HUDSON INSTITUTE PROJECT ON INNOVATION

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The Hudson Institute Project on Innovation is effort to understand and sustain American technological innovation. This paper sets forth the project's background, underlying assumptions, and major topics of research and discussion

Background

Throughout American history, technological innovations—from the cotton gin during the Washington administration to the tablet computer during the Obama administration—have repeatedly upended the status quo, transformed methods of production and patterns of living, and led to dramatic improvements in economic performance and personal well-being. Can this record be sustained in twenty-first century America? Given the many imponderables affecting the pace and direction of invention, can we specify measures likely to advance "the Progress of Science and useful Arts" in the fractious, populist, heavily indebted democracy that our nation has become?

These questions have come to the forefront of late because of a confluence of technological innovation and economic stagnation:

- On the one hand, America is in the midst of two innovation revolutions—in information technology (IT—underway for more than thirty years) and in oil and gas extraction (especially fracking—horizontal slick water fracturing, underway for fifteen years). Both are the result of brilliant inventions that have made several inventors folk heroes akin to the Edisons and Bells of times past. Both are generating tremendous, widely shared material benefits that are certain to increase in years to come.

- At the same time, the American economy has been performing poorly, and at least some of the problems transcend the financial collapse of 2008 and subsequent Great Recession. Median income, per capita GDP, and total factor productivity (an estimate of the contribution of new technology to productivity growth) have all been growing more slowly since the early 1970s than in earlier decades. The Internet boom fueled higher growth rates beginning in the mid-1990s—but then they regressed again *before* 2008, suggesting that long-term innovation-led growth may have peaked in the 1970s. Whatever the aggregate trends may portend, one sector that is essential to innovation and growth—education, including higher education—has been characterized by steeply growing costs and declining productivity, and has itself proven highly resistant to innovation.

These divergent developments have inspired two schools of thought. The first, pessimistic school[1] argues that America and the other advanced economies have entered a period of lower growth and slower innovation. If one compares 2012 living standards with those prevailing from ancient times through the eighteenth century, most of the improvements are the result of innovations from the 1800s through the 1960s—in transportation, housing and construction, machinery, electric power and lighting, communications, food, pharmaceuticals, plumbing, water supply, and waste treatment. The benefits were realized through urbanization, increased mobility, improved health and longevity, and the transformation of women's roles in the household and workplace—and most of these changes are naturally self-limiting and incapable of continued progress at historic rates.

The pessimists argue that, with the admittedly important exception of IT and the Internet, the pace of innovation has slowed markedly in the past forty years. Progress in transportation, energy, and the conquest of disease has been slower than expected, and recent advances in the extraction of fossil fuels may not even keep pace with the growth of global energy demand. At the same time, our culture has become more risk-averse (as in popular opposition to nuclear energy) and our politics more populist (as in popular support for pharmaceutical price controls). America has become wealthy and comfortable but static: it is losing the thrusting, entrepreneurial spirit that is necessary for exploiting such further opportunities for innovation as nature affords.

The second, optimistic school[2] argues that the pace of invention is inherently unpredictable and that the natural limits to progress have often been overestimated in the past. That some rates of technological improvement (such as transportation speed) have slowed or halted in recent decades tells us little about the future; that some innovation-led social transformations (such as women entering the workforce in large numbers) can happen only once does not mean that other, equally momentous changes are not possible. Not every measure of improving health status has slowed: life expectancy at 60 years has been increasing at a *higher* rate since 2000. While breakthrough technologies in energy production, distribution, and storage have proven elusive, the challenges are theoretically tractable: energy per se is

[1] Exemplified by Robert J. Gordon, "Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds," NBER Working Paper 18315, Aug. 2012; Peter Thiel, "The End of the Future," *National Review,* Oct. 3, 2011; and Tyler Cowen, *The Great Stagnation* (2011).

[2] Exemplified by Mark P. Mills, "The Next Great Growth Cycle," *The American*, Aug. 25, 2012; Matt Ridley, *The Rational Optimist: How Prosperity Evolves* (2010); Paul M. Romer, "Economic Growth," in *The Concise Encyclopedia of Economics* (David R. Henderson, ed., 2007); and Peter W. Huber and Mark P. Mills, *The Bottomless Well* (2005).

essentially infinite, and the problems of organizing and applying energy present abundant opportunities for continuing innovation. In the meantime, we have been making steady progress in the efficiency of energy use, and the recent breakthroughs in extracting shale oil and gas have lowered prices, repudiated peak-oil pessimism, and extended the era of carbon-based energy (and the time for developing fundamentally new technologies) far beyond earlier projections.

And, say the optimists, the IT revolution is much more than a transient bright spot. Many of its applications, such as computational manufacturing and driverless cars and aircraft, are only beginning to be realized. More profoundly, it is a "meta-innovation" that is taking the power of human understanding and discovery to a new level. "Big data"—the storing, organization, and manipulation of vast quantities of information—is transforming biomedical research and other natural and social sciences. The Internet is a quantum leap in exchanging, combining, and applying ideas—the fundamental process of the evolution of knowledge. IT and the Internet are already spurring progress in areas such as energy and education that have been resistant to innovation in recent decades. Still-tentative developments in education suggest that IT has a capacity for "creative disruption" that can solve not only scientific and economic problems but also political problems.

The pessimistic and optimistic interpretations have attracted much attention and provoked fascinating debates. But what difference do they make in assessing strategies for encouraging future innovation? The two schools agree that technological innovation—not just more people, land, and physical capital—is essential to economic growth. Neither doubts that the record of innovation and material progress during the past two centuries is unprecedented in recorded history, and that a continuation of that record cannot be taken for granted. And no sensible person is saying that mankind has now discovered most of the usable knowledge that nature has to offer. These important points of agreement tell us that innovation is a comprehensible and consequential subject, and that policies to promote or facilitate innovation are worth serious investigation.

Where the schools differ is over the prospects for robust innovation and economic growth in the immediate future. But the policy implications of these differences are subtle—they depend not only on whether the prospects are poor or excellent but also on the reasons for those prospects. Thus, a pessimist who believes that the innovation slowdown is primarily a result of adverse changes in policy, politics, and culture might counsel a *higher* priority for innovation-encouraging measures to counter those changes. And an optimist who believes that big innovations are coming on their own steam might be skeptical about "innovation policies"

of any sort—thinking that they would be inconsequential or, worse, would reflect the political status quo and thereby *retard* innovation. Finally, a world where peacetime economic growth averages 1 percent rather than 2 percent (per capita, per year) will soon be a very different place than the one most Americans have known for most of our history. If we have indeed entered such a world, then many other changes in government policy, civic institutions, and business strategy may take precedence over pro-innovation exertions.

These disagreements are rooted in uncertainties concerning the determinants of innovation and the effectiveness of measures aimed at changing its rate or direction. The uncertainties are inherent in the nature of innovation; policy is not going to resolve them, and should therefore accommodate them. This does not mean that innovation policy should be tentative or half-hearted. Rather, it should focus on measures that are concrete and non-speculative and are free of technological or ideological enthusiasms. Insofar as possible, innovation policy should emulate innovation itself—proceeding in the experimental spirit of the scientist and the trial-and-error spirit of the inventor and business entrepreneur. It should also embrace the spirit of diversification—complementing measures to promote other goals whose social value is widely acknowledged, such as competition, pluralism, and open entry to new ideas and new methods of production and organization.

Accommodating uncertainty also means focusing on revealed potential—where important new discoveries in science and technology have already been made and the process of development and deployment is underway (such as, today, information, energy, and biomedical technology). This principle may seem to conflict with the well-known principle of public economics, that government should concern itself with research but not development—that is, with the creation of basic knowledge, a non-rivalrous public good, rather than with practical applications whose investments can be captured in private markets. But the two principles need not conflict. Major innovations frequently displace existing methods of production and organization and undercut investments in those methods. And the existing methods are often entrenched in government policy, or in influential private institutions that may call upon government for assistance in suppressing threatening innovations. Checking the "status-quo bias" of established institutions may be the most direct and powerful form of innovation policy.

These principles are elaborated in the following section.

Premises and Heuristics

Innovation and innovation policy are the subjects of a large academic literature and of many recent books and government and professional task forces.[3] The Hudson project will not replicate these studies and proposals. It will proceed from a set of assumptions aimed at breaking new ground and producing distinctive results:

1. Fostering a high capacity for innovation is a legitimate, indeed vital, function of modern government. But different strategies will be advantageous to different nations. The governments of Finland and Singapore aggressively promote innovation in specific sectors, and are lauded for scoring near the top of national innovation rankings. But they are small, homogeneous nations, more akin to American states and cities than to the American nation. The United States should not attempt to emulate them (our federal government could not possibly be so tactical and authoritative in any event), but rather should pursue policies that recognize our own circumstances and take advantage of our unique size, diversity, and political traditions and large domestic markets.

2. Innovations may be categorized into major intellectual advances (Shannon's Second Theorem), major natural discoveries (electromagnetic radiation), major physical inventions (the transistor and the integrated circuit), and small incremental improvements in design and practice (innumerable and incessant in a dynamic economy—Paul Romer offers the example of coffee shops standardizing the size of lids on large and small coffee cups). Innovations may also be based on new or old or even ancient technology (the wheel and luggage had coexisted for millennia before anyone thought to put wheels on luggage).[4] U.S. innovation policy should specialize in major advances in pure ideas, natural discovery, and physical invention and rapid deployment of new ideas and technologies. Incremental improvements in design and practice, and new combinations of established technologies, are based on particular knowledge of specific problems and opportunities—where government is at a hopeless disadvantage to those on the scene, and can do little more than provide sound economic policies (tax, fiscal, monetary, regulatory) and enforce property rights. In contrast, government may have substantial advantages in exploring and developing the frontiers of knowledge and invention, as it did in exploring and developing the physical frontiers of times past. Current government practices—investing heavily in the scientific enterprise,

[3] Examples are Robert D. Atkinson and Stephen J. Ezell, *Innovation Economics: The Race for Global Advantage* (2012); the reports of the President's Council of Advisors on Science and Technology (posted at www.whitehouse.gov/ostp/pcast); U.S. Department of Commerce, "The Competitiveness and Innovative Capacity of the United States" (Jan. 2012); and American Chemical Society, "Innovation, Chemistry, and Jobs: Meeting the Challenges of Tomorrow" (2011).

[4] There are, to be sure, numerous intermediate examples—the computer mouse and graphical interface were much more momentous than standardized coffee cup lids, and the tape cassette and earphones had been around for only a few decades before they were combined into the Walkman. But the categories are useful for defining productive innovation policy.

sponsoring innovative projects of immediate public importance for military or other reasons, and celebrating and rewarding daring and accomplishment in science and technology—are the place to start, and can be improved and supplemented. The particulars should be suited to the purposes of expanding the dominion of new knowledge and technology and facilitating their prompt development for the benefit of the American public.

3. Federal innovation policies are often debated in terms of "more" or "less" within a generally accepted framework. These include the budgets of the National Institutes of Health and other research-grant agencies and of the Patent and Trademark Office; the scope and generosity of the Research and Experimentation tax credit and similar tax policies; and the breadth and duration of patent rights. The Hudson project will take up the substance of some of these policies but will not be a platform for advocating "more" or "less."

4. Innovation policy is separate from trade policy. The two are often conflated because of the effects of market globalization. Globalization is largely the result of innovations in transportation and communications. One of its effects is to depress U.S. wages in many lower-technology occupations now easily moved to lower-income nations, thereby increasing the returns to higher, less exportable skills in the United States. Another is to force American firms to contend with the very lenient intellectual property regimes of other nations such as China and Brazil, which often shade into outright piracy. U.S. policies and business practices need to respond to such developments, but doing so will have little effect on our innovation capacity and performance.

5. American innovation contributes to "national competitive advantage," but we should not try to protect our innovations for other than defense and security reasons. Thanks to globalization, the benefits of American innovations reach foreign nations much more promptly and thoroughly than in the past (even with strict intellectual property enforcement). That promotes foreign economic growth—sometimes at much higher rates than our own, because less developed nations are growing from a smaller base and because they may leapfrog our older technologies such as landline telephony. But this does not mean that foreign benefits subtract from American benefits (through trade and specialization, they add), and it does not suggest that we should discourage U.S. firms from making foreign investments or should direct our innovation policies toward non-exportable economic sectors. Our domestic markets are very large, rich, and diverse and can repay substantial investments in new knowledge and technology. And it is greatly to our advantage that major innovations should originate in the United States: American-bred innovations are more likely to reflect distinctly American values and interests and, as exports, to promote our values and interests around the world.

6. Major innovations often originate in the discoveries and inventions of large, established institutions—the research laboratories of government, universities, and business corporations. But the innovations themselves—the practical

applications, even of inventions from corporate labs—often come from small, start-up enterprises. The reason for this discontinuity is that organizations are shaped by what they make and market. Their structure, practices, and habits of thinking are adapted to their products: product and organization evolve together as a "problem-solving paradigm." But new inventions may lead to entirely new paradigms (as did the desktop computer). Incumbent institutions may be blind to this potential or, if they see it, may be unable to make more than marginal adjustments to exploit it. Those who are unfettered by (or discontented with) the old paradigm will be in a better position to build new structures and practices for pursuing a new one. And when new paradigms begin to succeed, threatened incumbents will look for opportunities to suppress them (a current example is taxi cab firms and their regulators attempting to restrict or ban the new Uber car-service paradigm).

These circumstances suggest that America's innovation capacity depends on coupling (a) a strong research base in science and technology with (b) a strong entrepreneurial culture and open-entry policies for new firms, ideas, and institutional forms. Innovation policy should pay equal attention to both. And the principle of open entry is not just for commerce: scientists and engineers, too, become invested in paradigms that have worked in the past. Most new ideas, products, and firms will of course be failures—but all of them, including those that could produce vast social improvements, begin without a constituency. Innovation policy should seek to create space for the new and unfamiliar to prove itself in competition with the old and established.

As noted in the previous section, government is prone to being the cat's paw of established paradigms. Obviously, it is politically problematic for the government to counter its own status-quo biases, but this has happened in the past and the examples are worth study and emulation.[5] There are many cases where government policies stand as barriers to major innovation.

7. Finance is the provision of resources to bridge the time and uncertainty between a plausible idea and its practical realization. U.S. regulatory policies are increasing biased against entrepreneurial, high-risk/high-return finance, and devoted to channeling financial resources toward current consumption (e.g., homeownership) rather than productive investment. These are appropriate concerns of innovation policy.

8. Major innovations with large social benefits frequently have large social costs as well. The cotton gin augmented the power of Southern slavery (although Northern innovations in manufacturing and transportation would later help to win the Civil War and end slavery). Today's mobile wireless technologies facilitate the coordinated actions of terrorist groups and democratic freedom fighters alike. The economic collapse of 2008 was caused in part by new fi-

[5] In the early 1970s, the White House Office of Telecommunications Policy single-handedly averted a government monopoly in satellite communications, which other agencies and influential business interests were energetically promoting.

nancial technologies whose consequences were poorly understood. Every parent of young children must contend with the undiscriminating power of the Internet and the seductive appeals of fast food and popular culture. These are important issues, but the Hudson innovation project will leave them to others.[6] The purpose and effect of technological innovation is to increase human powers; human beings are capable of both good and ill conduct, and our understanding and foresight are imperfect; therefore every new technology increases our power for good, for harm, and for mistakes and "unintended consequences." These truths do not suggest that the quest for greater knowledge and mastery is itself unworthy. They will, indeed, suggest to many that that quest is highly worthy and that Americans, especially, should remain in the forefront. Human progress may be said to consist of enlarging our knowledge and power while learning to apply them to good ends and to limit their use for bad ends.

Topics

The Hudson Project on Innovation is preparing papers on specific topics in innovation policy for discussion at workshops of scholars, business executives, and government officials. The papers will then be revised and published as a continuing monograph series. Our initial lineup is as follows:

1. *Technological Innovation and Economic Growth.* A review and interpretation of the scholarly literature from Adam Smith to the present time.

2. *American Accomplishment Today.* An extension to contemporary America of Charles Murray's landmark 2003 work, *Human Accomplishment: The Pursuit of Excellence in the Arts and Sciences, 800 BC to 1950.*

3. *Innovation and Entrepreneurship.* A study of the decline of new-business formation in the United States and its implications for innovation.

4. *Government Support for Science and Technology.* A critique of the structure and methods of federal grant-making for basic scientific research and engineering, with proposals for reform.

5. *Innovation in Higher Education: Technology, Institutions, and Finance.* An evaluation of the implications of new information and other technologies for the structure and financing of higher education, with original proposals for institutional innovation in university teaching, certification, and research.

6. *Three Opportunities for Dramatically Accelerated Innovation.* Although the nature and consequences of future innovation are usually highly uncertain, there are cases where we already know that existing technologies could produce major practical improvements—but are being held back by established institutions

[6] The superb quarterly *The New Atlantis* is devoted to the social, political, and moral dilemmas of new technology—see www.thenewatlantis.com.

embodying "status-quo bias." These three studies will propose fundamental reforms to current arrangements for allocating the electromagnetic spectrum, managing the air traffic control system, and regulating the introduction of new pharmaceuticals and medical devices, and provide estimates of the social benefits of each reform.

In addition, we are considering papers on the following additional topics, and will no doubt add more as the project proceeds:

7. *Real Crowdsourcing: The Prospects for Information and Prediction Markets.*
8. *From Theory to Practice: Speeding the Introduction of New Inventions*
9. *Financing Innovation.*
10. *Politics versus Science in Energy Innovation.*

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