10 Linking Scientific Research to Societal Outcomes

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Despite great advances during this century, science and technology have failed to address some of the most critical existing and emerging needs of society. In the late 1990s, the U.S. economy reached its 20th century apogee, largely driven by science and technology; but we still find ourselves with widening income gaps and in general, poor distribution of the benefits of science. Great scientific discoveries have been made over the past 50 years, but they sometimes seem to bear limited correspondence to the priorities and needs of all U.S. citizens and an increasingly global community. So, how can we design a science policy that will contribute its utmost to a multitude of widely distributed, highly beneficial social outcomes?

Vannevar Bush's 1945 report, *Science—The Endless Frontier,* established a social contract between science and society in which research investments were expected to advance the war against disease, ensure national security, and create jobs. But since the end of the Cold War, funding for science and technology has usually been rationalized in terms of contributing to economic growth and curing cancer. The President's Council of Economic Advisors and other economists have pointed out the high rates of return on investments in research and development. This spring, Federal Reserve Chairman Alan Greenspan repeatedly cited an unexpected leap in technology as primarily responsible for the Nation's record-breaking economic performance.

Science is certainly a significant contributor to economic growth, but a linear model does not do justice to its full contributions or impacts,

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nor does it help policymakers link scientific research to societal outcomes. And suggestions for the restructuring of U.S. science policy seem stuck in a funding-centered, input-driven paradigm.

Two assumptions that we have outgrown (assumptions that are too simple for the complexity inherent in science policy) are that science is a force for human good, all the time; and that socially optimal outcomes will emerge from the amalgamation of the results of individual scientific projects. In *Wired* magazine, Bill Joy, co-founder and Chief Scientist of Sun Microsystems, discusses where we might be headed if we do not think through what kind of a force science can be (see chapter 3). He points out the potentially negative outcomes of future research and shows us that science is not inexorably good. We should acknowledge the fear of what science makes possible, but we should also realize that what is possible is not certain. After all, science is discovery. The applications of that discovery or the future paths it makes possible are options. These options allow flexibility, speed, and agility in economic and social development.

As we go forward, we need to do two things with our science policy design. First, we need to focus on outcomes rather than only on inputs. Outcomes should receive attention and resources proportionate to their importance. Second, we need to restructure research portfolios so they more equitably distribute benefits and mitigate the social costs of technological change.

Science policy as it currently stands lacks a social dimension. Science and technology are formidable powers, but to benefit our society fully, science policy needs to be tempered with humanism. Policymakers need to consider social equity in the context of the distribution of the benefits of science; social purpose in terms of what might be the structural outcome of our scientific investments; and social enterprises, like research universities, for their economic effects.

Science has been increasingly called upon to inform policy-making, but successful linkages between the two have been extremely difficult to forge. We devote very little intellectual energy toward improving our incomplete understanding of the science-policy interface and the institutions focusing on this interface. Our scientific and technical abilities far outstrip our decision making methods and ability to understand the relationship between science and its many outcomes.

We have a science policy now that is heavily focused on the conduct of science and the funding of science. But what are the outcomes of this

science? Social outcomes of science include social equity changes, social structure evolution, and social enterprise development. We have had some increase in our ability lately to link these together, but we have not included these outcomes as measures, inputs, or mechanisms into our national science policy apparatus. In order to be responsive to the world we live in, and in order to design policy with hopes of giving direction or purpose to scientific discoveries and technological applications, we must consider the various, complex dimensions of this world. For example, the recent conclusion of the efforts to produce the first-draft map of the human genome will have profound effects on not only human health and medical care, but also food production and consumption, insurance, the structure of scientific research and institutions, marriage and social structure, and even, to some extent, human evolution. It is fair to say that most of these science-driven outcomes have not been as fully considered as the funding of the science itself.

An outcome-oriented policy would, in part, rely on the conduct of science to generate technology that could be transferred to the larger economy to create new industries. This would be an economic outcome of scientific research. These nascent industries would require, and thus facilitate, the creation of new skills. This education represents a social outcome of scientific research. With new industries and education come new social structures and new institutions, generated by and allowing the continuance of partnerships (between and among universities, government, and industry) and knowledge transfer, precipitating the ever-more-informed conduct of science. There is a derivative engine here that is working in the form of cycles. This is not to suggest, of course, that we can design a master plan to work all of these things out. Rather, it is to illustrate that science policy, as we go forward, should be embraced in its totality. We should think about the dynamics of the cycles involved in science policy because investments in science create new institutions, new structures, shifts in the economy, and changes in social structures, all of which come back and impinge on one other.

A visual interpretation of outcome-oriented policy would be the circular linkage of the conduct of science with economic, social, and scientific and technological outcomes. Scientific research and various societal outcomes would act as dynamic inputs and outputs for science policy. This is exciting stuff, and highly complex. The successful linkage of scientific research to societal outcomes depends on our understanding and ability to embrace this complexity.