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Contents

Nanotechnology: A Call for Policy Research

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ABSTRACT

We briefly overview U.S. policy initiatives related to nanotechnology and to the systematic investment in research that the U.S. Congress has approved to advance it over the nearly past two decades. Then, we summarize these U.S. research investments in nanotechnology, and we compare dimensions of nanotechnology activity in the United States to activity in other countries. The body of this paper is a nontechnical annotated bibliography of the relevant social science and policy literature; this bibliography is intended to serve as a reference document. Finally, we suggest specific directions for future policy research with a focus on a methodology for evaluating the social benefits of publicly funded nanotechnology R&D investments.

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1

Introduction

The birth of national interest in nanotechnology can be traced at least to a lecture given by Nobel Laureate Richard Feynman at the annual meeting of the American Physical Society at the California Institute of Technology in 1959: "There's Plenty of Room at the Bottom" (Feynman, 1960). Feynman stated:

> I would like to describe a field, in which little has been done, but in which an enormous amount can be done in principle. ... What I want to talk about is the problem of manipulating and controlling things on a small scale.... At the atomic level, we have new kinds of forces and new kinds of possibilities, new kinds of effects.
>
> – Feynman, 1960, p. 22 ff.

"Nanotechnology is the creation and utilization of materials, devices, and systems through the control of matter on the nanometer-length scale, that is, at the level of atoms, molecules, and supramolecular structures" (NSTC, 1999a, p. iii). Although nanotechnology was not mentioned by name in Feynman's lecture, the concept of U.S. scientists and engineers developing materials, as well as devices and equipment,

at an atomic scale was clearly envisioned. But, what would be needed were instruments to manipulate atoms.[1]

According to a recent report by the U.S. Congressional Research Service:

> Nanotechnology plays a central role in some current applications with substantial economic value. For example, nanotechnology is a fundamental enabling technology in nearly all microchips and is fundamental to improvements in chip speed, size, weight, and energy use. Similarly, nanotechnology has substantially increased the storage density of non-volatile flash memory and computer hard drives. In the longer term, proponents of nanotechnology believe it may deliver revolutionary advances with profound economic and societal implications.
>
> – Sargent, Jr., 2016, p. 2

Thus, the products and services that emerge from research into the applications of nanotechnology "may bring significant economic and social benefits to the United States and to the world" (Sargent, Jr., 2016, p. 23). As such, an objective of this paper is to provide a nontechnical reference document of the relevant social science and policy literature on nanotechnology. By so doing, we hope to engender not only a greater appreciation of the "significant economic and social benefits" (Sargent, Jr., 2016, p. 23) of nanotechnology but also to spur possibly more extensive research into the implications of public support of this technology — hence the subtitle of this paper, "A Call for Policy Research."

Toward these ends, in Section 2 we briefly overview U.S. policy initiatives related to nanotechnology and to the systematic investment in research that the U.S. Congress has approved to advance it over the nearly past two decades.

[1] An interesting nanotechnology timeline is at https://www.nano.gov/timeline. The elements on the timeline clearly predate Feynman.

In Section 3, we summarize these U.S. research investments into nanotechnology, and we compare dimensions of nanotechnology activity in the United States to activity in other countries.

In Section 4, we offer a taxonomy and overview of the relevant social science and policy literature related to nanotechnology. The taxonomy is a subjective classifying device for tracking the growth of this literature over time; the overview is a descriptive summary of how researchers in these disciplines have characterized the practice of nanotechnology. The Appendix to this paper presents an annotated bibliography of this literature.[2] Our extensive annotated bibliography not only fills a gap in the literature because the reviews that exist are limited in scope, but also our review points out the lack of policy research related to public investments in nanotechnology. This latter point is what motivates our perception of a need for policy research on this topic.

Finally, in Section 5, we suggest specific directions for future policy research with a focus on a methodology for evaluating the social benefits of publicly funded nanotechnology R&D investments.

[2] Any aspect of the literature related to nanotechnology from a social science or policy perspective that is not summarized in the Appendix is an unintentional oversight, and to such authors we offer our sincere apology. Public sector policy reports are not included in the Appendix table although they are referenced in the text of this paper.

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Professor Link's public service includes being a member of the National Research Council's research team that conducted the 2010 evaluation of the U.S. Small Business Innovation Research (SBIR) program. Based on that assignment, he later testified before Congress in April 2011 on the economic benefits associated with the SBIR program. Link also served from 2007-2012 as the U.S. Representative to the United Nations (Geneva) in the capacity of co-vice chairperson of the Team of Specialists on Innovation and Competitiveness Policies Initiative for the Economic Commission for Europe. Lastly, Link delivered the European Commission Distinguished Scholar Lecture in Seville, Spain, in October 2018.