Introduction

Many manufacturing companies that once flourished in the United States have succumbed to overseas competition or have relocated much of their activity abroad. Domestic employees of U.S. companies make few of the ubiquitous objects of daily life—most of the clothes and shoes that Americans wear, their furnishings, children's toys, TV sets, phones, and computers are produced by foreign companies, typically in foreign factories. Even the ships and containers that carry these goods to the United States most often come out of overseas shipyards and factories.

Now services appear to be reprising the journey of manufacturing. Just as the manufacturing exodus started with the low-wage, relatively unskilled work of assembling trinkets or stitching clothes, the offshoring of services started with data entry, routine software programming and testing, and phone banks that answer customers' questions (with varying degrees of success) or make telemarketing calls. At a later stage, overseas manufacturing went high end, producing numerically controlled machine tools, robots, and high-performance automobiles, for example. In a similar way, the offshoring of services has expanded to include what Peter Drucker called "knowledge work." Companies such as Microsoft are offshoring software architecture, not just low-end programming.[1] Overseas workers with advanced degrees are analyzing financial statements, testing trading strategies, designing computer chips, and reading X-rays for U.S. clients.

Most significant, in the eyes of some, is the offshoring of R&D. According to a cover story in *BusinessWeek,* when Western companies farmed out manufacturing in the 1980s and 1990s, they promised to keep "all the important research and development" in-house. That pledge has now become "passé." Companies such as Dell and Motorola are buying "complete designs" from Asian manufacturers. While electronics is "furthest down the road," the "search for offshore help" is "spreading to nearly every corner of the economy" as U.S. companies find that their current R&D spending "isn't yielding enough bang for the buck." While outsourcing may reduce costs in the short run, *BusinessWeek* cautions, Western companies could "lose their technology edge" as their Asian contractors move up the "innovation ladder."[2]

■ The Fear of Flatness

Compared to imports of manufactured products, the offshoring of services, particularly of R&D, is still small in terms of dollar amounts and number of jobs. Nevertheless, the phenomenon has touched a nerve. Television programs such as the Lou Dobbs show, Thomas Friedman's best-seller *The World Is Flat*, the New Jersey State Legislature (which sought to keep government agencies from offshoring services), the presidential campaign of John Kerry, the Economic Report of the President in 2004, the National Science Foundation, and several distinguished academics have all weighed in on the issue.

The offshoring of services attracts attention because the media are sensitive to its consequences. To imagine their jobs threatened by offshore labor has been a shock to college-educated knowledge workers, including those in the media, who expect to avoid prolonged involuntary unemployment and to earn a good living.* Knowledge workers are also the consumers likely to watch news network channels and read high-toned books and newspaper columns. Naturally, TV shows, books, and columns cover the interests of their core audiences.

* Many of the manufacturing workers whose jobs migrated overseas didn't expect secure high-paying jobs. High-paying employment for the long haul offered by unionized steel and automobile companies was never the norm in industries such as apparel and footwear. Moreover, job losses (or wage cuts) in manufacturing aren't always newsworthy: employment and incomes have long been uncertain, with or without imports, because of productivity improvements and cyclical downturns.

Besides menacing an influential class, the rise of offshoring up the so-called value chain—from telemarketing, to tele-radiology, to cutting-edge R&D—has raised concerns about the long-term prosperity of the United States. Many worry that the country's lead in science and technology, which they believe mitigated its loss of low-end manufacturing jobs, will erode as R&D relocates to low-cost locations. Harvard economist Richard Freeman warns that "American technological competitiveness" could soon be threatened "as large developing countries like China and India harness their growing scientific and engineering expertise to their enormous, low-wage labor forces."[3]

How should the United States prepare for what the blue-ribbon Committee on Prospering in the Global Economy of the 21st Century calls a "gathering storm"? One answer, given by a group that includes Ross Perot, Pat Buchanan, Lou Dobbs, and members of the New Jersey and other state legislatures, is America-first protectionism. A historical populist response to threats from overseas has been to throw up barriers, but that reaction fell out of favor after the Smoot-Hawley Act of 1930—which squeezed trade by raising tariffs on imported goods—is thought to have helped turn what might have been a recession into the Great Depression. Protectionism has now made a comeback of sorts, sometimes in the guise of demands for level playing fields that unfair traders abroad have allegedly tilted. This neoprotectionism has resonated with unexpected groups: a September 2007 *Wall Street Journal*/NBC poll found that a majority of Republican voters believed free trade was bad for the U.S. economy.[4]

Another, apparently more progressive, answer is given by the Committee on Prospering in the Global Economy, formed by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. Its prescription: more spending on science and technology. Specific recommendations include increasing federal outlays on long-term basic research by 10 percent a year for the next seven years; new research grants for outstanding early career researchers; a National Coordination Office for Research Infrastructure; 25,000 new undergraduate scholarships to U.S. citizens earning undergraduate degrees at U.S. institutions in the sciences, engineering, and math; 5,000 new graduate fellowships; the addition of 10,000 science and math school teachers; tax credits for employers who make available continuing education to practicing scientists and engineers; and automatic work permits for international students who receive doctorates in science and engineering in the United States.

Much of the establishment, Democratic and Republican, has embraced this "techno-fetishism and techno-nationalism" (to borrow terms from Ostry and Nelson).[5] Its advocates assert that prosperity requires continued leadership in cutting-edge science and technology. According to Thomas Friedman, in the "new era of globalization" people have the tools to "compete, connect and collaborate from anywhere." In such a world, the United States must "do whatever can be done first. It matters that Google was invented here." In language that might characterize predations in a high-security penitentiary, Friedman asserts: "What can be done will be done by someone, somewhere. The only question is whether it will be done by you or to you."[6]

Although their popularity in the mainstream is recent, techno-nationalist prognoses and prescriptions aren't new. Just as doomsday prophets rue the migration of services abroad today, a previous generation sounded similar calls about manufacturing and offered similar palliatives. In 1984, for instance, presidential candidate Walter Mondale said the United States was in danger of becoming a nation of burger flippers. A prize-winning article in the *Harvard Business Review* argued that the United States was "managing" its way to economic decline. A 1983 presidential commission declared: "Our Nation is at risk. Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world." The commission noted that the Japanese made automobiles more efficiently than did Americans, that the Koreans had recently built the world's most efficient steel mill, and that American machine tools, "once the pride of the world," were being displaced by German products. The commission's recommendations to counter the loss of this edge included a high school curriculum that included three years of math, three years of science, and one-half year of computer science. In a similar vein, some scholars in the 1980s attributed the lagging performance of the U.S. economy to the existence of too many lawyers and too few engineers and scientists, offering Japan and Germany as examples of better occupational ratios.*

As it happened, the United States prospered while the Japanese and German economies slackened. And it wasn't because the warnings were

* I was lucky to avoid the Japan-mania: in June 1981, I coauthored a *Wall Street Journal* op-ed titled "The Crucial Weaknesses of Japan Inc.," in which I pointed out that the much vaunted consensual Japanese system also limited the dynamism of its economy.

acted upon. There was no great improvement in math and science education in high schools. Enrollment in law schools remained robust, and managers continued to increase their share of overall employment. The U.S. share of scientific articles, PhDs in science and engineering, and patents continued to decline. The service sector (including hamburger chains) continued to expand, and manufacturing employment continued to stagnate.

All the while, new best-sellers continually "warn[ed] the American public of dire consequences of losing the 'race' for the 21st century."[7] And this was while the Japanese and the continental European economies were slowing and *before* the takeoff of the Chinese economy entered the public consciousness.

Of course the United States can't count on the same ending to every episode of the Losing Our Lead serial. The integration of China and India into the global economy is a seminal development, unprecedented in its scale. Could it be different this time? Is the United States finally on the verge of being pummeled by a technological hurricane? In my view, apprehensions about the offshoring of R&D and the growth of scientific capabilities in China and India arise from a failure to appreciate the complex nature of the modern innovation system and its interactions with globalization. Techno-nationalists, I argue, have a narrow conception of innovation and its relationship to globalization. Less simplistic analyses of the complex realities lead to a completely different prognosis.

■ A Complex, Multiplayer Game

Almost everyone agrees that technological innovation plays a crucial role in sustaining prosperity. Similarly, few deny the significance of globalization or doubt that technological innovation affects globalization and vice versa. But both technological innovation and globalization are complex, and they interact in complex ways. This complexity makes their effects on each other and on a nation's prosperity a challenge to understand. We must be careful to formulate policies that sustain rather than undermine economic prosperity by, for instance, favoring one form of innovative activity over another.

The difficulty of defining technological innovation reveals the great diversity of its forms.[8] To expose the nature of this diversity and understand its implications, I first, paradoxically, need to simplify. Therefore, I divide

the many forms of innovation into two categories, new *products* and the new *know-how* upon which they are based,* and further stratify both know-how and products into three levels, as I explain in the following.

For any new product, the underlying know-how ranges from *high-level* general principles, to *mid-level* technologies, to *ground-level* context-specific heuristics or rules of thumb. In microprocessors, for instance, high-level know-how includes the laws of solid-state physics; mid-level, the circuit designs and chip layouts; and ground-level, the tweaking of conditions in a specific semiconductor fabrication plant to maximize the quality and yield of the microprocessors produced.

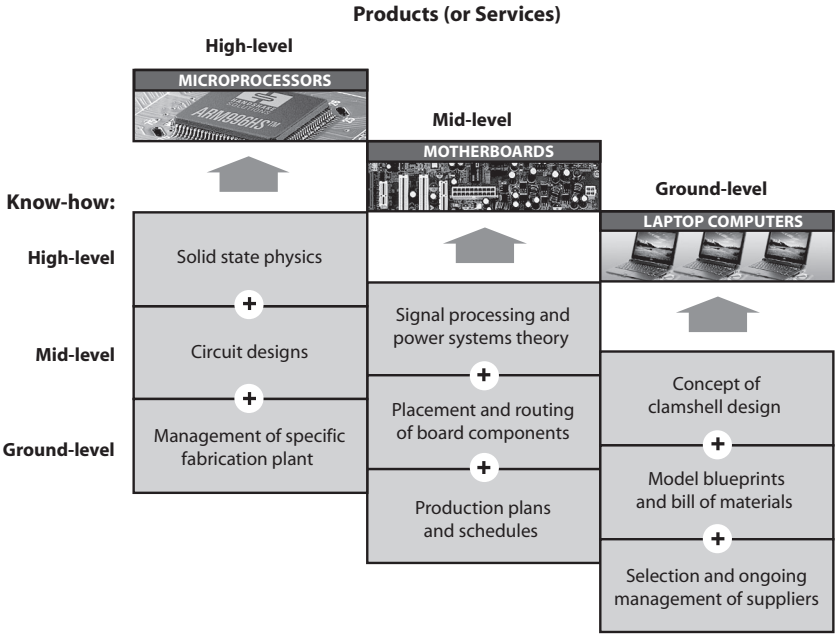
New products can similarly range from high-level building blocks or raw materials (microprocessors or the silicon used to make them), to mid-level intermediate goods (the motherboards that contain the microprocessor in laptop computers), to ground-level final products (laptop computers). As shown in figure I.1, each level of product is supported by multiple levels of know-how.†[9]

The figure shows a similar stratification of know-how for high-level coffee beans, mid-level coffee-roasting equipment, and the ground-level cup of espresso. Apparently multilevel technological innovation stirs up centuries-old beverages just as it does newfangled computers.

Individual forms of technological innovation, especially at the high level, usually have limited economic or commercial value unless they are complemented by lower-level innovations. A breakthrough in solid-state physics has value in the semiconductor industry only to the degree that it is accompanied by the development of new microprocessor designs; and the new designs may be useless without the development of plant-level tweaks for large-scale production of the microprocessor. Similarly, realizing the value of a new high-level microprocessor may require the development of

* This roughly corresponds to other commonly used taxonomies such as "ideas" and "objects"; "nonrival" and "rival" goods; and "bits" and "atoms." Note also that throughout this book, my usage of "products" includes services unless otherwise specified.

† Even these nine categories of know-how and three categories of products involve considerable simplification. First, there really aren't three distinct levels—know-how and products actually occupy a continuum from high level to ground level. Second, differences in level aren't the only way new know-how and products can be distinguished. Innovations can also vary in the degree to which they are novel, represent breakthroughs, have "general purpose" rather than "niche" applications, are proprietary or open source, and so on. In other words, the forms of innovation occupy a multidimensional space rather than a flat plane.



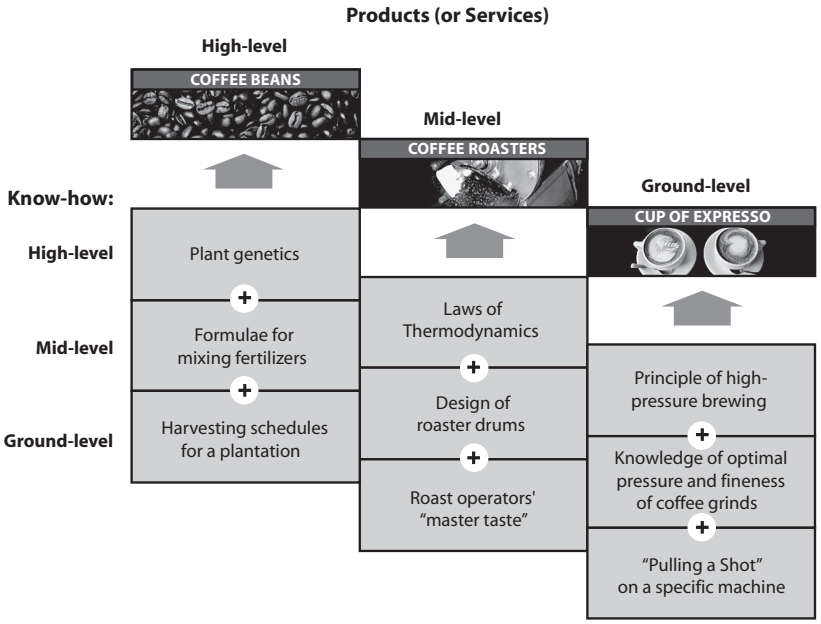


Figure I.1. Levels of innovation for know-how and products

new mid-level motherboards and ground-level computers. At the same time, high-level innovations often provide the building blocks, and a reason, for lower-level innovations. A breakthrough in solid-state physics may, for instance, provide the motive and the means for developing new microprocessor designs, and a new microprocessor may stimulate the development of new motherboards and computers. In other words, the different forms of innovation interact in complicated ways, and it is these interconnected, multilevel advances that create economic value.

Interconnected, multilevel innovations that aren't, in the usual sense, "technological" are also necessary for realizing the value of new know-how and products. A new "diskless" (or "thin client") computer, for instance, will generate revenue for its producer and value for its users only if it is effectively marketed by the former and properly deployed by the latter. Marketing and organizational innovations are usually required; for example, the producer of the diskless computer may have to develop new sales pitches and materials, and users may have to reorganize their IT departments. These marketing and organizational innovations can also be stratified into my scheme of three levels. On the marketing side, for instance, the vendor has to figure out a "unique selling proposition" (high level), a sales and marketing strategy (mid-level), and a plan for individual sales calls (ground-level).

The specialization and interrelationships of the individuals and organizations that undertake innovations add yet another dimension of complexity that should be factored into the formulation of public policies. Many different players develop new know-how and products—or complementary marketing or organizational innovations. They may be solo inventors and designers, small "entrepreneurial" firms, megacorporations, university labs, or independent research centers, with different individuals and organizations specializing in different levels or kinds of innovations. Some small firms, for instance, specialize in mid-level product design, others provide plant-level engineering services, and yet others develop advertising campaigns for new products. Large companies like IBM undertake a relatively wide range of innovations, but even here we see specialization at the level of subunits. For example, R&D labs at IBM undertake high-level material science research or semiconductor development. Other groups in the company develop specific systems and applications for particular market segments. This specialization in turn

means that no individual, lab, small business, or subunit of a large business can on its own develop the full set of innovations necessary to create economic value.

In my view, it is futile to argue about which innovations or innovators make the most valuable contribution to economic prosperity. Rather, different kinds of innovations and innovators often play complementary roles. To state the proposition in the terminology of cyberspace, *innovations that sustain modern prosperity have a variety of forms and are developed and used through a massively multiplayer, multilevel, and multiperiod game.*

Consider, for instance, the transistor, the key active component in almost all modern electronics. A German physicist, Julius Edgar Lilienfeld, registered the first three patents for field-effect transistors in 1928. In 1934, another German physicist, Oskar Heil, patented another field-effect transistor. However, none of the patented designs were ever built. In 1947, William Shockley, John Bardeen, and Walter Brattain of Bell Labs in New Jersey built the first practical point-contact transistor. Bell used this transistor in limited quantities, and it remained largely a laboratory curiosity. In 1950, Shockley developed the radically different bipolar junction transistor that was licensed to companies such as Texas Instruments (which used it to produce a limited run of radios as a sales tool). The chemical instability of the early transistors limited them to low-power applications, but developments in design slowly overcame these problems. In about two decades, transistors replaced vacuum tubes in radios and televisions and then spawned new devices such as the personal computer.

The German physicists' discoveries, in other words, kicked off an extended process of developing know-how at multiple levels. Some steps involved high-level breakthroughs, such as the discovery of the "transistor effect," which earned Shockley, Bardeen, and Brattain a Nobel Prize in Physics. Other steps, such as improving the chemical stability of transistors, required the development of lower-level, context-specific knowledge rather than a general law or principle; some of this lower-level knowledge (e.g., getting high production "yields" in a semiconductor plant) was very difficult to codify and is still considered a black art.

Companies that incorporated transistors into lower-level products such as radios also played an important role in realizing the economic value of transistors. Their contribution, too, had different levels and facets. To switch from vacuum tubes to transistors, radio manufacturers had to solve

engineering problems, create new designs, and figure out how to price, market, and distribute transistor radios.

A similar complexity characterizes the phenomenon of globalization. Cross-border interactions encompass a variety of flows that can be of importance to an innovator. These include licensing of know-how, the export and import of final products, the procurement of intermediate goods and services ("offshoring"), equity investments, and the use of immigrant labor. Each type of flow can be divided into further subcategories—for instance, the tasks performed offshore can be mundane, highly creative, or anything in between. The factors encouraging or impeding cross-border flows are also different for different types of flows. For example, licensing is affected by the security of intellectual property (IP) rights, exports and imports by transportation costs and customs duties, offshoring by differentials in the costs and quality of labor, equity investment by capital market structures, and the employment of immigrants by the availability of working permits. Whereas changes in these factors may have helped increase many kinds of cross-border flows, increases have not been uniform. For instance, international trade in manufactured goods has skyrocketed, but most service sectors remain "untraded"—services in retailing, real estate, and health care are almost entirely domestically produced and consumed.

The complexity of globalization spills over into its intersections with innovation. Some innovators can more easily export their products than others—but the extensive use of offshoring may not be a sensible choice for all heavy exporters. Developments such as plummeting communication costs have made the world smaller and the multiplayer innovation game more international in scope—but not to the same degree for all players and for all their cross-border engagements.

Techno-nationalist arguments based on sound-bites or parsimonious economic models cannot deal with the complexity of the multiplayer game. They rarely distinguish between different levels and kinds of know-how. Instead, they equate innovation with scientific publications or patents on cutting-edge technology produced in universities or in commercial research labs. They ignore the contributions of the other players in the innovation game that don't result in publications or patents.

Techno-nationalists also tend to oversimplify the phenomenon of globalization, often assuming that high-level know-how never crosses national

borders—only the final products made using the know-how are traded.* This assumption, we will see, is pivotal in theoretical models of North-South trade that Richard Freeman invokes to predict the woeful consequences of the erosion of U.S. technological leadership. In fact, high-level ideas cross national borders rather easily, whereas a large proportion of "final" output, especially in the service sector, does not.

To embrace the complexity that is ignored by many pundits, policymakers, and theorists, I have chosen a style of inquiry patterned after a common-law trial. I examined in detail what individual players do—and why—taking into account many contextual factors. As I have mentioned, my primary research focused on businesses backed by venture capitalists (VCs), many of which, as we will see, play in the middle of the innovation game. Studying them provides a panoramic view and allows us to make informed inferences about what the other players do. Although I began with all the possible global interactions of VC-backed businesses, in this research project I focus on three: the pursuit of overseas customers, offshoring, and the role of immigrants. These factors most concern the companies I studied—and also provide insights about the more controversial features of globalization.

■ Propositions

My analyses of the multiplayer game and its cross-border interactions suggest outcomes that differ sharply from the dire predictions of the techno-nationalists. According to my assessment, the United States isn't locked into a winner-take-all race for scientific and technological leadership, and the growth of research capabilities in China and India—and thus their share of cutting-edge research—does not reduce U.S. prosperity. My analysis suggests the opposite outcome: advances abroad will *improve* living standards in the United States. Moreover, the benefits I identify aren't the usual ones, by which prosperity abroad increases opportunities for U.S. exporters. Instead, I show that cutting-edge research developed abroad benefits domestic production and consumption in the service sector.

The implications of my analysis for public policy are also contrary to techno-nationalist prescriptions: I suggest that the United States embrace

* Technology transfer is central to the Bhidé-Phelps (2007) analysis of China's trade.

the expansion of research capabilities abroad, not devote more resources to maintaining its lead in science and cutting-edge technology.* This fundamentally different general strategy implies different choices of policy in a wide range of specific areas, such as the funding of scientific research, R&D subsidies, immigration laws, promoting savings and investment by reducing consumption, and training of scientists and engineers.

My assessment and prescriptions differ so sharply from those of the techno-nationalists for reasons that I preview below.

The World is a long way from being Flat—China and India aren't anywhere close to catching up with the United States in their capacity to develop and use technological innovations. Starting afresh may allow China and India to leapfrog ahead in some fields, in building advanced mobile phone networks, for example. But excelling in the overall innovation game requires a great and diverse team, which, history suggests, takes a very long time to build.

Consider Japan, which began to "enter the world" after the Boshin War of 1868. In the subsequent Meiji Restoration, the country abolished its feudal system and instituted a Western legal system and a quasi-parliamentary constitutional government. In a few decades, Japan had modernized its industry, its military, and its educational system. Today Japan is a highly developed economy and makes important contributions to advancing the technological frontier. But nearly a century and a half after Japan started modernizing, its overall capacity to develop and use innovations, as evidenced by average productivity,[10] remains behind that of the United States.

Similarly, Korea and Taiwan started industrializing (as it happens, under Japanese rule) about a century ago and enjoyed miraculous rates of growth after the 1960s. In several sectors of the electronics industry, Korean and Taiwanese companies are technological leaders. Yet their overall productivity suggests they have less capacity to develop and use innovations than has Japan. Is it likely, then, that within any reader's lifetime China and India will attain the parity with the United States that has eluded Japan, Korea, and Taiwan?

The fear of offshoring of innovation is similarly exaggerated—don't expect to hear a giant sucking sound anytime soon. *The massive relocation*

* I am *not* arguing for reducing public spending on basic scientific research. My point is simply that the threatened loss of scientific "preeminence" should not influence the level of spending.

of innovation appears highly unlikely. The fact that U.S. companies have started R&D centers abroad that do high-level research doesn't mean that all lower-level know-how development will quickly follow. Of the many activities included in the innovation game, only some are performed well in remote, low-cost locations. Many mid-level activities, for instance, are best conducted close to potential customers.

Any catch-up, even if it takes place gradually and in the normal course of development, will to some degree reduce the U.S. "lead." Furthermore, the global influence of techno-nationalism could accelerate this process. As alarmists in the United States don't fail to remind us, governments in "emerging" countries such as China and India—also in the thrall of techno-nationalist thinking—are making a determined effort to leap ahead in cutting-edge science and technology. I am skeptical that these efforts are going to do any more good for China's and India's economy than did similar efforts in Europe and Japan in the 1970s and 1980s.[11] But put aside the issue of whether investing in cutting-edge research represents a good use of Chinese and Indian resources; does whatever erosion of U.S. primacy in developing high-level know-how that this might cause really threaten U.S. prosperity? Should the U.S. government respond in kind by putting even more money into research?

Princeton economist Paul Krugman, in a 1994 *Foreign Affairs* essay, decried a "dangerous obsession" with "national competitiveness." The tendency to think that "the United States and Japan are competitors in the same sense that Coca-Cola competes with Pepsi," Krugman pointed out, is widespread; he quoted President Clinton's claim that "each nation is like a big corporation competing in the global marketplace." This premise, which is at the heart of techno-nationalism, Krugman persuasively argues, is "flatly, completely and demonstrably wrong."[12] Although "competitive problems could arise in principle, as a practical, empirical matter, the major nations of the world are not to any significant degree in economic competition with each other."[13]

The techno-nationalist claim that U.S. prosperity requires that the country "maintain its scientific and technological lead" is particularly dubious: the argument fails to recognize that *the development of scientific knowledge or cutting-edge technology is not a zero-sum competition.* The results of scientific research are available at no charge to anyone anywhere in the world. Most arguments for the public funding of scientific research are in fact

based on the unwillingness of private investors to undertake research that cannot yield a profit. Cutting-edge technology (as opposed to scientific research) has commercial value because it can be patented; but patent owners generally don't charge higher fees to foreign licensors. The then tiny Japanese company Sony was one of the first licensors of Bell Labs' transistor patent. It paid $50,000 for a license (after obtaining special permission from the Japanese Ministry of Finance) that started it on the road to becoming a household name in consumer electronics.

If patent holders choose to exploit their invention on their own (i.e., not grant licenses to anyone), this does not mean that the country of origin secures most of the benefit at the expense of other countries. Suppose IBM chooses to exploit internally, rather than freely license, a breakthrough from its China Research Laboratory (employing 150 research staff in Beijing). This does not help China and hurt everyone else. Rather, as I discuss at length later in this book, the benefits go to IBM's stockholders, to employees who make or market the product that embodies the invention, and—above all—to customers, who secure the lion's share of the benefit from most innovations. These stockholders, employees, and customers, who number in the tens of millions, are located all over the world.

In a world where breakthrough ideas easily cross national borders, the origin of ideas is inconsequential. Contrary to Thomas Friedman's assertion, it does not matter that Google's search algorithm was invented in California. After all, a Briton invented the protocols of the World Wide Web—in a lab in Switzerland. A Swede and a Dane in Tallinn, Estonia, started Skype, the leading provider of peer-to-peer Internet telephony. How did the foreign origins of these innovations harm the U.S. economy?

The techno-nationalist preoccupation with high-level research also obscures the importance of what happens at lower levels of the innovation game. High-level breakthroughs that originate in China or India can, in principle, be used to develop mid- and ground-level products of value to workers and consumers everywhere. But the benefits are not automatic: realizing the value of high-level innovation requires venturesome lower-level players who have the resourcefulness and gumption to solve challenging technical and business problems. Without venturesome radio manufacturers such as Sony, transistors might have remained lab curiosities.

Moreover, the benefits of lower-level venturesome consumption often remain in the country where it occurs, and all countries don't have the

same capacity for such consumption. Therefore, I argue, because high-level ideas cross borders easily, a nation's *"venturesome consumption"—the willingness and ability of intermediate producers and individual consumers to take a chance on and effectively use new know-how and products—is at least as important as, if not more important than, its capacity to undertake high-level research.* Maryland has a higher per capita income than Mississippi, Norway has a higher per capita income than Nigeria, and Bosnia has a higher per capita income than Bangladesh; the richer places are not ahead because they are (or once were) significant developers of breakthrough technologies. Rather, they are wealthier because of their capacity to benefit from innovations that originated elsewhere. Conversely, the city of Rochester, New York (home to Xerox, Kodak, and the University of Rochester) is reputed to have one of the highest number of patents per capita of any city in the United States. It is far from the most economically vibrant.

The United States, according to my analysis, has more than just great scientists and research labs: it also hosts an innovation game with many players who can exploit high-level breakthroughs regardless of where they originate. Therefore, the erosion of the U.S. lead in cutting-edge research isn't just harmless: *an increase in the world's supply of high-level know-how provides more raw material for mid- and ground-level innovations that increase living standards in the United States.* The U.S. technological lead narrowed after World War II as Western Europe and Japan rebuilt their economies and research capabilities. This led not to a decrease, but to an *increase* in U.S. prosperity.* The United States likely enjoys a *higher* standard of living because Taiwan and Korea have started contributing to the world's supply of scientific and technological knowledge.

The venturesome consumption of information technology (IT) innovations by the service sector in the United States plays an especially important role in my argument. The service sector now accounts for a large share of economic activity in the United States—nearly 70 percent of GDP in 2004 (up from 54 percent in 1974).[14] The benefits of innovations that improve the performance of U.S. service providers accrue mainly to U.S. workers and consumers because, in contrast to manufacturing, most services are

* As we will see in chapter 7, Paul Samuelson makes the opposite suggestion, that European and Japanese reconstruction may have dampened growth in the United States.

not traded—they are both produced and consumed in the United States. For example, an electronic health records system improves the productivity of U.S. health-care workers and the quality of care enjoyed by U.S. patients. In contrast, even if a U.S. innovator develops a more efficient process for making shoes, it may have little impact on U.S. productivity (since most shoes sold in the United States are imported).

As we will see, the exceptional capacity of service businesses such as Wal-Mart to use new high-level technologies has been one of the main reasons that productivity and incomes have grown faster in the United States than in Europe and Japan since the mid-1990s. Suppose researchers in, say, Germany develop a technology that helps retailers reduce inventories. The exceptional capacity of companies such as Wal-Mart to use it will lead to greater increases in productivity and living standards in the United States than in countries—possibly including Germany—where regulations, custom, and other factors may discourage retailers from using the new technology.

How should the United States (and other advanced countries) respond to the inevitable growth in the share of high-level know-how that is developed in low-wage countries? I argue that *techno-nationalist prescriptions to protect the U.S. lead in high-level know-how may do more harm than good by impairing the performance of the other players in the innovation game who use high-level know-how.*

On the surface, the prescriptions seem benign: how could training more scientists and engineers, investing more in basic scientific research and R&D, or improving the quality of math and science education do harm? Beware the consequences of nostrums harvested from piecemeal analyses! Consider, for instance, the argument for subsidizing research in cutting-edge science and technology. Advocates cite research showing that such investments have produced higher "social" returns than "private" returns because they produce knowledge spillovers for other producers that cannot be captured by the firms undertaking the R&D. Obviously, profit-maximizing businesses will invest less in R&D than would be best for society as a whole. Everyone therefore benefits if R&D spending is promoted through subsidies or tax credits. Or so the advocates would have us believe.

Those outside the choir have reason to be skeptical about the sermon. Increasing the rewards for doing something does usually lead people to do more of it. But more effort doesn't always lead to more output. Einstein's research produced great knowledge spillovers: could they really have been

increased if he had been given a tax break that induced him to spend more time doing research? Moreover, doing more of X may mean doing less of Y, reducing rather than increasing the public good. Suppose Einstein had spent more time doing theoretical physics and less giving thoughtful and influential speeches about world peace and the dangers of nuclear weapons. Would society have been better off?

Similarly, even if diverting resources from, say, marketing to R&D actually increases knowledge spillovers, the reduction in marketing activities can lead to a net loss to society. One reason is that spillovers of technical knowledge are not the only kind of value that innovations generate. Commercially successful innovations also produce what economists call a consumer surplus—the utility or value that buyers receive in excess of the price they pay. In many cases (e.g., a new drug while it remains under patent), the consumer surplus (the difference between the price of the drug and its value to the purchaser) can represent the primary source of the so-called social value of the innovation.[15]

But commercial success (which generates the consumer surplus) generally requires both technical effort (such as R&D) and marketing effort. Notwithstanding Ralph Waldo Emerson's claim about the world beating a path to the door of someone who builds a better mousetrap,[16] new products and processes, even great ones, don't sell themselves. Companies have sales and marketing departments for a reason. And doing more R&D and less marketing may reduce consumer surplus to a greater degree than it increases the spillovers of technical knowledge.

There is another reason diverting resources from marketing to R&D may be harmful: just as R&D can produce spillovers of technical knowledge, marketing can produce spillovers of "consumer knowledge," and reduced marketing tends to diminish the latter kind of spillovers. To take a concrete example, Dan Bricklin and Bob Frankston's invention of the spreadsheet created huge spillovers for Lotus Development Corporation (which later developed 1-2-3) and Microsoft (whose Excel spreadsheet now dominates the category). In fact Bricklin and Frankston's personal financial returns from the venture were negligible. But the spillovers that Bricklin and Frankston generated weren't just of the technical kind. Lotus and Microsoft profited enormously from pioneers' efforts to educate customers and create a market for spreadsheets. If Bricklin and Frankston had done more R&D and less marketing, the *total* spillover of technical and consumer knowledge could well have been less.

Consumer knowledge spillovers are nearly impossible to measure, whereas estimating the spillovers of technical knowledge is merely extraordinarily challenging. But the measurement problem should not lead to the conclusion that inducing businesses to undertake more R&D and less marketing would benefit society. Net of the costs, society could be better off—or it could be worse off. No one can actually know which, especially at the level of the economy as a whole.*

Businesses have long recognized the importance of multipronged investment in R&D, organizational capabilities, marketing, and so on, that is at least roughly balanced. Innovative products don't help companies that can't sell them,† and the capacity to sell innovative products is wasted if there are no products to sell. The importance of multipronged investment in the creation of the large modern corporation is a recurring theme in the work of the preeminent business historian Alfred Chandler.

It is certainly possible that the mix of investments that maximizes a firm's profits shortchanges the common good—a ratio of R&D to marketing ideal for stockholders may be too high or too low for society at large. But variations between firms make it virtually impossible to formulate public policies that will induce them to choose a mix of investments that is better aligned with society's interests. In a complex, dynamic economy, what constitutes a well-balanced portfolio of investments for IBM now—from the point of view of its stockholders *or* society at large—won't necessarily suit General Motors and may not be appropriate for IBM in the future. Given such variations across organizations and time, what justifies giving *all* firms tax credits for R&D but not for marketing? Why should the tax code assume that developing a new drug is always better for society than improving the effective use of existing treatments through more intensive marketing? The alternative approach of designing incentives for individual firms is, in a market-based economy, unworkable. Who, save for die-hard advocates of state control, would suggest the creation of a board

* I imagine most mainstream economists would not dispute the logic of this analysis. However, observing that the net effects of R&D subsidies are indeterminate is too obvious to merit publication in a scholarly journal and is of little interest to policymakers. Studies of knowledge spillovers from R&D are publishable and interesting; and the accumulation of many "peer-reviewed" published studies is used to assert a scientific justification for R&D subsidies.

† A reader recalls the example of how Xerox stumbled in the copier market: "Xerox thought it was all about R&D and erecting patent barriers to entry, while Canon and Minolta innovated with product size and user maintenance, originally with less good technology, and finally destroyed Xerox' dominance."

that would make a case-by-case determination of whether to subsidize R&D or marketing?

The same problem arises with schemes to train more engineers and scientists. Why should public policy encourage individuals to pursue careers in science and engineering instead of taking a liberal arts degree and becoming managers or entrepreneurs? Managers and entrepreneurs play important roles in the innovation game—how can we know that having fewer of them will improve the common good?

This is not an argument for a laissez-faire, benign neglect of technology. Indeed, I argue in chapter 16 that technological progress expands the minimal functions of government. For example, compared to an agrarian society, a technologically advanced economy requires a more sophisticated system for demarcating and enforcing intellectual property rights; and, as Jaffe and Lerner's critique of the U.S. patent system indicates, good systems do not always emerge spontaneously.[17] Similarly, the emergence of cyberspace engenders cyber-crime, which necessitates cyber-cops. But effective intervention also requires humility—an appreciation of how difficult it is to fathom the complexity of the modern economy—and alertness to the unintended consequences of policies based on a limited understanding.

In addition, although complacency is dangerous, fretting about imaginary threats impairs our ability to confront real problems. A pointless preoccupation with the growth of R&D in China and India distracts us from more significant issues that arise from their integration into the global economy: what will happen to energy prices and climate change if the per capita fossil fuel consumption of more than two billion people approaches that of the developed world? As Phelps and I have argued, China has increased its capacity to produce modern goods for international markets more quickly than it has increased its capacity to consume such goods.[18] The resulting savings glut has been channeled to U.S. borrowers through a financial system with serious defects, recently revealed by the subprime crisis. Reforming the financial system, it seems to me, is of critical importance in a global economy. There is also no shortage of serious domestic issues, ranging from the fiscal consequences of an aging population to the status of 12 million illegal immigrants.[19]

Globalization has important consequences for the distribution of incomes, and this has been the subject of an extensive and well-merited debate. I have nothing to add to this discourse except to note the following: even

if cross-border flows (and innovation) aren't zero sum at an aggregated national level—that is, Americans don't suffer when the Chinese advance—they may increase disparities of income in both countries. Indeed, any kind of trade—internal or international—and technological innovation can increase income disparities: Robinson Crusoes working with rudimentary tools on isolated islands are more likely to enjoy similar standards of living than members of a specialized, technologically advanced society. Rapid changes in trading patterns and technology can also cause unsettling dislocations.

Even if trade and innovation lead to unpleasant consequences for some, societies can ameliorate these consequences without impeding trade or technological progress (for instance through "adjustment" programs, negative income tax rates, or low-wage subsidies). Indeed, the historical evidence suggests that societies that have blocked trade and hindered technological advances have typically dragged down overall living standards *and* concentrated wealth and power in the hands of a few individuals. How a country may ameliorate the unfortunate consequences of globalization and innovation without losing their benefits is a serious question, but it lies outside the scope of my book. My focus is on the overall wealth and prosperity of nations, and I focus on just one aspect of globalization, its intersection with technological innovation.*

■ An iConic Illustration

The iPod, the portable media player that Apple introduced in 2001, has been a runaway hit—by the end of 2006, Apple had sold nearly 70 million units. Its story illustrates many of the propositions I have just outlined.

Apple was cofounded and is tightly managed by a college dropout, and it did not develop cutting-edge technology or employ many PhDs in science or engineering to develop the iPod. The iPod wasn't the first music player of its

* The much larger aspect of globalization pertains to trade in seasoned goods and services. Many fine books about the causes, benefits, and losses have been written about this. The top 24 books (out of 46,288) as of this writing on Amazon under "globalization" include those (in order of appearance) by my Columbia colleagues Joseph Stiglitz and Jagdish Bhagwati (who sharply disagree), Martin Wolf, Dani Rodrick, Daniel Cohen, and Francis Cairncross. My thinking has of course been informed by reading some of these works, but their overlap with this book is limited.

kind: Singapore-based Creative Technology was selling the Nomad jukebox nearly two years before Apple introduced the iPod. Indeed, Creative later sued Apple for patent infringement and received a $100 million settlement. The attractiveness of Apple's products lies in their "simplicity, intelligence and whimsy" rather than in new technology.[20] The iPod and other Apple products are popular because they are "masterpieces of industrial design and enlightened human interfacing. They make competitors' products—even when they're better machines—seem plodding and prosaic."[21]

Susan Kevorkian, an analyst at IDC, points out that "Creative's original Nomad jukebox was designed to look like a CD player. Apple innovated on the hard-drive based portable media player form factor by making it smaller and rectangular—e.g. by embracing the form factor of the hard drive, rather than trying to disguise it." The iPod's subsequent evolution made it more than an "entertainment device." It became "a fashion accessory" that provided "hipness by association," a means to store and manage data and entertainment files, and way to "stay current on the go with audio books, news and information podcasts and video clips."[22]

Apple CEO Steve Jobs's talent for marketing is another not-so-secret weapon for the company. In spite of (or possibly because of) Jobs's disdain for market research, Michael Malone regards him as "the greatest marketer of our time, the most charismatic figure in electronics history."[23] Another industry observer jests that Jobs may have, beyond natural charisma, a supernatural "reality distortion field."[24] The company as a whole is credited with an outstanding marketing flair.

Other aspects of the iPod phenomenon are sometimes overlooked: Apple has been a skilled integrator—a deft orchestrator of a multiplayer game—not a go-it-alone innovator. Apple's iTunes Store provides a legal and convenient ("end to end") way for consumers to buy individual songs (for 99 cents in the United States) that can be played on an iPod. In order to establish the store, Jobs orchestrated: he had to overcome difficult contracting problems with the music companies that owned the copyrights to the songs. On the product development side, Apple started with software based on PortalPlayer's reference platform and contracted with a company called Pixo (founded by Paul Mercer, also a college dropout) to help design and implement the user interface.

Especially noteworthy are the high-level know-how and products used in the iPod mix that originated abroad. The English company ARM, for instance, developed the "intellectual property core" for the "brains," or the

CPU, of the player. The Fraunhofer Institute for Integrated Circuits in Germany licensed MP3 sound compression technology patents to Apple. Fraunhofer itself was not the sole inventor of MP3 technology; Phillips (Holland), Thomson (France), Sisvel (Italy), and Bell Labs (United States) also made important contributions. The 1.8-inch hard drives that put "1000 songs in your pocket" and were used in the first five generations of the iPod came from the Japanese company Toshiba. Later, the iPod Mini used 1-inch "microdrives" supplied by Hitachi (Japan) and Seagate (United States). Flash memories, which were used instead of hard drives in the iPod Nano, were supplied by Toshiba and Samsung (Korea). Wolfson Electronics, headquartered in Edinburgh, Scotland, developed the audio codecs.[25]

The venturesome spirit of U.S. consumers has also played a crucial role in the success of the iPod—and several other Apple products. According to Malone, Steve Jobs can introduce "clumsy, overpriced 1.0 version[s] and trust that the army of several million Apple true believers will rush out and buy. That is the crucial, often overlooked, key to Apple's continuing success. Other wildcatters have to pray the market recognizes their brilliant new products quickly enough before they go bankrupt. Apple, by comparison, always knows that it will be able to finance versions 2.0, 3.0, etc., on sales to its captive market—and by then, it will have perfected a definitive product the whole world wants to own."[26]

Although Apple markets the iPod all over the world, its army of true believers enrolls largely in the United States. In 2000, the year before the iPod was launched, the United States (which accounts for less than 5 percent of the world's population and about 30 percent of its GDP)[27] accounted for 85 percent of the global shipments of MP3 players.[28] As the market matured and prices fell to levels where consumers in less well-to-do countries could afford players, the U.S. share of the global market also declined—but not to levels commensurate with the U.S. share of world GDP. According to a Morgan Stanley estimate, in 2005, the United States accounted for about 70 percent of worldwide shipments of digital music devices. U.S. consumers have been particularly receptive to Apple's high-end, high-priced products: according to Morgan Stanley, Apple's share of the U.S. market is nearly two and a half times its share in other markets. In 2005, Apple sold 27.1 million iPods in the United States—more than five and a half times the 4.8 million it sold in the rest of the world.[29]

The bottom-line question, however, is how the iPod's success helps the U.S. economy.

The product has surely been profitable for the company—Apple is estimated to earn a gross margin of 20 percent to 30 percent on iPod sales, stellar in the consumer electronics industry. This growth in profits—and expectations of more to come—helped increase the stock price from about $10 a share in October 2001, when the iPod was introduced, to about $70 a share by the end of 2005. But who are the shareholders? Foreigners can buy Apple's stock as easily as U.S. investors, so the geographic distribution of Apple's shareholding is simply a matter of the preferences of investors. Similarly, a lot of labor has been employed in manufacturing the nearly 70 million iPods that were sold from 2001 to 2006. But where? The players are made, or more properly assembled, in China—using components that are also made in the Far East.

The iPod has affected U.S. jobs mainly in the "untradeable" service sector. It is difficult to estimate how many Americans have been employed in the distribution, marketing, and sales of the players, but the value added of these activities seems to be roughly equal to the value added of the production activities undertaken in the Far East.[30] An equally significant benefit is the value the iPod has created for its venturesome consumers. The tangible and intangible benefits it provides make it virtually impossible to estimate the magnitude of this consumer surplus, but the iPod would not have enjoyed runaway success unless it provided value significantly in excess of its purchase price. Therefore, just as the venturesomeness of U.S. buyers made a large contribution to the success of the iPod, U.S. buyers have reaped a large share of the value it created.*

It is also worth asking how things might have been different if the Finnish company Nokia had become the leading vendor of MP3 players. Asia would probably have remained the venue of choice for assembly and component manufacturing. Apple's (potentially global) shareholders would likely have been poorer and Nokia's (also potentially global) shareholders richer. A hundred or fewer product designers and engineers might have worked in Finland instead of California (although it should be noted that some of Nokia's designers are based in California). But in terms of the significant economy-wide effects on service sector employment and consumer surplus, the critical question pertains to the attractiveness of the U.S. market: if Nokia had also focused on U.S. consumers, little would have changed. In other words, in a world where the high-level innovations—MP3 standards,

* Note, however, that even if other economies may not have received the same benefits as the U.S. economy, they haven't suffered any harm either.

ARM microprocessor designs—are mobile, what happens at the lower levels of the innovation game is crucial.

Why Study VC-Backed Businesses?

Although the iPod provides a catchy illustration, my propositions derive from a detailed examination of businesses with much lower profiles—U.S.-based, VC-backed businesses that had not yet gone public at the time of my study.* VC-backed businesses are, of course, only one of the players of the innovation game; in fact, large public companies devote far more resources to innovative activity and develop significantly more new know-how and products. Large companies also account for a much larger share of cross-border activity. Nevertheless, for several reasons a study of VC-backed businesses provides a useful view of the economic drivers of the innovation game and its cross-border interactions.

First, *VC-backed businesses are relatively uncomplicated players*. To use an analogy: the fruit fly is among the most studied organisms in biological research, particularly in genetics, because it provides a simple model: it has only four pairs of chromosomes, three autosomes and one sex chromosome. Its genome is compact, having about half the number of genes as the human genome, and was almost completely sequenced in 2000. Analogously, VC-backed businesses offer a simple and clear model of technological innovation and its cross-border ramifications, especially in comparison to large corporations.

They concentrate on technological innovation. For reasons that I will discuss later, VCs tend to focus their investments in "high tech" sectors where innovation is vigorous. In 2005, for instance, 85 percent of VC investments in the United States were in information technology/telecom or life sciences—sectors that account for less than 20 percent of U.S. GDP, but are the loci of a great deal of innovative activity. VC-backed businesses are pure innovators: their business models are entirely predicated on commercializing new products or know-how.

The economic considerations that go into their choices about innovation and cross-border interactions are therefore easier to observe. VCs have the power and incentive to require businesses to try to maximize their financial

* I describe the details of my study in the next chapter.

returns—and to minimize the impact of emotion, empire-building, ego, and political jockeying. The economic rationale behind those businesses' technology investments, and the degree to which those businesses focus on overseas markets, use offshoring, and recruit immigrants are therefore fairly transparent.

In contrast, only a minority of large companies focuses on high-tech industries, and even the ones that do aren't pure innovators. They also attend to sizable businesses that have already matured. The interactions between the innovative and ongoing activities of large firms can obscure their moves and motivations. For instance, what does one make of the research centers that many large high-tech companies have set up in China? To what extent are the centers a quid pro quo for selling existing products to the Chinese government? How many actually undertake cutting-edge research, and how many are really facilities that adapt existing products for the Chinese market, dressed up for PR purposes as research centers? Factors such as intramural conflicts between divisions and the egos of CEOs of large companies can make it difficult to identify the economic factors behind their choices about globalization and innovation.

A second advantage of studying VC-backed businesses is that they provide *a window on the middle level of the innovation game* in terms of both product and know-how *and thus help us identify some of its distinguishing features* vis-à-vis other levels. Research on innovation tends to focus on high-level knowledge developed in labs or R&D centers that typically results in scientific publications and patents.* Most of the VC-backed businesses I studied, however, did not undertake high-level research or develop high-level products such as the transistor. Rather, their innovations combined or extended high-level know-how and products. According to one CEO, his company undertook integration projects, not science projects.†

* Freeman and Soete's (1997) *The Economics of Industrial Innovation* (third edition) is an instructive case in point. This encyclopedic, 470-page volume extensively reviews the literature on innovation. In defining their scope, however, the authors write: "This book is primarily concerned with the innovations arising from the professional R&D system and with the allocation of resources to that system." They admit that the system employs less than 2 percent of the working population but assert that it "originates a large proportion of the new and improved materials, products, processes and systems, which are the ultimate source of economic advance."

† As we will see in chapter 2, the core technical contribution of VC-backed businesses is often not "patentable," because what was not "obvious" about the combinatorial know-how was hard to codify (and at least in principle, a patentable invention must be both nonobvious and replicable by a practitioner who reads the patent).

VC-backed businesses didn't develop technical know-how only—they also developed "nontechnological" complements such as sales and marketing pitches and architectures and routines for their internal organizations.

My study also shows how mid-level players combine and extend higher-level innovations. The VC-backed businesses used different people and procedures than the typical lab doing high-level research: They employed a much smaller proportion of PhDs in their technical staff, and their overall workforces contained a larger proportion of managers and sales and marketing staff. In contrast to the physicists who developed the modern transistor inside the precincts of Bell Labs, the development teams of many of the VC-backed businesses I studied had a close, ongoing relationship with users. Communication and persuasion were as crucial as technical virtuosity, and the technical tasks themselves involved more ad hoc improvisation than classical scientific experimentation.*

Third, studying VC-backed businesses *provides insights about the use of "high tech" innovations by "low tech" service businesses*. The great majority of the VC-backed businesses I studied developed innovations used by other businesses—few targeted individual consumers. Many of the business customers weren't companies producing high-tech products; a large proportion were low-tech businesses providing services rather than tangible goods. Low-tech businesses providing services (such as Wal-Mart and the Prudential Insurance Company) account for a large share of economic activity. The value-added by the business sector as a whole accounted for about 77 percent of U.S. GDP in 2004,[31] and as has been mentioned, services accounted for nearly 70 percent of GDP; consequently, customers' effective use of the kinds of high-tech innovations developed by the businesses in my study matters a great deal to the performance of the U.S. economy.

Although VC-backed businesses provide a relatively easy-to-study model of innovation, especially at the mid-level, they aren't the only or even the dominant mid-level players. I do not subscribe to a common belief in their extraordinary capacity for innovation. A predisposition to believe different forms of organization have different capabilities and limitations induces skepticism: if VC-backed businesses are much more productive in generating

* A large proportion—but not all—of the VC-backed businesses I studied played at the middle level of the innovation game. Some developed higher- or lower-level innovations. These variations in my sample also highlighted differences in how the innovation game is played at different levels.

innovations than corporate R&D units, as some researchers have claimed,[32] why haven't we seen a significant redeployment of corporate R&D resources to the VC model?[33] And why are VCs and company founders so eager to adopt an inferior organizational form through an IPO or merger with publicly traded companies? To my way of thinking, research comparing innovation productivity based on patent counts and the like is misleading, because different kinds of organizations use different processes to produce different (and often complementary) innovations.* There are good and bad trumpet players and flautists; but to say that trumpet players as a class are more productive because they blow more wind through their instruments misses the point. Just as symphonies require many instruments—replacing flautists with trumpeters doesn't improve a performance—the multiplayer innovation game draws on the contributions of VC-backed businesses and large corporations, of scientific research and R&D, and of marketing and management.

Indeed, my study of what VC-backed businesses do—as well as what they rely on others to do—highlights the high degree of specialization of the individual players, both within and across organizations. For instance, VC-backed businesses often rely on other innovators to develop high-level know-how or products. Similarly, they depend on their early customers to provide ongoing feedback; more than one referred to such customers as "development partners." My study also suggests considerable variety in the nature of interactions. Some (as with early customers) can require a face-to-face dialogue, rich in nuance and information. Other, more terse interactions[34]—for example with licensors of technologies—can occur remotely. And although such observations do not add up to a comprehensive account of the multiplayer innovation game, this variety of organizations and interactions has important implications for assessing how the United States should respond to the emergence of new sources of cutting-edge research abroad.

Although I derived my propositions through an inductive process, from observations of mid- and ground-level innovations—a territory outside the field of vision of many scholars—my research is by no means sui generis. As in a common-law trial or judicial enquiry, it is crucial in inductive research to keep an open mind—but impossible to start with a tabula rasa, a clean slate. One cannot "just observe": a first-time visitor from London will see

* The comparisons also rely on assumptions that are, in my view, somewhat implausible, although they are commonly relied on in well-regarded research (see chapter 6).

New York very differently than will a visitor from Lagos. Although good investigators avoid looking only for data that confirms a theory, preconceptions and prior beliefs inevitably inform the questions researchers ask and the inferences they make.[35] The box titled "Prior Art" describes the theories and ideas that guided this inquiry and the framing of my inferences.

Prior Art

Just as a devout Hindu might begin a journey with a prayer to the Lord Ganesh, it is obligatory to start a discussion on modern innovation by invoking Joseph Schumpeter. The thousands of pages he wrote over more than four decades contained sharp, unequivocal claims as well as tangles of contradictions: Jon Elster describes Schumpeter as an elusive writer who could contradict himself in the course of a single paragraph.[36] Nevertheless, as Rosenberg puts it, "His model has become the accepted one for all innovative activity."[37]

I do not question Schumpeter's overall thesis—that innovation drives long-term growth. And like many others I applaud the highly textured and historical nature of his analysis. But I am otherwise not a devotee. More granular theories can provide superior insights—provided they get the details right. As far as I can tell, Schumpeter's eloquent and voluminous writings about innovation and entrepreneurship weren't informed by a systematic study of actual innovators or entrepreneurs. His model (or at least the common conceptions of it) has many elements that are, to put it politely, incongruent with a large body of empirical research as well as with my own observations of the modern innovation system. I believe that misconceptions in the Schumpeterian model are at the heart of many alarmist prognoses of the consequences of the erosion of the U.S. technological lead.

Mainstream economics does not make the extensive mistakes and exhibit the muddle that I find in Schumpeter. But as I mentioned in the preface, I share Phelps's view that it has limited utility in helping us understand the evolving, unruly processes of innovation.[38]

Rather, the two theorists whose views of entrepreneurship form the core of the "priors" that have informed my observations and interpretations are

Frank Knight and Friedrich Hayek. Other particularly noteworthy influences are Chandler's work on large industrial enterprise, Elster's book on technical change, Nelson and Winter's evolutionary theory, and Phelps's analysis of modern capitalism. This is of course only a partial list.

My metaphor of a multiperiod, multiplayer game is largely a contemporized amalgam of Nelson and Winter's evolutionary theory, Rosenberg's research on incremental innovation, and the idea of an innovation system popularized by Nelson and other scholars. The construct of "venturesome consumption" incorporates the ideas of many researchers, including work on technology diffusion by David, Griliches, Mansfield, and Nelson and Phelps; work on consumer-led innovation by Rosenberg and Von Hippel; and work on "absorptive capacity" by Cohen and Levinthal. Craft, Ghemawat, Leamer and many others have made the point that the world is far from flat. On the policy side, my critique of techno-nationalism is of a piece with Krugman's attack on the pursuit of "competitiveness" and with the argument that David has made for decades against public policies that emphasize the development of new technologies and neglect their diffusion.

As the preceding indicates, many of my individual propositions, especially about innovation, are not novel (although gaps in my knowledge of the prior research led to some "independent rediscoveries"). My contribution (aside from observations of VC-backed businesses, which I believe represents new field data) lies in combining propositions about innovation and cross-border interactions to provide a fresh assessment of an anxiety-inducing feature of globalization.

■ What Lies Ahead

To continue the analogy of a trial, I present the depositions and testimonies of my witnesses before I make my broader arguments and judgments. Specifically, book 1 focuses on the results of my interviews with the CEOs of VC-backed businesses. It explores the nexus between the role these businesses play in the innovation game and their cross-border interactions. The exploration reveals important features of the innovation game, including the extent of its globalization. Book 2 broadens and integrates the inferences

from book 1 to rebut techno-nationalist alarmism about the erosion of the U.S. lead in cutting-edge science and technology. It also suggests an approach to formulating public policies that is more in sync with the way the technologically advanced world really works.

The depth and detail provided in book 1 make, I believe, the broader arguments of book 2 more persuasive in the following way: since we could not independently verify what the CEOs told us, the context, the circumstantial evidence, and the statements our "witnesses" gave during "cross-examination" will allow readers to assess the credibility of the "testimony." The details should also help readers evaluate the quality of my generalizations. For instance, because I focused on VC-backed businesses, I had to make judgments about what features of their innovative activity and cross-border engagements would apply to other players in the innovation game. Similarly, I had to make inferences about players, such as customers and outsourcing companies, that the companies in my sample did business with but whom we did not interview. My sharing of the background facts gives readers an opportunity to decide if they agree with my judgments and inferences.

I also believe that the detailed evidence is a necessary antidote to the sweeping pronouncements of popular gurus and to highly abstracted theories of growth and trade that are far removed from the reality of modern capitalist innovation. I can think of no way to apprehend this reality without the laborious, methodologically tricky process of talking to the people who shape it—or at least taking the time to peruse the results of such an enquiry.

Presenting the more detailed and special case first may not be to every reader's taste. Some may prefer to review the broader closing arguments and judgments first. I have therefore written the two books in the form of more or less independent modules. Some readers may choose to start with book 2 and then return to book 1 for the underlying evidence—or to learn more about VC-backed businesses.