiders whose experiences and passions complement your own. Castillo Holley says that when she works with innovators, she first tries to identify what they are passionate about. She encourages innovators to focus on those passions and then surround themselves with people who can help with everything else.

— *Ben Casnocha, author of* My Start-Up Life: What a (Very) Young CEO Learned on His Journey Through Silicon Valley

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Four Secrets of Innovation

Alex Soojung-Kim Pang

© AP Images/John Pendgraft

Scientist Stacey Reed works in Florida for PetroAlgae, which is taking to market technology to harvest oil from algae.

Scientists and business people are learning more than ever how to collaborate for innovation. Alex Soojung-Kim Pang is research director at the Institute for the Future, associate fellow at the Saïd Business School of Oxford University, and visiting scholar at Stanford University's history and philosophy of science and technology program.

In today's innovation-obsessed, knowledge-intensive global economy, it might come as a surprise that for most of their long histories, science and business have had almost nothing to do with each other. Had you suggested to a silversmith working in ancient China, a captain plying the spice trade during the Age of Exploration, or a Quaker brewer in 18th-century Philadelphia that science could improve commerce, he would have looked at you as if you were crazy. Even today, describing the relationship between science and business — and figuring out how science and industrial policy can be designed to work to the benefit of both parties — is a challenge.

The task is made difficult by two things. First, both science and business are moving targets, so what works for one may be inappropriate for the other: Vast corporate research and development (R&D) laboratories that deliver incremental improvements in mature industries are likely to sink in fast-moving emerging markets. Second, scientific ideas and talent don't work like other economic inputs: They're hard to control and monopolize. Consequently, the connections between science and industry have been hard to characterize, and the economic benefits of science harder to quantify than one might expect.

While there are plenty of examples of scientific savants

inventing things with commercial benefit — Galileo's telescope and Benjamin Franklin's lightning rod are examples — science contributed little to business until the birth of the chemical and electrical industries in the 19th century. These were the first fields in which scientists, guided by the latest theories and experiments, could make more substantive contributions than craftsmen working through rules of thumb or trial and error. By century's end, a few companies — DuPont, AEG, General Electric — had created in-house research and development labs to support new product development and solve the problems encountered by ever-growing technological systems.

The development of penicillin, radar, jet aircraft, and the atomic bomb during World War II conclusively showed that science could be harnessed for competitive advantage. After the war, most big companies created R&D labs; some, like the Bell Labs system, employed thousands of people.

© AP Images

Tesla Motors workers assemble an electric-motor Roadster in Silicon Valley, a place with long experience in battery design.

But even in this golden age of corporate research and development, it wasn't always clear how science helped the bottom line. Labs needed a measure of autonomy to do good research, but it was always difficult to bring discoveries back into product lines. In some famous cases, companies sponsored paradigm-shattering research but couldn't cash in: Xerox's Palo Alto Research Center (PARC) developed the first personal computers, but after Xerox couldn't figure out what to do with them, many of PARC's key researchers migrated to Apple Computer and its Macintosh project. (To its credit, Xerox pounced on laser printing, developed at the same time at PARC, and made billions of dollars off the technology.)

Indeed, the personal computer helped drive a new era in both science and business innovation. Along with the Internet, cheap sensors, open-source software, microfluidics used in inexpensive "lab on a chip" systems, and other technologies, the personal computer has driven down the cost of high-performance technology, made it possible for small start-ups to do cutting-edge research, and turned science into a disruptive business force beyond the control of either corporate strategy or government policy. Examples such as PARC suggest that companies would be better off supporting narrower, applied projects than sponsoring open-ended research that might ultimately benefit competitors. And what's true for companies is true for countries, too: China spends far less on research and development than the United States, but American multinationals can't build R&D labs in China fast enough.

So we seem to be entering a new age in which science is more important for innovation than ever, but is more unpredictable and harder to benefit from. In an age that values innovation, companies and countries have a harder time than ever encouraging and profiting from science.

But does that mean that science policy is now impossible? Certainly not, and successful regions and countries have learned several secrets.

Cultural Considerations

The first and biggest secret is that there is no simple linear relationship between science and business. The idea that discoveries in pure science inevitably drive advances in applied science that lead to new technologies and business is wrong. Moving ideas from the laboratory to the living room is not a mechanical process; it's a human one. It requires translators and intermediaries who can help product developers and companies see the commercial potential of new ideas. It often requires investors and entrepreneurs who can form organizations to support cutting-edge research and product development. And it requires companies able to manufacture, distribute, and market new products. Many countries have invested in universities and basic research, expecting some direct payoff; in fact, policy makers have to think in terms of building infrastructures and cultures.

© AP Images

Brazil's President Luiz Inacio Lula, at a Petrobras plant in Rio de Janeiro, holds a sample of biodiesel, a product of science and commerce.

Well-built innovation cultures don't just support innovation; they give it roots. This is the second secret: While scientific knowledge may be mobile, science-driven business is often firmly rooted in a rich matrix of local culture and craft skill. The smartest regions aren't just trying to create world-class centers for nanotechnology or alternative energy or quantum computing; not only can such ventures be outrageously expensive, but research groups organized around superstar scientists can move away when the next great offer comes along. Instead of pursuing a generic model of greatness, savvy policy makers are making more targeted bets that link cutting-edge research with local skills.

Denmark, for example, is emerging as a leading center for pervasive computing. Why? Pervasive computing — which studies how computers can be made more useful by being embedded in everyday objects — operates at the intersection of electronics, software, psychology, and ergonomics. This is a field that requires deep knowledge of how people use technologies, and Danish scientists have found that knowledge in the country's world-class design community.

Likewise, Silicon Valley is reinventing itself as a center of alternative energy by building on its long experience in battery design. It's unsexy, but the knowledge required to make laptops run half an hour longer gives electric car start-up Tesla Motors a decisive advantage. For policy makers, this suggests that it is essential to promote industries that draw on existing skills. Not only will this make new companies more distinctive and harder to steal, but it can also benefit existing industries.

Beyond the Laboratory

The third secret is that translating scientific discoveries into products is a unique talent. Science and

business are pretty different enterprises, with different skills and incentives. If they're going to work together successfully, each needs its independence. A good scientist who is brilliant at putting together grants and research groups won't automatically do well in the marketplace. For one thing, the mental drive necessary to work for years on intractable problems differs from the cognitive skills necessary to build a company.

But too often we fail to recognize that new discoveries don't easily translate into new products. For example, successful "green-tech" researchers are discovering that creating a brilliant new wind turbine design or discovering a super-efficient photovoltaic material won't change the world unless you figure out how to fit these discoveries into existing utility infrastructures, satisfy the concerns of safety regulators, drive manufacturing costs down, and convince consumers that the pain of switching technologies will be worth it. This kind of translational, systems-building activity is a talent of its own, and it requires people who can move between the worlds of science and business, identify opportunities, and build networks that turn ideas into innovative technologies.

The fourth secret is that the interconnections between science and business are growing. Until recently, science has had a big impact on manufacturing and product development, but its effect on fields such as human resources has been spottier. Now it's starting to make serious inroads in new areas. New tools in neuroscience — particularly brain scanning technology such as functional magnetic resonance imaging (fMRI) — are allowing us to see the brain as it makes decisions, looks at advertisements, or responds to other stimuli.

The vast quantities of data generated by user activity on Web sites such as Amazon.com are allowing scientists to more accurately model crowd behavior and taste. Wall Street has seen an influx of physicists and advanced mathematicians applying arcane scientific theories to model financial risk. The development of new climate models and accounting tools for assessing the costs and benefits of sustainability programs is allowing companies to better assess how going green will affect their bottom line.

Finally, a few businesses are developing innovative processes based on the way science works. The open-innovation movement, with its emphasis on sharing core intellectual resources, encouraging collaboration between far-flung partners, and informally rewarding contributors, looks a lot like a scientific community.

A Complex Relationship

So the challenge for companies and countries is to invest in businesses that combine cutting-edge science with local cultural resources; to build links between science and business, while letting each flourish; and to take advantage of emerging sciences that can help industries better understand human behavior, see the long-term impact of policy and strategy, and develop new business processes.

The relationship between science and business was never simple. Today it's becoming more complex and multifaceted, and in the process more profitable — if you know its secrets. ■

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Rael Lissoos

An innovator combines three good products into a new service.

Courtesy of Shuttleworth Foundation

Rael Lissoos

Sometimes innovation sprouts from the combination of several existing technologies. Working together, they can form something new where the sum is greater than the individual parts.

Rael Lissoos made a mark on his native South Africa taking this very approach. He produced a low-cost telecom network by combining three independent pieces of innovation: cheap Wi-Fi routers, open-source software that connects routers to form a meshed network (extending the range of single networks), and Wi-Fi phone handsets (phones that can place calls if connected to a Wi-Fi connection).

Lissoos set up the router-software-Wi-Fi handset model — called "Village Telco" — in the poor township of Orange Farm, South Africa. First, he made sure the Wi-Fi routers worked and Internet access flowed freely. Then he gave Wi-Fi phone handsets to the villagers. Ta-da! Villagers now had free access to make and receive telephone calls.

But Lissoos is an entrepreneur, not just a philanthropist. His company, Dabba, connected the local village networks to the countrywide phone network. Then he bought prepaid phone cards and sold them to villagers in pay-as-you-go form. Because the calls originate on his Wi-Fi phone network with costs much lower than normal, Lissoos can undercut other phone card sellers on price. Using the inexpensive phone card, a villager can call anyone in the country.

"What we are doing will either encourage the telecom companies to bring their prices down, or we'll continue to work toward getting Dabba to reach as many people as possible," Lissoos said last year after being honored at the Berlin Forum on Social Engineering for his work. "Either way, the right people will benefit."

To aid expansion, Dabba has partnered with Cisco, the Silicon Valley network manufacturer, to help roll out new wireless networks in different parts of South Africa and run training programs on how to configure them.

Like any innovation that disrupts existing ways of doing business — in this case, the South African telecom market — Dabba has riled existing mobile carriers and received scrutiny from the country's communications regulator. But new combinations of technology that lower costs and increase access usually beat out challengers, even when those challengers are mighty government regulators.

Rael Lissoos saw innovation in South Africa by dreaming of new ways to use old things. He's not alone. In fact, consultant Frans Johansson wrote a book on this strategy titled *The Medici Effect*. "When you step into an intersection of fields, disciplines, or cultures," Johansson wrote, "you can combine existing concepts into a large number of extraordinary new ideas."

— *Ben Casnocha, author of* My Start-Up Life: What a (Very) Young CEO Learned on His Journey Through Silicon Valley

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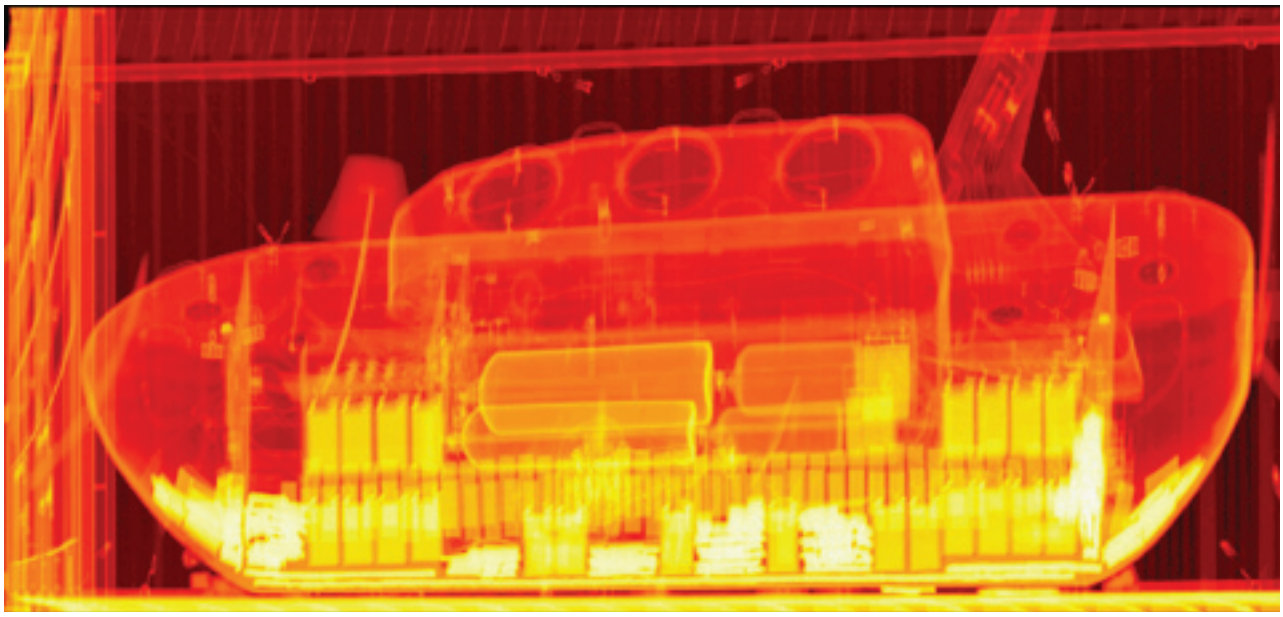
Small-Business Innovation: A Role for Government

Charles W. Wessner



Courtesy of National Science Foundation

The three-dimensional X-ray technology used to inspect this submarine cargo was developed by a small California company with an SBIR grant.

A public-private partnership helps small businesses bring their innovations to market. Charles Wessner is director of technology, innovation, and entrepreneurship at the National Academies, which comprises groups of scientific experts that give advice to the federal government.

Governments around the world are committing high-level policy attention and significant resources to the challenge of knowledge-based competition and growth. Success in this endeavor depends on effectively transforming national investments in research into competitive products for the market.

Too often, national policy reflects a belief in a linear process of innovation, one that assumes that more funds for research will lead automatically to the development and commercialization of new products for the market. Yet real-world innovation processes are normally incremental, with technological breakthroughs often preceding, as well as stemming from, basic research.

Initial capital to encourage cooperation between universities and businesses is key to this transformation. To convert research into products, the United States does not rely on free markets alone.

The Small Business Innovation Research (SBIR) program offers competitively awarded U.S. government grants to small companies and university researchers and, in so doing, signals new information about innovative products to capital markets. A proven program, SBIR is increasingly being adopted and adapted around the world as a means to accelerate innovation and augment the return on national investments in education and research.

COMPLEXITY, COLLABORATION

Innovation is a complex process, often involving cooperation among multiple participants across an economy. Successful efforts to bring new ideas to the

market are most often the result of highly collaborative processes that blur the lines between basic and applied research and the development and commercialization of new technologies. This means that to encourage innovation, we need to identify and remove obstacles to cooperation among scientists, research administrators, entrepreneurs, financiers, and other participants in the knowledge economy. And to encourage such cooperation, it is important to provide appropriate incentives.

It is useful to link cooperating participants together in an innovation ecosystem, a concept that highlights the connections among the many efforts involved in bringing innovation to market. These efforts include those organized within, as well as collaboratively across, large and small businesses, universities, and research institutes and laboratories. They also include business investment "angels," state government funds, venture capital firms, and financial markets. Innovation ecosystems themselves can vary in size, in composition, and in their impact on other ecosystems.

This need for collaboration calls for intermediating institutions that successfully align individual self-interest with the broader objective of bringing a new technology to market. In some cases, hidden or missing information can preclude successful coordination. For example, potential sponsors may not understand an entrepreneur's vision of a new commercial concept. In other situations, some individuals may be motivated to free-ride on the contributions of others or fail to share resources equitably with others, leading to a breakdown in cooperation. Where knowledge is "slippery," potential investors may not be able to recoup their capital in developing a new idea. In such cases, rules concerning the protection of intellectual property can encourage the collaboration needed for innovation.

Courtesy of National Aeronautics and Space Administration

NASA's Glenn Research Center in Ohio awarded an SBIR grant to a small Ohio company that specializes in metalworking and heat simulation.

Institutions are the rules that shape human behavior. These include, most generally, rules that protect property and the regulations and incentives that structure capital, labor, and financial and consumer markets. Rules governing competition also condition the operation of markets. Antitrust rules, for example, prevent participants with significant market power from restricting the entry of newcomers with innovative ideas.

Innovation ecosystems are also shaped by shared social norms and value systems, especially those concerning attitudes toward business failure, social mobility, and entrepreneurship.

Within an innovation ecosystem, specifically designed programs that shape incentives for entrepreneurs to seize opportunities, take risks, and collaborate with others in turning new research ideas into products for the market are critical.

From Promise to Product

Although small, innovative businesses increasingly are recognized as major drivers of high-technology innovation and economic growth, they often face challenges in bringing their ideas to market. One major challenge concerns the availability of capital, especially at the early stages of a technology's development.

Because new ideas are by definition unproven, the knowledge that an entrepreneur has about his or her innovation and its commercial potential may not be appreciated fully by prospective investors. The term "valley of death" has come to describe the period of transition from when a developing technology is deemed promising but too new to validate its commercial potential, until the time that it can attract the capital necessary for its continued development.

The presence of such information asymmetries means that inherent technological value does not lead inevitably to commercialization; many good ideas perish on the way to the market. Even capital markets in the United States, widely believed to be broad and deep, often fail to identify promising entrepreneurial ideas and finance their transition to market.

In 2008, venture capitalists in the United States invested $28 billion over the course of 3,808 endeavors. However, more than two-thirds of venture capital in the United States was directed to firms in the later stages of development that year, and only 5 percent of venture funding was directed to the earliest, or "seed," stage of funding. Market cycles can exacerbate the challenges of obtaining early-stage capital. The financial crisis of 2009 has led venture capital investors to retrench, favoring even more strongly ventures closer to market over those in the early stages of development.

SBIR Program

To help new firms cross the valley of death, the U.S. Small Business Administration initiated in 1982 its Small Business Innovation Research program. This public-private partnership provides competitively awarded innovation grants and contracts to small businesses with technologies that show promise and commercial potential, thus helping them grow and develop new products that help government agencies address a variety of national missions.

SBIR is funded by a set-aside, or "tax," of 2.5 percent on the external research and development budgets of 11 U.S. government agencies. Each year these agencies identify various research and development topics — representing scientific and technical problems related to their missions that require innovative solutions — for pursuit by small businesses under the SBIR program. These topics are bundled together into individual agency solicitations — publicly announced requests for SBIR proposals from interested small businesses — that are placed on a Web site.

Any small business can identify a topic that it is capable of pursuing from these solicitations and propose a project for an SBIR grant. Each of the 11 agencies then selects, through a two-phase competitive process, the proposals that most closely meet its selection criteria, and it awards contracts or grants to the proposing small businesses. Typically, about 20 percent of the proposals submitted are accepted each year. This tough competition weeds out weak ideas; proposals have to show technical feasibility and commercial potential.

The high standard of this selection mechanism means that being awarded an SBIR grant acts as a certificate

2009 Innovation Index Country Ranking

1. Singapore
2. South Korea
3. Switzerland
4. Iceland
5. Ireland
6. Hong Kong
7. Finland
8. United States
9. Japan
10. Sweden
11. Denmark
12. Netherlands
13. Luxembourg
14. Canada
15. United Kingdom
16. Israel
17. Austria
18. Norway
19. Germany
20. France
21. Malaysia
22. Australia
23. Estonia
24. Spain
25. Belgium
26. New Zealand
27. China
28. Cyprus
29. Portugal
30. Qatar
31. Hungary
32. Czech Republic
33. Slovenia
34. South Africa
35. Bahrain
36. Slovak Republic
37. Chile
38. Italy
39. Malta
40. Lithuania
41. Tunisia
42. Greece
43. Latvia
44. Thailand
45. Mauritius
46. India
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49. Russia
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Source: The Boston Consulting Group and National Association of Manufacturers

of quality — a positive signal to private investors of the technical and commercial promise of the technology. In this way, the SBIR program helps overcome the information gaps between the small-business entrepreneur and a potential financier, thus bridging the valley of death and encouraging cooperation across the innovation ecosystem.

Foreign Adoption

The U.S. innovation system is market oriented, but its operation is strengthened by policies and programs that provide the initial capital necessary to encourage more entrepreneurial participation, which creates and signals more information for prospective investors or public procurement agencies. The Small Business Innovation Research program is a positive example of a competitive program that creates new companies, provides new low-cost solutions for government missions, and generates novel applications for government research.

Recognizing the advantages of the SBIR concept, governments around the world are undertaking similar programs to encourage entrepreneurship and innovation. Finland, Sweden, and Russia have adopted SBIR-type programs. The United Kingdom has a program similar in concept. Following a successful pilot, the Netherlands has expanded such a program across its government ministries. Japan, South Korea, and Taiwan have also adopted the SBIR concept, with varying degrees of success, as a part of their national innovation strategies. And India has recently adopted an SBIR-type program to advance its biotechnology sector. This level of emulation across national innovation systems is striking and speaks to the common challenges addressed by SBIR awards and contracts.

While national innovation systems differ in scale and flexibility, policy makers around the world face similar challenges in stimulating innovation. They have to address the challenge of expanded global competition by becoming more innovative and productive, while justifying research and development expenditures by creating new jobs and new wealth. Innovation programs such as SBIR can help transform these national investments in research more effectively into competitive products for the market. The SBIR concept has proven to be highly adaptable to a variety of national innovation systems and is an example of global best practice in innovation policy. ■

The opinions expressed in this article do not necessarily reflect the views or policies of the U.S. government or the National Academies.

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56. Jordan
57. Mexico
58. Turkey
59. Lesotho
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67. Albania
68. Azerbaijan
69. Sri Lanka
70. Morocco
71. Indonesia
72. Brazil
73. Vietnam
74. Colombia
75. Armenia
76. Macedonia
77. Georgia
78. Ethiopia
79. Jamaica
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81. Kyrgyz Republic
82. Honduras
83. Moldova
84. Pakistan
85. Algeria
86. Paraguay
87. Mongolia
88. Nigeria
89. Uruguay
90. Uganda
91. Burkina Faso
92. Argentina
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109. Burundi
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Government and Innovation

James P. Andrew

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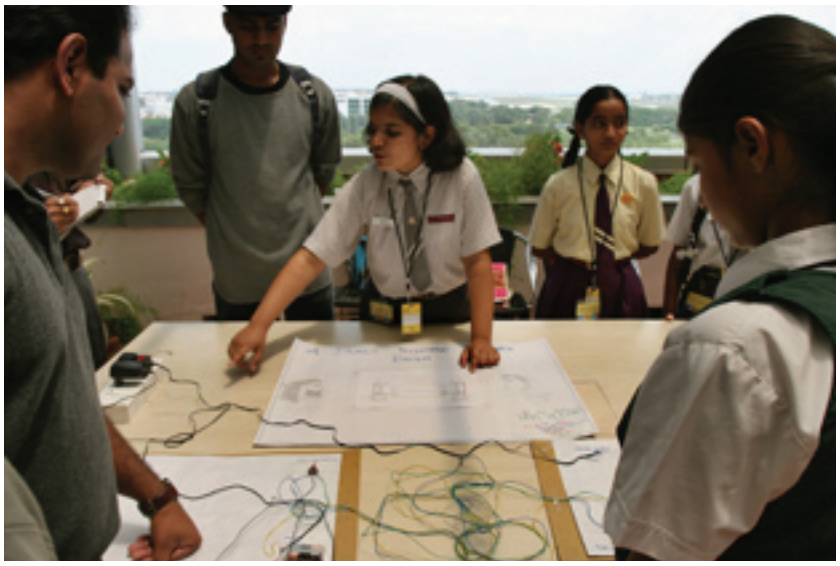
Sacramento, California, high school senior Anthony Beanes works on a three-dimensional animation project, part of his vocational training.

Effective governmental policies can have a positive impact on domestic companies' ability to innovate. Consistent government policies that address workforce quality, the payback from innovation, and the ease of utilizing the results of governmental efforts will have the biggest impact. James P. Andrew, a senior partner and managing director in the Chicago office of the Boston Consulting Group (BCG), leads the firm's innovation practice. He welcomes inquiries at andrew.james@bcg.com.

Much has been written about innovative companies and what sets them apart. Less obvious is the role that government can and does play to create the conditions for success. A recent report by BCG, in conjunction with the National Association of Manufacturers, highlights the interdependence of government and business and the mutual need for innovation leadership.

A critical driver of growth, competitiveness, and shareholder value, innovation is cited by senior executives around the world as integral to their company's success. But innovation benefits countries, too. Those with thriving industries have higher incomes, a better quality of life, and a higher standard of living than their less-robust peers.

The need to stay one step ahead of the competition is even more urgent in today's global economy. The emergence of companies from low-cost countries such as India, China, Brazil, and Eastern Europe has transformed the playing field. With good, cheap products flooding the market from every corner of the globe, competing on cost alone is a losing battle for most businesses. To stay in the game, companies must differentiate themselves through



© AP Images/Aijaz Rahi

IBM's Bangalore, India, headquarters holds a camp for innovative students to promote education in science, mathematics, and engineering.

innovation: new products and services, new ways of working, new ways of going to market. And governments must support these innovation efforts through effective policies.

Strengthen the Workforce

A skilled, educated workforce is the most critical element of innovation success, yet finding quality talent is an ongoing challenge for companies. Governments can improve workforce quality by investing in effective education and making sure that immigration policies support, rather than hinder, innovation.

While wholesale education reform is a lengthy process and the full impact may not be felt for many years, some educational and workforce development reforms are available much more quickly. For example, better integration of academic and technical education in secondary schools can ensure that graduates are ready for work or college. When professional and technical programs are aligned with industry needs and standards, students gain industry-recognized credentials and companies gain skilled workers. In addition to education policies, less restrictive immigration policies can strengthen the workforce. Skilled immigrants can improve the innovation climate of a country. A 2009 survey by the National Bureau of Economic Research found that states with more skilled immigrants had more patents among immigrants and the native-born alike. Everyone benefited.

Boost the Payback

Companies must be able to earn a return on their innovation efforts. If not, they'll either stop investing or relocate to a different state or country where they can make more money. Governments can help lower costs and boost profits by enforcing strong protection for patents, copyrights, and other intellectual property and by providing tax breaks, skills training, and policies that lower structural costs related to fiscal policy, regulation, and energy.

Research and development (R&D) tax credits are the most common way to lower innovation costs. The recent BCG/NAM report demonstrated a strong positive relationship between R&D tax programs and national economic performance. Of the top 20 developed economies as measured by gross domestic product, 19 have R&D tax relief programs. Interestingly, the absolute amount of the tax credit was less important.

Supporting revenue streams is also important. Most countries have policies to register and protect intellectual property. Losing the rights to an invention or product because of country policy or poor enforcement is a top issue for business executives and can lead to loss of revenues. Faced with this risk, companies are likely to take their innovation activities elsewhere.

Be Consistent

Innovation takes time and careful planning. Companies will innovate more when they can count on government support being there tomorrow and for years to come. To be effective, policies and tax benefits must be consistent and reliable over the long haul, since some innovation investments can take up to a decade to bear fruit.

Other policies — such as education and workforce environment — can take even longer to come to full fruition. Governments must stay the course until these policies deliver results. Given how long the innovation process can take, consistency of support and continuity of policies are critical.

Make Innovation Easier

Governments can improve the ease and efficiency of developing and commercializing ideas through research and better access. All governments, particularly those with limited funds, will find it advantageous to engage in partnerships with businesses, nonprofit organizations, and educational institutions to increase the scale of operations and attain greater results. Although U.S. universities and government agencies fund a great deal of innovative science, business executives tell us that accessing these resources is very difficult.

Governments need to ask what companies need and how they can help — and listen to the answers.

Promote Cluster Development

Clusters are groups of related, interdependent companies within the same industry that are concentrated in a geographic area. By attracting or creating groups of manufacturers in specific industries, governments can help drive innovation performance and, if they make the right choices, sharply improve their country's economy. This approach can be particularly effective for smaller countries and individual states. For large countries, clusters are relatively less important because any one cluster may be too small on a relative basis, at least initially, to have a meaningful impact.

Although small countries can make bets in specific industries to kick-start innovation (and growth more broadly), such a strategy is not without risk. Concentrated economies, no matter how successful they are for a time, ultimately rise and fall based on the results of a limited number of industries. Some notable recent collapses offer cautionary tales. It's a high-risk, high-reward policy.

Lead by Example

Vocal and visible support — in the form of R&D funding, tax credits, policy changes, and so forth — sends the message that innovation is important. Make innovation a common cause, for the greater good of all. Countries such as South Korea, China, and Singapore, whose governments publicly and actively support innovation, are attracting an increasing share of the world's innovators and innovation.

These actions closely align the mutual interests of companies and governments, helping governments more effectively serve their constituents. For countries that want to encourage innovation, it's time for all levels of government to make innovation a top priority and prove their commitment with concrete action. The stakes couldn't be higher — nothing less than global competitiveness, secure jobs for their people, and a higher quality of life. ■

See also Steve Strauss, "Government's Role in Encouraging Small Business," in the January 2006 eJournal USA, *"Entrepreneurship and Small Business"* [http://www.america.gov/st/econ-english/2008/July/20080814221735XJyrreP0.4618189.html]

The opinions expressed in this article do not necessarily reflect the views or policies of the U.S. government.

Paul Nelson, left, of Allied Vehicles in Glasgow, Scotland, works on a Peugeot electric auto project supported by the government.

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Michael Bremans

A Belgian innovator comes up with a way to make a clean profit.

Courtesy of Michael Bremans

Michael Bremans

Can you do well by doing good? Can a successful innovation generate lots of profit for the inventor and also make a positive contribution to the environment? For Mick Bremans, a Belgian innovator, the answer is yes.

Bremans is chief executive officer of Ecover, which produces domestic cleaning products made of natural plant and mineral ingredients. The products compare to others in the industry in both quality and price; where they differ is their environmental friendliness. Ecover's liquid soaps, washing powders, and detergents do not contain environmentally harmful phosphate or chlorine, and they all come in recyclable polyethylene bottles.

An eco-friendly line of products appeals to environmentally conscious consumers, a growing subset of the population. High appeal, of course, means high sales, which means more profit for Ecover ($15 million in 2007). Everybody wins: the innovator, the consumer, and Mother Nature.

The story would be different if Bremans's products were sub-par or more expensive. A mediocre product with a "green" label is not enough for consumers. A good product but one that's more expensive will also not succeed, despite a green label. Consumers want comparable quality and price and eco-friendliness. For companies, this is not easy to do. Usually, making a product out of nature-friendly materials costs more, which drives up the final product price for consumers. So the green companies that succeed must run very efficient operations.

Bremans, who in 2008 was named a Hero of the Environment by *Time* magazine, believes that decentralizing decisionmaking in an organization leads to more efficiency and more innovation.

"Innovation must live and breathe throughout the modern organization," Bremans says. "This involves all levels — even factory workers. Besides, who understands flows, processes, machines, and products better than the people working with them on a daily basis?"

Capturing the ideas and insights of all employees may seem obvious, but it hasn't always been that way at Ecover. When Bremans came on board, the setup was more traditionally hierarchical: "When I joined Ecover, it was primarily the research department that came up with new ideas of what the company should be doing. Today, every department plays a part in growing the business."

Ecover is therefore an example of innovation not only in the environmentally friendly products it produces, but also in the processes that promote efficiency and cost savings.

Now in 26 countries, Ecover's success shows that it really is possible to do well, do good, and be innovative — all at the same time.

— *Ben Casnocha, author of* My Start-Up Life: What a (Very) Young CEO Learned on His Journey Through Silicon Valley

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Intellectual Property Rights and Innovation

Michael A. Gollin

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Employees sort AIDS medicine at a lab in Port Elizabeth, South Africa, a country that opposes strong patents for such medicine.

An effective system for protecting patents, copyrights, and other intellectual property promotes innovation by balancing exclusive rights with accessibility. Michael Gollin is a partner with the Venable LLP law firm in Washington, D.C., chairman of Public Interest Intellectual Property Advisors, and author of Driving Innovation: Intellectual Property Strategies for a Dynamic World.

Innovation feeds on the known and converts it into the new. Creative people successfully build old ideas into new ones, put them into practice, and build on them again. Innovation challenges the establishment, creating winners and losers, and causes many ventures to fail.

The tumultuous developments in communications and genomics, the spread of cell phones, AIDS medicine, popular music, and textbooks all share the fundamental dynamics of this innovation cycle.

The United States recently announced a national innovation strategy, joining a growing group of countries seeking to harness innovation to serve their national interest. An effective innovation strategy must focus on the most important, but least understood, of the forces driving innovation — the complex system of institutions, laws, and practices referred to as intellectual property (IP).

IP rights include patents, copyrights, trademarks, and trade secrets, each of which is subject to separate laws in every country. IP laws evolved over centuries as a tool to derive public benefits from the innovation cycle. Because it is so tightly linked to innovation, intellectual property holds a key to our future.

Intellectual property rights apply to innovative endeavors as diverse as computer technology, pharmaceuticals, agriculture, music, and publishing. IP systems capture, channel, and shape innovation. In an effective, well-balanced IP system, exclusive rights serve as incentives that amplify the innate human will to create.

That exclusivity also establishes a framework for collaboration and investment in creative ideas to push them out into society. But the exclusivity and control available to creators and their investors is carefully limited so that other people can access and build on new products and ideas, and the innovation cycle can move forward.

A balanced IP system promotes innovation. Innovative companies rely on their own IP rights, and their ability to steer around the rights of others. If exclusivity is too weak or too strong, imbalances in the IP system can limit innovation and its benefits.

Finding Balance

IP rights have expanded from wealthier countries into poorer countries over the past decade. But extensive research, debate, reform, and training about intellectual property in recent years show no signs of leading to a global consensus on the impact of current IP systems on human welfare, much less how potential reforms would help or hurt larger society.

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Sweden's Pirate Party advocates free music file-sharing and no patents.

When Venice's leaders passed the first patent law in 1474 with 116 votes, there were 10 votes against it. In the late 19th century, there were fierce debates about whether countries should join the first round of international IP treaties established at that time, and entrenched groups argue today both for and against stronger IP rights.

The inevitable tendency of IP systems to go out of balance explains the intense and ongoing debates about IP rights over the years. Patient advocates in Brazil, South Africa, and elsewhere argue that patents on AIDS medicines are too strong to permit fair access to existing drugs, while drug researchers counter that weaker patents would destroy the incentive to invest the fortunes necessary to discover new drugs. Unlicensed software, music, and videos are downloaded freely on the Internet, to the dismay of industry. Meanwhile, the sudden rise of the Pirate Party in Swedish politics, with its platform of free music file-sharing and no patents, shows that we can not predict the future of IP rights with any confidence.

To illustrate why IP systems tend to get out of balance, imagine a simple society including you and me. You want free access to my innovations (with no IP restrictions), but you want to limit my access to yours (with strong exclusivity). I want free access to your innovations, but I want exclusive control. If I invent a new drug and you record a new song, you want to use my drug and I want to listen to your song. We could try to block each other out by keeping the innovation secret. But we would have problems attracting investors, and we might not innovate again.

There is an inherent conflict between our opposed desires — for exclusivity over our own innovations and for access to the other person's. We might be able to make a deal with each other; then again, we might not. The only certain resolution makes neither of us completely happy, but works for society: The win-win outcome is a balanced IP system, with each of us being able to obtain limited exclusivity as innovators, and with limited access assured as well.

Balancing IP systems make sense in a world with globalized innovation. For example, movies are produced in Hollywood, Bombay (Bollywood), and Nigeria (Nollywood). Hollywood producers advocate for stronger enforcement of copyright overseas because the uncontrolled duplication of hit movies undercuts their profits. But it is not very convincing for them to argue, in essence: "Protect my rights in your country because it is good for me." There is a more persuasive argument: "Support an effective, balanced system of IP rights because it will help you."

Indeed, I have spoken with both Indian and Nigerian movie producers who, too, are protesting the rampant piracy of their movies — in stores in the United States! There is a global interest in a balanced IP system that promotes innovation everywhere.

Whether for life-saving drugs or cultural expressions such as music and movies, an effective IP system includes mechanisms to balance access and exclusivity, case by case. The legal and procedural details differ for each type of innovation, for each type of IP right, and in each country, but the common thread is that there are ways for innovators to gain exclusive rights, and paths for

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The U.S. film *Spider-Man 3* opens in India; film producers in both countries want stronger foreign enforcement of copyright.

others to gain access to the innovations protected by those IP rights, including negotiation and legal proceedings. Unfortunately, these mechanisms can be very expensive and frustrating. Hence, companies and organizations working within the system seek greater efficiency as part of an effective IP system.

Expressing Individual Choice

Intellectual property rights can be viewed as instruments of competitiveness and economic growth, with patenting and trademark activity linked to gross domestic product. But IP systems can also be seen as instruments by which innovators express individual choices regarding their creations. In this light, intellectual property contributes not only to commercial interests, but also to human development — freedom of choice in personal expression and how we lead our lives. One author may be happy to give an open-access license to her work on Wikipedia, but another may choose to publish a copyright-protected article. Innovators should have that choice.

Innovation and IP laws have always created winners and losers and always will. This is, of course, unsettling. But rather than choosing the winners, government's role should be to ensure that the IP system maintains an effective balance between the freedom of an innovator to exclude others and the freedom of others to access the innovation. An IP system can provide a higher degree of individual freedom, and more competition, than a centralized system of grants, incentives, and prizes awarded by governments and philanthropies. Centralized systems can drive innovation in a particular state-sanctioned direction, but at the cost of individual choice and flexibility.

The inventor's enthusiasm, the author's pride, the entrepreneur's confidence, competition — these are forces we can build on with innovators around the world. In doing so, we must meanwhile ensure that people of all walks of life can enjoy access to the fruits of innovation in medicine, food, information, entertainment, and education. ■

See also Focus On: Intellectual Property Rights, *a publication of the Bureau of International Information Programs* [http://www.america.gov/publications/books/ipr.html]

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Additional Resources

Books, articles, Web sites, and films on innovation

Books and Articles

Aguirre, DeAnne, Laird Post, and Sylvia Ann Hewlett. "The Talent Innovation Imperative." *Strategy and Business*, no. 56 (Autumn 2009): pp. 38-49.

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Web Sites

Foreign Policy Research Institute
Program on Teaching Innovation
Addresses the history of innovation from economic, scientific/technological, and sociological perspectives.
http://www.fpri.org/education/innovation/

Innovation and Economic Growth: Lessons From the Story of ENIAC
Audio lecture from electronics pioneer Rocco Martino on how the computer became the catalyst for the largest increase of international wealth in history.
http://www.fpri.org/multimedia/20090309.martino.eniac.html

Innovation — Life, Inspired
Companion Web site to Public Broadcasting System's 2004 television series.
http://www.pbs.org/wnet/innovation/

Innovation Timeline
Traces innovations from the invention of fire.
http://www.wired.com/culture/geekipedia/magazine/geekipedia/innovation

Jerome and Dorothy Lemelson Center for the Study of Invention and Innovation
Established at the National Museum of American History of the Smithsonian Institution to document the stories of innovators and their discoveries.
http://invention.smithsonian.org/home/

What Matters: Innovation
McKinsey & Company site featuring essays by researchers, academics, journalists, policy makers, and executives on big questions.
http://whatmatters.mckinseydigital.com/innovation

Filmography

ABC's Nightline: If You Can't Beat 'Em, Blog 'Em (2005)
http://ffh.films.com/id/12407/If_You_Cant_Beat_Em_Blog_Em.htm
Summary: Examines the blogger community, reviews major news stories that were broken by bloggers,

demonstrates ways in which blogging differs from traditional reporting methods, and presents interviews with individuals who have used their personal blogs in innovative ways.
Running time: 22 minutes.

Masters of Technology (2004)
http://shop.wgbh.org/product/show/10160
Producer: WGBH Boston (Public Broadcasting System)
Summary: A series of one-on-one conversation, with exceptional men and women who have made a significant impact on technology.
Running time: Five parts, 30 minutes each.

October Sky (1999)
http://www.imdb.com/title/tt0132477
Director: Joe Johnston
Summary: The true story of Homer Hickham, a coal miner's son who developed an interest in rocketry after he was inspired by the Sputnik launch. With a group of friends, he experiments with rockets they build themselves, and they are encouraged by a teacher to enter the National Science Awards competition.
Running time: 108 minutes.

Swiss Family Robinson (1960)
http://www.imdb.com/title/#0054357/
Director: Ken Annakin
Summary: The heroic tale of a shipwrecked family on a deserted island that uses teamwork and ingenuity to overcome the obstacles of nature and transform their new home into a "civilized" community.
Running time: 126 minutes.

Ten9Eight: Shoot for the Moon (2009)
http://ten9eight.com
Director: Mary Mazzio
Summary: Inspirational stories of several teens from low-income communities who competed in the Oppenheimer Funds/NFTE National Youth Entrepreneurship Challenge 2009.
Running time: 85 minutes.

They Made America (2004)
http://www.pbs.org/wgbh/theymadeamerica/
Producer: Public Broadcasting System
Summary: Profiles 12 American innovators whose ideas and entrepreneurial spirit gave birth to commercial milestones such as the steamboat and cultural touchstones such as the Barbie doll.
Running time: Four parts; 60 minutes each.

The U.S. Department of State assumes no responsibility for the content and availability of the resources listed above. All Internet links were active as of November 2009.

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