The Venturesome Economy: How Innovation Sustains Prosperity in a More Connected World*

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The growing integration of the world's economy in general, and the increased participation of China and India in international trade in particular, raise important questions: Will competition from more than a billion Chinese and Indians reduce wages and imperil the prosperity of the West? What, if anything, is to be done?

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 U.S. 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. 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. 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 2005 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* cautioned, Western companies could "lose their technology edge" as their Asian contractors move up the "innovation ladder."[1]

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.[2] Knowledge workers are also, of course, the people most likely to watch news network channels and read books and newspaper columns.

Besides menacing an influential class, the rise of offshoring up the so-called value chain—from telemarketing, to teleradiology, to cutting-edge R&D—has raised concerns about the long-term prosperity of the U.S. Many worry that the country's lead in science and technology will erode as R&D

1. P. Engardio and B. Einhorn, "Outsourcing Innovation," *BusinessWeek* (March 21, 2005).

2. The reality is that many manufacturing workers whose jobs migrated overseas never expected secure high-paying jobs. High-paying employment for the long haul offered by unionized steel and automobile companies has never been 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.

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 U.S. 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. One 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 was blamed by economists for squeezing global trade, thereby helping 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.

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% 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 U.S.

Much of the establishment, Democratic and Republican, has embraced this "techno-nationalism."[4] 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 U.S. must "do whatever can be done first. It matters that Google was invented here." In language suggestive of 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."[5]

Although their popularity in the mainstream is recent, such 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 that the U.S. was in danger of becoming a nation of burger flippers. A prize-winning article in the *Harvard Business Review* argued that the U.S. was "managing" its way to economic decline.[6] 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 a 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 nations with better occupational ratios.[7]

As it happened, the U.S. prospered while the Japanese and German economies slackened. And it wasn't because the warnings were 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 continued to warn the American public of the dire consequences of "losing the race for the 21st century." 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.

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3. Richard B. Freeman, "Does Globalization of the Scientific/Engineering Workforce Threaten U.S. Economic Leadership?" 2005 NBER working paper.
4. This term was coined by Sylvia Ostry and Richard Nelson in Techno-Nationalism and Techno-Globalism: Conflict and Cooperation, (Washington D.C.: Brookings Institution Press, 1995).
5. Thomas Friedman, *The World is Flat* (2006).
6. Abernathy and Hayes, *HBR,* 1983.
7. 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.

Of course, the U.S. 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 U.S. 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 are greatly exaggerated, stemming 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. In the pages that follow, I present a more realistic and complex picture of innovation and its effects that leads to a very different prognosis.

In my view, the United States is not 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. Indeed my analysis suggests the opposite—that 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 production and consumption in the U.S. service sector.

And the implications of my analysis for public policy are thus also contrary to techno-nationalist prescriptions. I suggest that the U.S. embrace the expansion of research capabilities abroad, not devote more resources to maintaining its lead in science and cutting-edge technology.[8] This fundamentally different general strategy implies different policy choices in a wide range of specific areas, such as the funding of scientific research, R&D subsidies, immigration laws, promotion of savings and investment through reduced consumption, and training of scientists and engineers.

The Theory of Global Gains from Trade

Classical economic theories of the 18th and 19th centuries provide limited guidance in addressing these questions. These theories assume that trade takes place between countries with comparative advantages that are based on immutable natural advantages: It behooves Britain, where it rains a lot, to focus on rearing sheep and shearing wool and to let sunny Portugal grow grapes and make port. Because geographic conditions are fixed, in classical economic theory the wool-for-port trade continues forever.

But how does this apply to today's global economy, and what promise does it hold out for the world's poorer countries? As Edmund Phelps and I have argued, the comparative advantage of today's developing countries derives mainly from their historical failure to use the technological innovations that made the West rich. The impetus for trade between rich and poor countries arises from the differences in their accumulated technological capabilities rather than in their geographic endowments. Moreover, trade based solely on differences in technological capabilities is likely to extinguish itself with time. Openness to trade helps China become more technologically advanced and prosperous; but increased prosperity causes wage differentials with the U.S. to shrink, ultimately making it unprofitable for China to import cotton from the U.S. and send back shirts and skirts.[9]

There is now, to be sure, a considerable body of modern economic research that attempts to incorporate the dynamic interactions of trade and innovation. But even these theories continue to exclude many crucial real-world features of the modern economy. As Phelps observed in his Nobel Prize lecture, the "distinctive character of the modern economy" involves "uncertainty, ambiguity [and] diversity of beliefs." Entrepreneurs "have to act on their 'animal spirits,'" often launching their innovations first and discovering the benefits and costs afterward.[10] But, as Phelps writes elsewhere, instead of treating the modern economy as it really is ("an evolving, unruly, open-ended system"), the "established body of economic theory" implies a "deterministic future." Economists ignore disagreements about what might happen; uncertainty is watered down to well-defined probability distributions.[11]

All theories, of course, simplify, but the degree of simplification ought to depend on context and purpose. Boat builders can ignore the possibility of tidal waves and icebergs when they design recreational sailboats, but not when they design supertankers. Unfortunately, because tractable mathematical models cannot cope with a large number of variables, economists often have to simplify far more than is warranted by the context. Depending on the simplifying assumptions, different models can produce conflicting results; model A may show technological advances in backward economies to be good for advanced economies, while model B shows precisely the opposite. But with both models so far removed from real-world conditions, we cannot identify which is the more likely result.

8. 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.

9. Amar Bhidé and Edmund Phelps, "A Dynamic Theory of China-U.S. Trade: Making Sense of the Imbalances," *World Economics* (July-September 2007).

10. Edmund S. Phelps, 2007. "Macroeconomics for a Modern Economy," *American Economic Review* 97.

11. Edmund S. Phelps's (unsigned) summary of the Aims and Scope of *Capitalism and Society*, posted at http://www.bepress.com/cas/aimsandscope.html (February 27, 2007).

A Different Approach

Fortunately, we do have a pragmatic, well-tested model for integrating a wide range of facts and theories when a situation so demands: the common-law trial.[12] Many witnesses provide testimony about various facets of the case. Some of it is qualitative, some of it is not. Lawyers offer theories to tie the facts together, using precedents or case law to inform their interpretations. In certain kinds of trials, criminologists, psychologists, pathologists, economists, and other such experts also testify. As both sides muster facts, precedents, and experts that favor their own theory, the sum of their arguments provides a comprehensive view.

Of course, this combination of induction and deduction does not produce incontrovertible results. Unless one side makes a palpably unreasonable argument, judges and jurors face considerable ambiguity. Experts disagree. The same facts, depending on how they are weighted, suggest the application of different precedents and legal theories. Moreover, although common-law judges must respect precedent, they also have to keep in mind the distinctive circumstances of the case at hand as well as the fact that changes may make some precedents obsolete. Inevitably decisions turn on subjective judgments, not on objective deduction. And well-considered decisions rendered by an experienced judge may be reversed on appeal. Nevertheless, most of us wouldn't trade this judicial process for a more objective approach that excludes all but a few quantifiable variables. We wouldn't want cases decided using, for instance, the kinds of scoring models employed to issue credit cards.[13]

This book and its findings are the result of my own common-law type of inquiry about the nexus between globalization and innovation. Unlike a planned trial, however, my inquiry started rather long ago and it has evolved in a rather unexpected way. Twenty years ago, while on the faculty of the Harvard Business School, I started studying new and emerging businesses. Virtually all the businesses I examined operated entirely within the U.S.; they didn't buy or sell anything abroad. When the "offshoring" of services gained momentum, I wondered whether the "entrepreneurial" companies that my research had focused on were involved in this new form of international trade.

In 2002, I undertook a comprehensive study of the climate for entrepreneurship in Bangalore, which famously has been at the center of the offshoring boom in India.[14] In the course of this research, I observed that large multinational companies were the main users of offshore services; small U.S. businesses lacked the scale needed to take advantage of the low-cost labor force. The experience piqued my curiosity: if entrepreneurial businesses weren't well suited for offshoring, was there another facet of globalization that mattered to them?

Returning to the U.S., I began studying the cross-border interactions of businesses financed by professional venture capitalists (VCs). I focused on VC-backed businesses because I believed (for reasons discussed later) that this genre was likely to have more international activity than other kinds of small or entrepreneurial businesses. Since my Bangalore experience suggested that offshoring was not important to most new and emerging businesses, I decided to examine, in the broadest possible way, how the world outside the U.S. affects the decision-making and performance of U.S.-based, VC-backed businesses. To this end my research associate and I asked the CEOs of 106 such businesses three main questions about the possible ways they might engage in cross-border activities and transactions: (1) To what degree, and why, did their businesses serve overseas customers and secure goods, services, intellectual property, and capital from abroad? (2) Did they face competitors from abroad? (3) What role did immigrants play in starting and staffing their companies?

I had few preconceptions about the form or extent of the globalization that I would observe—rather, I relied on interviewees to tell us what kinds of cross-border interactions were important to their businesses. Similarly, I started with no hypotheses about why VC-backed businesses have cross-border engagements; I expected to formulate hypotheses while collecting the data.[15] This inductive approach does not always produce interesting results; I have more than once done fieldwork that failed the "So what?" test. With this project, I was fortunate. My fieldwork, by shedding light on the specific question of what VC-backed businesses do, has also provided a revealing perspective on the interaction between innovation and globalization and its consequences for the long-run prosperity of the U.S. as well as its trading partners.[16]

12. In principle, the efforts of researchers to model complex adaptive systems (at places like the Santa Fe Institute and MIT's Systems Dynamics Group) offer another possibility. Though the underlying concepts seem compelling, even after a couple of decades of work by brilliant minds the approach has not yet yielded many useful insights for assessing phenomena like international trade and innovation.

13. Arguably the common-law trial reasoning and process is in fact what is used by such economists as the chairman of the Federal Reserve when they have to confront a complex and dynamic world. A less deliberate, more "seat of the pants," variant is often used to make business decisions.

14. My study, however, focused mainly on whether and how the boom had created opportunities for small local businesses in Bangalore. See Bhidé (2008), "What Holds Back Bangalore Businesses?" *Asian Economic Papers* 7, no. 1 (Winter): 120-53.

15. Many scholars in the social sciences regard the collection of data in the absence of well-formulated hypotheses as *verboten*. By contrast, natural scientists seem (like common-law jurists) more open to a two-way flow between facts and hypotheses: some researchers design experiments to test the predictions of a theory; others collect data that may subsequently be woven into a theory because they regard certain facts as prima facie useful and important. For instance, upon discovering a new planet, astronomers will try to measure its circumference and distance from its star. When biologists find a new species, they want to know what it eats, how much it weighs, and so on. I happen to believe that the study of the workings and dynamics of human society would benefit from a similarly even-handed approach in which theorizing doesn't always precede data-collection. I find it puzzling, for instance, that for all the many books and articles that have recently been written about multinational corporations, it is hard to find data on the proportion the overseas activities of these corporations represent of their total revenues, assets, or employment.

16. The innovation game in the U.S., of course, has many other important players I have not studied in detail. That said, even a narrow probe from an unusual angle can provide a clearer view of new ideas or more accurate interpretations of existing facts about what lies under the surface. I also hope that the inductive nature of the exercise will reassure my readers: As mentioned, I did not collect data in support of a point of view, and had no expectation about what I would observe or what the broader implications might be. If the sequence had been reversed—if I had used the interviews to test previously formulated hypotheses—I myself would be skeptical of the results.

A Complex, Multiplayer Game: Toward a New Model of Global Interconnectedness and Gains from Trade

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 as became especially clear in our interviews with the CEOs, 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. It should also caution us against embracing policies that, while intended to sustain economic prosperity, end up undermining it by favoring one form of innovative activity at the expense of others.

The difficulty of defining technological innovation reveals the great diversity of its forms. To give the reader some sense of this diversity and its implications, I start by dividing the many forms of innovation into two main categories—new *products* (or *services*) and the new *know-how* upon which they are based[17]—and then further stratify both of these categories into three distinct levels.

For any new product or service, the underlying know-how can be seen as ranging 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 knowledge includes the circuit designs and chip layouts; and ground-level expertise involves, for example, 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 1, each level of product is supported by multiple levels of know-how.[18]

The figure shows a similar stratification of know-how for a much more mundane product, one that comprises (high-level) coffee beans, (mid-level) coffee-roasting equipment, and the (ground-level) cup of espresso. Here we see multilevel technological innovation stirring 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 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 new mid-level motherboards and ground-level computers. At the same time, high-level innovations often provide the building blocks, as well as the motive, for lower-level innovations. A breakthrough in solid-state physics may, for instance, provide the motive and 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.

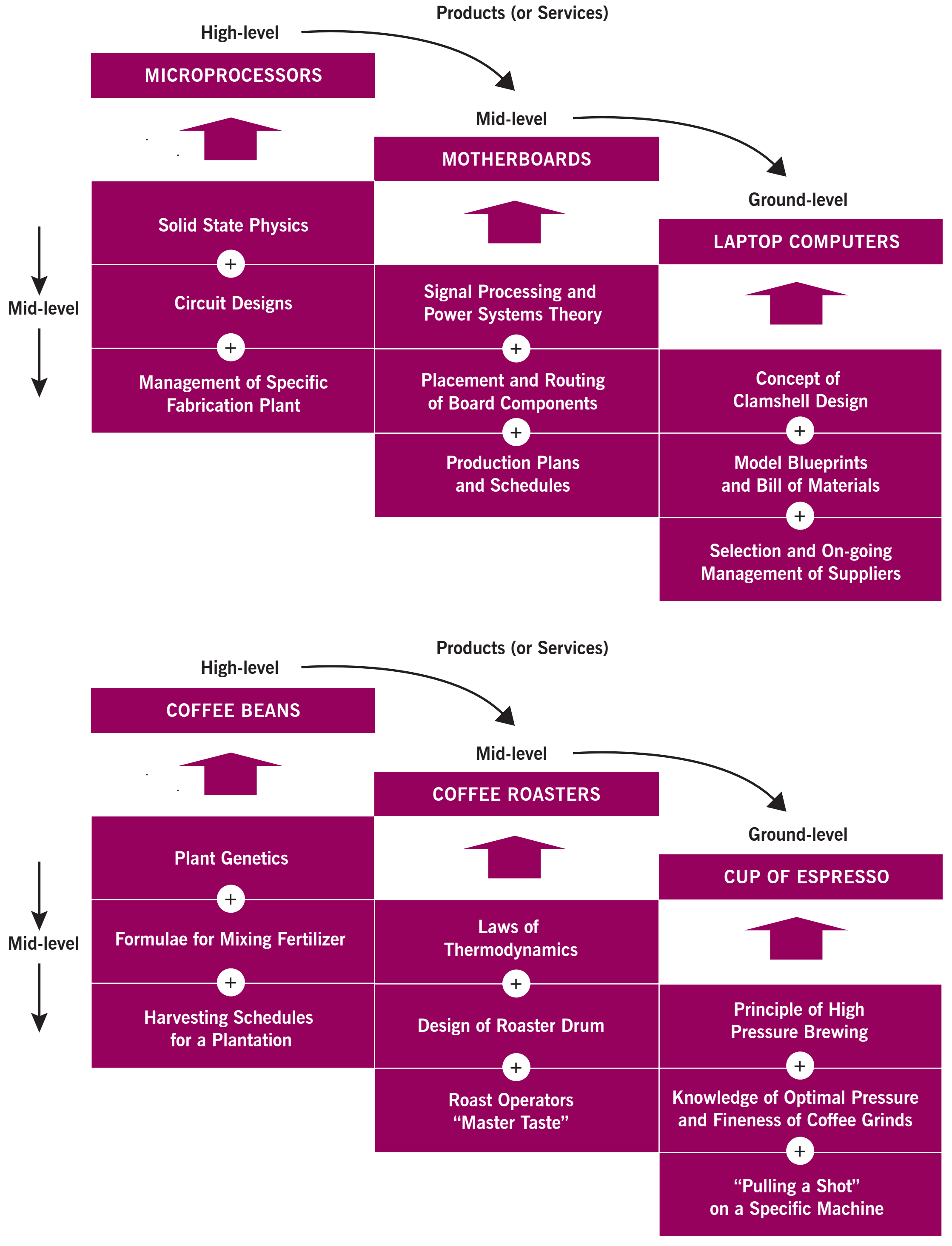
Interconnected, multilevel innovations that are not, in the usual sense, "technological" are also necessary for realizing the value of new know-how and products. A new "diskless" (or "thin client") computer, for instance, will generate revenue for its producer and value for its users only if it is effectively 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 using 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

17. 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.

18. 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 1 **Levels of Innovation for Know-how and Products**



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 develop *on its own* 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 in 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 these patented designs was 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. Then, 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.

In other words, the initial discoveries of German physicists set 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. And some of this lower-level knowledge (such as getting high production "yields" in a semiconductor plant) has been very difficult to codify and is still considered a black art.

Companies that incorporated transistors into lower-level products like 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. While international trade in manufactured goods has skyrocketed, most service sectors remain "untraded"—services in retailing, real estate, and health care, for example, 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 bytes 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.[19] This assumption 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.

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

The reality, however, is that *high-level ideas cross national borders rather easily, whereas a large proportion of "final" output, especially in the service sector, does not*.

The Propositions

My analysis of the multiplayer game and cross-border interactions suggests outcomes that differ sharply from the dire predictions of the techno-nationalists. According to my assessment, the United States is not 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. Indeed my analysis suggests that advances abroad will *improve* living standards in the U.S. Moreover, the benefits I identify are different from the conventional economist's account whereby 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. And contrary to the policy prescriptions of techno-nationalists, I suggest that the U.S. embrace the expansion of research capabilities abroad instead of devoting more resources to maintaining its lead in science and cutting-edge technology.[20]

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

The world is a long way from being "flat"—China and India aren't anywhere close to catching up with the U.S. 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 the country's average productivity, remains behind that of the U.S.

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 than Japan to develop and use innovations. Is it likely, then, that within any reader's lifetime China and India will attain the parity with the U.S. 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 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 U.S. continue 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. But I am skeptical that these efforts are going to do any more good for China's and India's economy than similar efforts in Europe and Japan in the 1970s and 1980s.[21] But putting 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 this might cause really threaten U.S. prosperity? Should the U.S. government respond in kind by putting even more money into research?

Nobel laureate Paul Krugman has long decried what he refers to as the "dangerous obsession" with "national competitiveness." As Krugman wrote in a 1994 article in *Foreign Affairs*, the widespread tendency to think that "the United States and Japan are competitors in the same sense that Coca-Cola competes with Pepsi" is "flatly, completely and demonstrably wrong." Although "competitive problems could arise in principle, as a practical, empirical matter," Krugman goes on to say, "the major nations of the world are not to any significant degree in economic competition with each other."[22]

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 recog-

20. As noted earlier, 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.

21. Examples include the supersonic Concorde and the French government's effort to make Machine Bull a counter to IBM's dominance of the computer industry.

22. Paul Krugman, 1994. "Competitiveness: A Dangerous Obsession." *Foreign Affairs* 73, no. 2 (March-April): 28-44.

nize 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. Sony paid all of $50,000—and only after first obtaining special permission from the Japanese Ministry of Finance—for the license that started it on the road to becoming a household name in consumer electronics.

Moreover, if patent holders choose not to grant licenses but to exploit their inventions on their own, 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, instead of licensing, 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, 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 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 U.S. 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, far from hurting the U.S. economy, may well be a blessing for the following reason: *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.[23] And the U.S. 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 U.S. plays an especially important role in my argument. The service sector now accounts for a large share of economic activity in the U.S.—nearly 70% of GDP in 2004 (up from 54% in 1974). The benefits of innovations that improve the productivity and general performance of U.S. service providers accrue mainly to U.S. workers and consumers because, in contrast to manufacturing, most services are not traded; they are both produced and consumed in the U.S. 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

23. Contrary to the suggestion of Paul Samuelson that European and Japanese reconstruction may have dampened growth in the U.S.

“Nondestructive Creation”: Beyond Schumpeter

But what if the many service sector jobs that have hitherto been sheltered from international competition go the way of call-centers? In the long run, very few jobs—in services and manufacturing—are safe. In the past decades countless service sector employees—bank-tellers, typists, compositors and payroll clerks—have lost their jobs because of new technologies and off-shoring.

At the same time, however, the number and proportion of service sector jobs have continued to increase because of a process I have called “non-destructive creation.”[24] Innovation, in Schumpeter’s immortal metaphor, certainly involves a great deal of “creative destruction”—think of the automobile doing away with the stage coach. But that phrase is in some ways misleading, and understates the social gains from the process. Airplanes did not destroy automobiles, to cite just one example. Some of the goods and services we now use are substitutes for those used by our forebears, but many satisfy entirely new wants. Moreover new goods often create more service sector jobs than manufacturing jobs—think again of airplanes. Therefore, even as some service sector jobs become obsolete (or are off-shored), the net number continues to increase with the widening range of goods in our consumption basket, *regardless of where these goods might be manufactured*. More X-rays may or may not be read by offshore radiologists, but the invention of PET-scans and MRIs provides even more employment opportunities for U.S. based radiologists, para-medics, and technicians.

impact on U.S. productivity (since most shoes sold in the United States are imported).

As we shall 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 U.S. than in Europe and Japan since the mid-1990s. The U.S. is not just an important source of IT innovations, but also a venturesome user; indeed the U.S. is ahead of all other large economies in its IT expenditures per unit of G.D.P. And expenditures are high because U.S. users, especially in the service sector, are exceptionally good at harnessing IT innovations regardless of where they originate. 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 U.S. than in other countries—possibly including Germany—where regulations, custom, and other factors may discourage retailers from using the new technology.

How should the U.S. (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? 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.

But 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. And even if diverting resources from, say, marketing to R&D actually increases knowledge spillovers, the reduction in marketing activities could 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 *consumer surplus*—the utility or value that buyers receive in excess of the price they pay. In many cases (for example, 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.

But the commercial success that generates the consumer surplus generally requires both technical effort (such as R&D) and marketing effort. Companies have sales and marketing

24. I introduced the term during a lecture called “Non-destructive Creation: How Entrepreneurship Sustains Development” that was given at the Royal Society of Arts in London, November 17, 2004.

departments for a reason: new products and processes, even great ones, don't sell themselves. 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.

Business historians since Alfred Chandler have emphasized the contribution of balanced, "multi-pronged" investment in R&D, marketing, and general organizational capabilities to the creation and success of the large modern corporation both in the U.S. and elsewhere.[25] As corporate managements have long recognized, innovative products don't help companies that can't sell them,[26] and the capacity to sell innovative products is wasted if there are no products to sell.

Now 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 that is ideal for stockholders may be too high or too low for society at large. But differences among companies 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? In a market-based economy, the alternative approach of designing incentives for individual firms is unworkable. Who, save for die-hard advocates of state control, would suggest the creation of a board 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 later in this book that technological progress expands the minimal functions of government. For example, as 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 suggest, good systems do not always emerge spontaneously.[27] 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.

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 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.

25. Chandler, A. D., Jr. 1990. *Scale and Scope: The Dynamics of Industrial Capitalism*. Cambridge: Belknap Press of Harvard University Press.

26. One 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's dominance."

27. See Jaffe, Adam B., and Josh Lerner. 2004. *Innovation and Its Discontents: How Our Broken Patent System Is Endangering Innovation and Progress, and What to Do about It.* Princeton: Princeton University Press.

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."[28]

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—that is, 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 way to store and manage data and entertainment files, and to "stay current on the go with audio books, news and information podcasts and video clips."[29]

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."[30] Another industry observer jests that Jobs may have, beyond natural charisma, a supernatural "reality distortion field."[31] 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 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.[32]

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."[33]

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 U.S. (which accounts for less than 5% of the world's population and about 30% of its GDP)[34] accounted for 85% of the global shipments of MP3 players.[35] 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 U.S. accounted for about 70% 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 U.S.—more than five and a half times the 4.8 million it sold in the rest of the world.[36]

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% to 30% on iPod sales, which is 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.

28. Malone, M. S. 2007. "iGenius." *Wall Street Journal*, January 11, A15. Malone 2007.
29. Email from Susan Kevorkian, March 8, 2007.
30. Malone 2007.
31. Dvorak 2007.
32. Malone (2007), cited earlier.
33. Malone (2007).
34. When measured at market exchange rates. At purchasing power parity rates, the U.S. share of the world's GDP is about 21 percent.
35. IDC estimate reported by CNN.com on March 30, 2001, posted at http://edition.cnn.com/2001/TECH/ptech/03/30/mp3.hotcakes.idg/index.html.
36. Morgan Stanley report by Richard Bilotti and Svetlana Ksenofontova, cited by Yoffie, D. B., T. D. Merrill, and M. Slind. 2006. "iPod vs. Cell Phone: A Mobile Music Revolution?" Harvard Business School Case No. 707-419.

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 beneficial effect of iPod on U.S. jobs has come 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.[37]

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.[38]

Given the main arguments of this book, 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 answer to this critical question ends up turning on the attractiveness of the U.S. consumer market: provided Nokia also focused on U.S. consumers, little would have changed. In other words, in a world where the high-level innovations—MP3 standards, ARM microprocessor designs—are mobile, what happens at the lower levels of the innovation game is crucial.

What Can We Learn from 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.[39] 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, there are several reasons why 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*. 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% of VC investments in the U.S. were in information technology/telecom or life sciences—sectors that account for less than 20% 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 predicated entirely 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 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.

By 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 innova-*

37. According to an estimate cited in Yoffie, Merrill, and Slind (2006), the "bill of materials" for a video iPod in 2005 accounted for just under half of the $299 retail price. The bill of materials includes the difficult-to-estimate profit margins of the suppliers. The value-added in the distribution and logistics chain is also difficult to estimate, because of Apple's vertically integrated structure. According to industry experts, the distribution channels usually account for 30 to 40 percent of the retail price of consumer electronics goods.

38. 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.

tion game in terms of both product and know-how and, in so doing, they *help us identify some of its distinguishing features* of mid-level innovation. 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.[39] 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. VC-backed businesses develop not only technical know-how, but also "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 important as technical virtuosity, and the technical tasks themselves involved more ad hoc improvisation than classical scientific experimentation.[40]

Third, studying VC-backed businesses *provides insights into 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% of U.S. GDP in 2004. And since services, as noted earlier, now account for nearly 70% of GDP, 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. My predisposition to believe that different forms of organization have different capabilities and limitations makes me skeptical. After all, if VC-backed businesses are so much more productive in generating innovations than corporate R&D units, as some researchers have claimed,[41] why haven't we seen a significant redeployment of corporate R&D resources to the VC model?[42] 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.[43] There are good and bad trumpet players and flautists; but to say that trumpet players as a class are more productive than flautists 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, and of marketing and management as well as scientific research and R&D.

Indeed, one of the clearest and most telling insights from my study of what VC-backed businesses do—as well as what they rely on others to do—is the high degree of specialization by 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 limited interactions—those, 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 U.S. should respond to the emergence of new sources of cutting-edge research abroad.

39. Freeman and Soete's *The Economics of Industrial Innovation* (third edition, 1997) 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% 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." See Freeman, Chris, and Luc Soete. 1997. *Economics of Industrial Innovation*. 3rd ed. Cambridge: MIT Press.

40. 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.

41. The best-known example is a paper by Kortum and Lerner (2000). Using a variety of methods, but then "focusing on a conservative middle ground," they estimate that "a dollar of venture capital appears to be three times more potent in stimulating patenting than a dollar of traditional corporate R&D." They then suggest that "venture capital, even though it averaged less than 3% of corporate R&D from 1983 to 1992, is responsible for a much greater share—about 8%—of U.S. industrial innovations during this decade." Kortum, Samuel S, and J. Lerner. 2000. "Assessing the Contribution of Venture Capital to Innovation." *RAND Journal of Economics* 31:674-92.

42. VC investments have expanded manifold in the last two decades, but in the greater scheme of things the amounts are still underwhelming. According to the National Venture Capital Association, VCs invested a total of $22.2 billion in 2005—less than what private equity firms often spend on a single acquisition and comparable to the sum of IBM's and Intel's capital and R&D expenditures.

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

Debts to Earlier Work

Although I derived my propositions about innovation and global competition through an inductive process involving observations of mid- and ground-level innovations—a territory outside the field of vision of many scholars—my research is by no means without antecedents or influences. Much as a devout Hindu would begin a journey with a prayer to the Lord Ganesh, any discussion on modern innovation must begin by invoking Joseph Schumpeter. The thousands of pages he wrote over more than four decades detailing the workings of a process he called "creative destruction" have prompted one scholar to describe his thinking as "the accepted model for all i nnovative activity." But, as others have pointed out, in making one's way down the stream of Schumpeter's sweeping, claims, one begins to encounter contradictions.[44]

I do not question Schumpeter's overall thesis—that innovation drives long-term growth, and that some businesses are displaced by new technologies. 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 give us better 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 incongruous with, if not outright contradicted by a large body of empirical research as well as my own observations of the modern innovation system. I believe that misconceptions in the Schumpeterian model—notably, the zero-sum notion that all innovations come at the expense of existing products and services—are at the heart of many alarmist prognoses of the consequences of the erosion of the U.S. technological lead. And although mainstream economics does not make the extensive mistakes and exhibit the muddle that I find in Schumpeter, I share Phelps's view that it offers limited insight into the evolving, unruly processes of innovation.

But if neither Schumpeter nor mainstream economists offer much guidance, there are two economic theorists—Frank Knight and Friedrich Hayek—whose views of entrepreneurship have informed and reinforced my observations and interpretations. Other particularly noteworthy influences (and a list of their works is provided below) 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 multi-period, 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.

Two Thoughts in Closing

The key to widespread prosperity, especially into a venturesome economy like the U.S., is widespread productivity improvements, not just the exceptional performance of a few inventors, scientists, or entrepreneurs. Widespread productivity improvements in turn require the widespread *use* (as opposed to just the development) of innovative technologies, and thus venturesome consumption of innovations as well as their development. In other words, a dynamic economy involves a massively multiplayer game; it is not a spectator sport where we are entertained by a few professional athletes.

Moreover, this game is not, as many people seem to believe, a "zero-sum" game in which the gains of "the winners" come wholly at the expense of "the losers." In 1779,

44. Jon Elster describes Schumpeter as an elusive writer who could contradict himself in the course of a single paragraph. (See Elster, Jon. 1993. *Explaining Technical Change: A Case Study in the Philosophy of Science.* Cambridge: Cambridge University Press.) Nevertheless, as Rosenberg puts it, "His model has become the accepted one for all innovative activity." Rosenberg, Nathan. 1976. *Perspectives on Technology*. New York: Cambridge University Press.

Adam Smith wrote in a letter to Lord Carlisle, head of the British Board of Trade: "Should the industry of Ireland, in consequence of freedom and good government, ever equal that of England, so much the better would it be not only for the whole British Empire, but for the particular province of England. As the wealth and industry of Lancashire does not obstruct but promote that of Yorkshire, so the wealth and industry of Ireland would not obstruct but promote that of England." Now we may say that should the scientific and technological prowess of China and India ever come to equal that of the United States, so much the better for the U.S.

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