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# ARTICLE

## INNOVATION IN THE SERVICE OF SOCIETY

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### ABSTRACT

*While modern science and technology have produced astounding advances, their contributions to social welfare often fall short of expectations. This Article provides a holistic framework for promoting “socially responsive” innovation that increases the social benefits, decreases the social harms, and improves the distributional effects of massive investments in science and technology. Traditionally, policymakers have relied significantly on centralized governance regimes such as mission-based science funding and technological regulation to guide the development and use of new innovations. While valuable, centralized approaches feature several shortcomings, and this Article proposes a distributed model of innovation governance to supplement them. In so doing, it draws on the CHIPS and Science Act of 2022, which bolstered the National Science Foundation’s longstanding practice of considering the broader social impacts of proposed research projects when awarding research grants. Building on these reforms, this Article proposes a model of distributed innovation governance that extends beyond central policymakers to confer greater authority to promote socially responsive innovation on a wide range of public and private stakeholders, peer reviewers, scientists, and engineers.*

*This Article argues for orienting various innovation gatekeepers—including federal funding agencies, scientific journals and conferences, and the Patent and Trademark Office—toward considering the broader social impacts (not just technical merit) of innovative projects when awarding key resources. By tying research funds, publication and presentation opportunities, and patents to assessments of social impact, this proposal creates a powerful incentive for*

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*scientists and inventors to consider and improve the contributions of their work to social welfare. This Article shows how government action can shift norms in the innovative community—including among private actors—to embrace socially responsive science and technology. This distributed governance model offers several benefits, including preserving scientific autonomy, guarding against the overpoliticization of innovation policy, and exploiting significant amounts of private information distributed among scientists and engineers.*

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*The Republic of Science shows us an association of independent initiatives, combined towards an indeterminate achievement. It is disciplined and motivated by serving a traditional authority, but this authority is dynamic . . . .*<sup>1</sup>

—Michael Polanyi

#### INTRODUCTION

Nestled in the CHIPS and Science Act of 2022 are the seeds for a revolutionary model of innovation governance.<sup>2</sup> Among other provisions, the legislation reshapes how the National Science Foundation (“NSF”) grants billions in research funds to thousands of scientists and engineers every year.<sup>3</sup> The Act bolsters NSF’s practice of evaluating grant proposals not only on “intellectual merit”—underlying scientific value—but also on “broader impacts”—the contribution of the proposed research to broader social, economic, and political objectives. In a novel development, the Act further requires that NSF grant proposals must address “ethical and societal considerations,” which may include any foreseeable risks from proposed research and potential technical or social solutions to mitigate those risks.<sup>4</sup>

By considering social impacts when granting research funds, NSF creates a powerful incentive for scientists and engineers to examine the broader social implications of their research. This incentive also applies to thousands of academic peer reviewers who assist NSF in screening grant applications. This practice can shift scientific norms toward valuing research not only for its technical merit but also for its contributions to social welfare. This Article argues for strengthening and expanding this model of innovation governance to guide science and technology to better serve social interests.

Although the United States alone spends \$656 billion on research and development (“R&D”) every year,<sup>5</sup> there is a palpable sense that modern science and technology are not meeting the needs of society. The innovation economy

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<sup>1</sup> Michael Polanyi, *The Republic of Science: Its Political and Economic Theory*, 1 MINERVA 54, 71-72 (1962), reprinted in 38 MINERVA 1, 19 (2000).

<sup>2</sup> CHIPS and Science Act of 2022, Pub. L. No. 117-167, §§ 10341, 10343, 136 Stat. 1366, 1557-58 (2022) (codified at 42 U.S.C. §§ 19051-52). This Article uses “innovation” in a broad sense to encompass scientific and technological activities. This is in contradistinction to more technical definitions of “innovation” in the economics literature referring to the commercialization of existing inventions. See Ted Sichelman, *Commercializing Patents*, 62 STAN. L. REV. 341, 366 n.149 (2010).

<sup>3</sup> *Fiscal Year 2022 Appropriations*, NAT’L SCI. FOUND., [new.nsf.gov/about/budget/fy2022/appropriations](https://www.nsf.gov/about/budget/fy2022/appropriations) [perma.cc/J3K4-8EV7] (last visited Apr. 3, 2024) (detailing how NSF used \$8.8 billion appropriated by Congress, \$7.2 billion of which funded “Research and Related Activities”).

<sup>4</sup> CHIPS and Science Act of 2022 § 10343(b)(1).

<sup>5</sup> AMY BURKE, ABIGAIL OKRENT & KATHERINE HALE, NAT’L SCI. FOUND., *THE STATE OF U.S. SCIENCE AND ENGINEERING 2022*, at 14 (2022), [nces.nsf.gov/pubs/nsb20221/](https://nces.nsf.gov/pubs/nsb20221/) [perma.cc/U8C8-F2RR].

commits billions to software startups while underinvesting in solutions for urgent challenges such as global climate change and neglected diseases.<sup>6</sup> In addition to insufficiently engaging with some problems, scientific and technological advances can make some problems worse. From social media that spreads misinformation, to automation that drives unemployment, to big data analytics that threaten privacy, novel innovations can create numerous harms.<sup>7</sup> Relatedly, there is growing concern that enormous investments in innovation disproportionately benefit monied, corporate interests rather than the least privileged members of society.<sup>8</sup> In sum, to adapt legal scholar Peter Drahos's phrase, the current state of affairs reflects a troubling deficiency of "socially responsive" science and technology.<sup>9</sup>

The inability of science and technology to meet prevailing needs is not just an abstract social problem, it is an urgent public policy challenge. In 2019, of the \$656 billion spent on R&D in this country, the U.S. government accounted for \$139 billion.<sup>10</sup> Beyond direct funding, the government supports innovation in myriad other ways, notably by operating a patent system tasked with promoting "the Progress of Science and useful Arts."<sup>11</sup> Given enormous public support for R&D, citizens and policymakers should question if they are getting sufficient social return on investment. This Article argues for a new model of innovation governance to enhance such social returns.

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<sup>6</sup> See Peter Drahos, *Responsive Science*, 15 ANN. REV. L. & SOC. SCI. 327, 332-33 (2020) (critiquing the commodification of science that has led to underinvestment in global challenges such as antibiotic resistance and climate change).

<sup>7</sup> See Peter Lee, *Patent Law's Externality Asymmetry*, 43 CARDOZO L. REV. 1923, 1942-48 (2022) [hereinafter Lee, *Externality Asymmetry*] (describing negative externalities arising from several technologies, including social media, autonomous vehicles, and big data analytics).

<sup>8</sup> See Dominic Basulto, *Global Innovation May Have a 1 Percent Problem*, WASH. POST (Jan. 21, 2016, 8:54 AM), [washingtonpost.com/news/innovations/wp/2016/01/21/global-innovation-may-have-a-1-percent-problem/](https://www.washingtonpost.com/news/innovations/wp/2016/01/21/global-innovation-may-have-a-1-percent-problem/) (noting that while innovation has lifted many out of extreme poverty, it may have made income inequality worse).

<sup>9</sup> See Drahos, *supra* note 6, at 335-36 (arguing that science, because it can generate, measure, and reduce risk, takes on "societal obligations of responsibility and responsiveness"). This Article situates itself within a broad movement to consider and enhance the social impact of research and innovation. This movement has a slightly different character, and proceeds under different names, in different contexts. In Europe, this movement is often characterized as "responsible innovation." See, e.g., *Framework for Responsible Research and Innovation*, UK RSCH. & INNOVATION (Mar. 16, 2023), [ukri.org/about-us/epsrc/our-policies-and-standards/framework-for-responsible-innovation/](https://ukri.org/about-us/epsrc/our-policies-and-standards/framework-for-responsible-innovation/) [perma.cc/8FTH-UQCH]. In the artificial intelligence ("AI") context, the movement to ensure that AI systems are consistent with human values and goals is known as "alignment." See Cade Metz, *What's the Future for A.I.?*, N.Y. TIMES (Apr. 4, 2023), [nytimes.com/2023/03/31/technology/ai-chatbots-benefits-dangers.html](https://www.nytimes.com/2023/03/31/technology/ai-chatbots-benefits-dangers.html) (defining "alignment" as "[a]ttempts by A.I. researchers and ethicists to ensure that artificial intelligences act in accordance with the values and goals of the people who create them").

<sup>10</sup> See BURKE ET AL., *supra* note 5, at 14, 19.

<sup>11</sup> See U.S. CONST. art. I, § 8, cl. 8.

Traditionally, the objective of maximizing the benefits of science and technology while mitigating their harms has informed two kinds of policy interventions, both of which represent “centralized” innovation governance. First, the federal government has pursued mission-based funding to achieve particular policy objectives. Unlike open grants for curiosity-based research (discussed further below),<sup>12</sup> mission-based funding involves political decisionmakers targeting discrete R&D priorities for support. Centralized, mission-based innovation funding has a long history, encompassing programs such as the Manhattan Project, Apollo Program, Human Genome Project, Cancer Moonshot, and Operation Warp Speed.<sup>13</sup>

Second, another form of centralized governance involves ex post legislation to address harms from science and technology.<sup>14</sup> For instance, the Biden Administration recently released the Blueprint for an AI Bill of Rights, which references a comprehensive suite of regulations to address the harms of automated systems.<sup>15</sup> Other jurisdictions also regulate technological harms in this centralized fashion. For example, the European Union’s General Data Protection Regulation (“GDPR”) and California’s Consumer Privacy Act (“CCPA”) seek to curb technological threats to privacy.<sup>16</sup> This approach relies on a central governmental entity—such as a legislature or administrative agency—identifying some innovation-related harm and developing laws or regulations to address it.

While centralized innovation governance serves valuable functions, it also suffers from several shortcomings. First, mission-oriented science funding dilutes the tremendous generative power of scientific autonomy.<sup>17</sup> As discussed further below, the extent to which government should conscientiously direct the activities of publicly funded scientists has been the subject of intense policy debates. A wide literature contends that researchers produce the most robust science when they can determine their own research agendas without political interference.<sup>18</sup> Second and relatedly, centralized governance can also overly

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<sup>12</sup> See *infra* Part IV.

<sup>13</sup> See *infra* Section II.A.

<sup>14</sup> An ex ante precautionary approach, which seeks to prevent adverse effects from uncertain technologies, represents another centralized-governance approach. While the United States exercises precaution in several regulatory programs, this approach has had more traction in the European Union. See Gary E. Marchant, *Governance of Emerging Technologies as a Wicked Problem*, 73 VAND. L. REV. 1861, 1868 (2020) (“The European Union is the recognized leader in applying the precautionary principle, having adopted the principle as a binding legal requirement in its foundational legislation.”).

<sup>15</sup> WHITE HOUSE OFF. OF SCI. & TECH. POL’Y, BLUEPRINT FOR AN AI BILL OF RIGHTS: MAKING AUTOMATED SYSTEMS WORK FOR THE AMERICAN PEOPLE 18-20 (2022) [hereinafter *Blueprint for AI*], [whitehouse.gov/wp-content/uploads/2022/10/Blueprint-for-an-AI-Bill-of-Rights.pdf](https://www.whitehouse.gov/wp-content/uploads/2022/10/Blueprint-for-an-AI-Bill-of-Rights.pdf) [perma.cc/QNN5-N4VU].

<sup>16</sup> See *infra* notes 92-93 and accompanying text.

<sup>17</sup> See *infra* Section II.B.1.

<sup>18</sup> See *infra* notes 110-24 and accompanying text.

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politicize innovation funding and regulation, subjecting those decisions to the whims of changing political administrations.<sup>19</sup> Finally, centralized governance suffers from the limited amount of information available to policymakers.<sup>20</sup> Such centralized approaches may fail to exploit substantial amounts of private information possessed by scientists and engineers in the field.

Given these limitations, this Article advocates a “distributed” or decentralized governance model to supplement centralized approaches in promoting socially responsive innovation. Extending beyond core policymakers, this model confers greater authority and responsibility for ensuring socially responsive science and technology to a wide range of stakeholders and legions of active scientists and engineers. It does so by leveraging governmental and nongovernmental institutions that support decentralized innovative activity by broad sets of actors.

This Article argues for orienting various innovation gatekeepers—including federal funding agencies, scientific journals and conferences, and the U.S. Patent and Trademark Office (“PTO”)—toward considering the broader social impacts (not just technical merit) of innovative projects when granting valuable resources to scientists and engineers. This proposal would infuse social considerations into the criteria by which gatekeepers grant valuable research funds, publication and presentation opportunities, and patents to researchers and inventors. In so doing, this model would create a powerful incentive for scientists and engineers to confront, contemplate, and modify the broader social impacts of their work.

Of course, “broader impacts” is an inherently amorphous term, and this Article argues that it must retain a high degree of flexibility. As used in this Article, it refers to the contribution of a scientific or technological project to social welfare, independent of its technical merit. To provide more structure, and to respond to the most serious deficiencies of modern science and technology,<sup>21</sup> this Article suggests three factors to assess the broader impacts of a research project or invention. Within this model, the broader impacts of some scientific or technological project would encompass its: social benefits, social harms and ways to mitigate those harms, and distributive effects, particularly the degree to which it serves the needs of marginalized communities.<sup>22</sup>

This Article proposes a model of innovation governance that is “distributed” in several senses of the term. Reflecting the principle of subsidiarity, this approach distributes greater authority to promote socially responsive innovation beyond central decisionmakers to a wide array of government agencies, nongovernmental organizations, and private actors. In some instances, this distributed model even mobilizes peer-review systems that involve thousands of academic researchers. Furthermore, this model distributes considerations of broader impacts across the lifecycle of a typical R&D project, from upstream

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<sup>19</sup> See *infra* Section II.B.2.

<sup>20</sup> See *infra* Section II.B.3.

<sup>21</sup> See *infra* Part I.

<sup>22</sup> See *infra* Section IV.C.

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funding, to publication and presentation of research findings, to downstream patenting and commercialization.

This distributed model would consist of three components. First, federal funding agencies should consider the broader social impacts—not just scientific merit—of proposed research when allocating research funds.<sup>23</sup> While this proposal may seem far-fetched, it draws upon both longstanding practice and recent developments. As mentioned, NSF has long considered broader impacts when allocating grants, a practice bolstered by the CHIPS and Science Act of 2022.<sup>24</sup> This Article argues for reforming and expanding this practice. It responds to criticisms of NSF’s broader impacts criterion and suggests ways to improve its implementation. It also suggests that Congress or NSF modify the broader impacts criterion to explicitly consider a research proposal’s social benefits, social harms, and distributional effects. This Article further argues for extending the practice of assessing broader impacts to other federal agencies that fund research, such as the Department of Energy (“DOE”), National Institutes of Health (“NIH”), National Institutes of Standards and Technology, and Department of Agriculture. By generalizing this practice, billions of dollars in federal research funding can help strengthen a norm among scientists and engineers of considering the wider social implications of science and technology.

Second, this Article argues for incorporating a broader impacts criterion in peer-review processes to select manuscripts for publication and presentation at scientific journals and conferences.<sup>25</sup> This may seem an odd prescription for a law review article given that scientific journals and conferences do not fall within the regulatory purview of policymakers. However, government action plays a significant role in shaping the norms of the scientific community and scientific institutions.<sup>26</sup> Drawing from the law-and-norms literature, this Article examines the movement among artificial intelligence (“AI”) computer scientists to incorporate a broader impacts criterion in peer-review selection of articles for publication and presentation at a leading academic conference. Although framed as a grassroots, bottom-up movement, the organizers modeled this effort on formal government policy, namely NSF’s consideration of broader impacts. This case study reveals a double dividend from evaluating broader impacts in federal research funding: this practice directly incentivizes scientists and engineers to consider broader social goals, and it also indirectly cultivates a “broader impacts norm” that can migrate to adjacent institutions, such as scientific journals and conferences.

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<sup>23</sup> See *infra* Part IV.

<sup>24</sup> See *supra* notes 2-4 and accompanying text.

<sup>25</sup> See *infra* Part V.

<sup>26</sup> Cf. Albert C. Lin, *Herding Cats: Governing Distributed Innovation*, 96 N.C. L. REV. 945, 985-87 (2018) [hereinafter Lin, *Herding Cats*] (exploring the role of nongovernmental intermediaries in regulating individual behavior and the government’s influence over such intermediaries).

Third, toward the downstream end of the R&D lifecycle, this Article argues for considering the broader social impacts of inventions when granting patents, which confer twenty years of exclusive rights on novel technologies.<sup>27</sup> As conventionally understood, the patent system does not meaningfully consider the broader social and ethical implications of inventions when evaluating patentability. However, building upon previous scholarship,<sup>28</sup> this Article proposes that the PTO require patent applicants to include a “Broader Impacts Statement” in their applications. In this statement, inventors would describe the social value of an invention, any harms it may cause as well as any mechanisms to mitigate those harms, and how (if at all) the invention serves the interests of marginalized communities. Failure to submit a good-faith disclosure would result in rejection of the patent application. PTO examiners would be able to accelerate the examination of technologies deemed to serve significant social interests and delay examination of technologies that pose significant social harms.

Taken together, this distributed model of innovation governance would do much to advance socially responsive science and technology. Notably, it would mitigate the deficiencies of centralized regulation. Rather than dictating what kinds of projects to pursue, considering broader impacts as one set of factors when awarding key resources would preserve greater autonomy for scientists and engineers. Furthermore, delegating responsibility for ensuring socially responsive science and technology to legions of researchers and inventors would counteract the politicization of centralized innovation policy. Finally, this decentralized approach would exploit real-time information possessed by scientists and engineers about the benefits and harms of their innovations.

These dynamics inform a surprising efficiency advantage of this proposal. Some might argue that policies governing research and technological development should simply focus on maximizing innovative output, leaving regulation of the harms of innovation to other fields of law, such as public health law, environmental law, or tort law. This is somewhat analogous to the familiar law-and-economics argument that legal rules should seek to maximize welfare while leaving distributive (and other) concerns to the tax-and-transfer system.<sup>29</sup>

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<sup>27</sup> See *infra* Part VI.

<sup>28</sup> See Lee, *Externality Asymmetry*, *supra* note 7, at 1992-93 (proposing that certain patent applications must disclose the societal impacts of claimed inventions to the PTO).

<sup>29</sup> See generally LOUIS KAPLOW & STEVEN SHAVELL, *FAIRNESS VERSUS WELFARE* (2002) (arguing for basing policy decisions on their welfare effects without considering fairness or justice); Louis Kaplow & Steven Shavell, *Any Non-Welfarist Method of Policy Assessment Violates the Pareto Principle*, 109 J. POL. ECON. 281 (2001) (arguing that policy evaluation that gives weight to principles other than welfare may make everyone worse off); Louis Kaplow & Steven Shavell, Reply, *Notions of Fairness Versus the Pareto Principle: On the Role of Logical Consistency*, 110 YALE L.J. 237 (2000) (arguing that consistently adhering to any concept of fairness would decrease welfare in some contexts); Louis Kaplow & Steven Shavell, *Why the Legal System Is Less Efficient than the Income Tax in Redistributing Income*, 23 J. LEGAL STUD. 667 (1994) (arguing that legal rules should prioritize economic efficiency, not distributive justice, which is more efficiently achieved through taxes and transfers).

However, engaging scientists and engineers themselves in regulating emerging technologies promises significant efficiency gains. While the law-and-economics critique implicitly posits that centralized policymakers have as good (and probably better) information as other parties for redistributing wealth, such is not the case regarding regulating new technologies. Researchers and inventors enjoy an information asymmetry where they are likely to better understand the social implications of their innovations than legislators and bureaucrats. Furthermore, legislative processes are notoriously slow, and unbridled scientific and technological advances are likely to exacerbate the deficiencies of centralized policymakers in regulating innovation. Finally, cultivating a norm of socially responsive innovation among scientists and engineers can prevent a whole host of problems from arising in the first place, thus obviating the need for costly ex post regulation and reversals of established practices. In a variety of ways, delegating greater responsibility for considering the social implications of innovation to scientists and engineers can promote regulatory efficiency.

In addition to these benefits, distributed governance has a “soft” character that complements the “hard” regulation of centralized approaches. These decentralized approaches do not require or prohibit any kind of innovative activity. Rather, they nudge members of the scientific and technological community toward internalizing a norm of socially responsive innovation.<sup>30</sup> Ironically, such “soft” regulation may encourage the greatest conformity with social objectives by encouraging scientists and engineers to voluntarily assimilate welfare-enhancing norms.

Of course, distributed innovation governance features several limitations. Scientists and engineers may be ill-equipped to assess the social impact of their work. Relatedly, there are concerns that self-interested scientists and engineers would downplay the risks of their projects when seeking valuable resources from external gatekeepers<sup>31</sup> Additionally, there are legitimate concerns that a broader impacts criterion would chill innovation.<sup>32</sup> This Article does not suggest that

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<sup>30</sup> It bears emphasizing that this framework represents a *governance* approach as opposed to traditional, command-and-control regulation. As used in this context, governance focuses on the creation and deployment of norms to achieve a “more sophisticated approach for responding to economic and social conditions that are often too complex, uncertain, volatile, and heterogeneous” for conventional regulation. See Lin, *Herding Cats*, *supra* note 26, at 981; see also Orly Lobel, *The Renew Deal: The Fall of Regulation and the Rise of Governance in Contemporary Legal Thought*, 89 MINN. L. REV. 342, 344 (2004) (“The [governance] model enables practices that dislocate traditional state-produced regulation from its privileged place, while at the same time maintaining the cohesion and large-scale goals of an integrated legal system.”).

<sup>31</sup> See Mikael Johansson & Åsa Boholm, *Scientists’ Understandings of Risk of Nanomaterials: Disciplinary Culture Through the Ethnographic Lens*, 17 NANOETHICS 229, 240 (2017) (noting some scientists who “express an affectionate and personalized stance” towards nanomaterials “downplay risk as a topic of relevance”).

<sup>32</sup> See Melissa Flagg & Arti Garg, *Science Policy from the Ground Up*, ISSUES SCI. & TECH., Fall, 2021, at 51, 53 (noting vague and inconsistent NSF broader impacts scrutiny can discourage scientists from pursuing certain types of research).

distributed innovation governance is a panacea, but it does insist that it is a valuable complement to existing governance approaches.

This Article makes several notable contributions. It offers a novel model for leveraging science and technology gatekeepers to promote innovation that serves social needs. It provides the first legal examination of NSF's broader impacts funding criterion, its reforms in the CHIPS and Science Act, and its possible extension to other forms of innovation support. In so doing, it synthesizes several distinct literatures. First, it draws upon an extensive literature on governing innovation, particularly emerging technologies.<sup>33</sup> Second, it mines a wide historical, sociological, and science-policy literature on the governance of scientific communities.<sup>34</sup> Third, it integrates legal scholarship on alternative governance regimes beyond traditional regulation, in particular the deployment of norms as governance mechanisms.<sup>35</sup>

This Article proceeds in seven parts. Part I argues that despite massive investment—much of it from public sources—contemporary science and technology often fail to address important social needs. Part II explores traditional approaches to increasing the benefits and curbing the harms of innovation through centralized innovation governance. It also examines significant limitations of these approaches. Accordingly, Part III argues for a distributed governance model to supplement centralized approaches.

Part IV considers NSF's broader impacts criterion for awarding research funds. It addresses criticisms of the criterion and suggests ways to reform it and extend it to other federal funding agencies. Part V argues that scientific journals and conferences should consider the broader social impacts of research projects when granting publication and presentation opportunities. While academic journals and conferences are not subject to government regulation, this Part shows the subtle but powerful ways that government action can shape the norms of scientific institutions. Part VI draws on these analyses to propose a broader impacts criterion for patent law, which has historically shied away from considering the social implications of inventions when evaluating patent applications. Part VII addresses several limitations of distributed innovation governance and offers additional arguments in its favor.

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<sup>33</sup> See, e.g., Lin, *Herding Cats*, *supra* note 26, at 947 (discussing difficulties of regulating new distributed technologies); Marchant, *supra* note 14, at 1863 (noting traditional regulation fails to keep up with the pace of innovation for emerging technologies).

<sup>34</sup> See, e.g., J. D. BERNAL, *THE SOCIAL FUNCTION OF SCIENCE*, at xiii (6th ed. 1946) (stating that “uncoordinated and haphazard” developments have led science to “a structure of appalling inefficiency both as to its internal organization and as to the means of application to problems of production or of welfare”); Polanyi, *supra* note 1, at 54 (noting that scientists “are in fact cooperating as members of a closely knit organisation”).

<sup>35</sup> See, e.g., Lobel, *supra* note 30, at 358 (arguing for using norms, rather than traditional statist projects, to regulate complex, modern policy challenges).

## I. INNOVATION AND ITS DISCONTENTS

While commentators invoke the term “crisis” too readily, there are palpable concerns that modern science and technology are not addressing society’s most urgent priorities.<sup>36</sup> The United States spent \$656 billion on research and development in 2019.<sup>37</sup> This is an enormous sum, and it begs the question whether these massive investments in science and technology are yielding a fair return on investment. This question implicates not just private expenditures, but also public policy, given that the U.S. government accounts for about \$139 billion per year in R&D expenditures.<sup>38</sup> In addition to direct funding, the government supports innovation through other policies, most notably by operating a patent system that grants exclusive rights on about 350,000 inventions per year.<sup>39</sup> This Part explores several innovation deficiencies that persist despite massive social and governmental investment in R&D. These deficiencies, moreover, illustrate the need for more socially responsive science and technology.

First, enormous investments in innovation may not be allocated to the most pressing needs of society. Despite significant social expenditures on innovation, it is far from clear that many of the most urgent technical challenges of the day—from climate change to the persistence of certain devastating diseases—receive adequate investment.<sup>40</sup> The overwhelming majority of innovation expenditures are market-based allocations by private actors. While markets are extolled for supposedly allocating resources efficiently,<sup>41</sup> markets suffer from several widely recognized deficiencies. In short, market-based investment in innovation will tend to maximize private value, which may deviate considerably from

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<sup>36</sup> Of course, a broad survey of all that ails science and technology far exceeds the scope of this Article. Shortcomings are legion, including diminishing public trust in science, governance difficulties, failures of reproducibility, and problems of research integrity and scientific fraud. Drahos, *supra* note 6, at 328.

<sup>37</sup> BURKE ET AL., *supra* note 5, at 14.

<sup>38</sup> *Id.* at 19.

<sup>39</sup> See U.S. Patent Statistics Chart Calendar Years 1963-2020, U.S. PAT. & TRADEMARK OFF., [uspto.gov/web/offices/ac/ido/oeip/taf/us\\_stat.htm](https://uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm) [perma.cc/7B98-J7UP] (last visited Apr. 3, 2024).

<sup>40</sup> See D. Foray, D.C. Mowery & R.R. Nelson, *Public R&D and Social Challenges: What Lessons from Mission R&D Programs?*, 41 RSCH. POL’Y 1697, 1697 (2012) (listing these and other examples).

<sup>41</sup> See Harold Demsetz, *Information and Efficiency: Another Viewpoint*, 12 J.L. & ECON. 1, 11-14 (1969) (arguing that assignable property rights and market exchanges discourage inefficient freeloading and incentivize efficient investment in generating knowledge); Brett M. Frischmann, *Evaluating the Demsetzian Trend in Copyright Law*, 3 REV. L. & ECON. 649, 654-55 (2007) (“According to neoclassical economic theory, the market is an economic system that relies on the price mechanism to efficiently coordinate productive activities and allocate resources to their most productive use. But the market may fail for a variety of reasons.”).

maximizing social value.<sup>42</sup> For instance, while malaria treatments may have greater social value than treatments for male pattern baldness, the latter enjoy greater market value (and attract more private investment) due to the purchasing power of the relevant patient populations.<sup>43</sup> Commentators bemoan “a U.S. drug pricing system in which rewards for medical innovation bear little relation to the social value of the drugs in question.”<sup>44</sup> Relatedly, markets and prices do not capture the full social value of goods, including innovations, that generate high positive externalities. For example, markets will tend to underinvest in infrastructural innovations that facilitate large swaths of downstream productivity.<sup>45</sup> Additionally, markets provide poor incentives to generate public goods, which may be highly socially valuable yet difficult to monetize. Drahos argues that in the realm of innovation, “[t]here is an undersupply of global public goods in fields such as climate change, medicines, and biodiversity.”<sup>46</sup>

While government funding for innovation is seen as a corrective measure for market failure, it also suffers from several shortcomings.<sup>47</sup> Political interests and legislative rent seeking skew public innovation funding away from socially optimal allocations. For instance, the political salience of national defense and the power of the defense lobby likely explain why the Department of Defense

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<sup>42</sup> See Lee, *Externality Asymmetry*, *supra* note 7, at 1978 (discussing how externalities help drive a wedge between private returns and social value in markets); Peter Lee, *Enhancing the Innovative Capacity of Venture Capital*, 24 *YALE J.L. & TECH.* 611, 678 (2022) (analyzing empirical accounts illustrating that venture capitalists seek to maximize profits, not social value or innovation).

<sup>43</sup> See Ofer Tur-Sinai, *Technological Progress and Well-Being*, 48 *LOY. U. CHI. L.J.* 145, 149-50 (2016) (noting that the patent system, which responds to market demand, may overincentivize the production of certain innovations of relatively low social value at the expense of more beneficial innovations); see also Darrell M. West, *R&D for the Public Good: Ways To Strengthen Societal Innovation in the United States*, BROOKINGS (Oct. 10, 2022), [brookings.edu/articles/rd-for-the-public-good-ways-to-strengthen-societal-innovation-in-the-united-states/](https://www.brookings.edu/articles/rd-for-the-public-good-ways-to-strengthen-societal-innovation-in-the-united-states/) [<https://perma.cc/H4VK-6MSM>] (“[P]rofitable consumer products likely will get advantaged over unprofitable societal innovations, even if the latter are important for public health and national security.”).

<sup>44</sup> Daniel J. Hemel & Lisa Larrimore Ouellette, *Valuing Medical Innovation*, 75 *STAN. L. REV.* 517, 524 (2023).

<sup>45</sup> See Brett M. Frischmann, *An Economic Theory of Infrastructure and Commons Management*, 89 *MINN. L. REV.* 917, 925 (2005) (“[T]he government has played and continues to play a significant and widely-accepted role in ensuring the provision of many traditional infrastructures.”).

<sup>46</sup> Drahos, *supra* note 6, at 330 (citations omitted); see also Foray et al., *supra* note 40, at 1697 (noting underinvestment in technological solutions addressing climate change, various diseases, overpopulation, and underpopulation).

<sup>47</sup> Cf. Demsetz, *supra* note 41, at 1 (warning against the “nirvana” fallacy that just because markets have deficits, they are socially inefficient, and arguing in favor of comparative institutional analysis).

accounts for 40% of federal R&D spending.<sup>48</sup> Furthermore, the power of fossil fuel industries vis-à-vis cleantech companies dulls political support for funding technologies that reduce greenhouse gas emissions.<sup>49</sup> As discussed further below, federal expenditures on innovation are also subject to shifts in political ideology.<sup>50</sup> In sum, neither market-based nor politically determined innovation expenditures necessarily address society's most pressing needs. The movement in policy circles toward "responsible research and innovation" reflects the imperative that "[r]esearch and innovation must respond to the needs and ambitions of society, reflect its values, and be responsible."<sup>51</sup>

Second, beyond not addressing urgent social challenges, science and technology are actually making some problems worse. While innovation contributes enormously to social welfare, it also creates new harms. Automation technologies threaten millions of jobs.<sup>52</sup> Opioids, once heralded as breakthrough painkillers, have created an epidemic of addiction and death.<sup>53</sup> Social media

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<sup>48</sup> See David C. Mowery, *Defense-Related R&D as a Model for "Grand Challenges" Technology Policies*, 41 RSCH. POL'Y 1703, 1708-09 (2012) (noting the strategy by defense contractors of increasing their political influence by using subcontractors and buying components from many states and Congressional districts); JOHN F. SARGENT JR., CONG. RSCH. SERV., R46869, FEDERAL RESEARCH AND DEVELOPMENT (R&D) FUNDING: FY2022, at ii (2022) (reporting that the Department of Defense accounted for 40.1% of total federal research funding).

<sup>49</sup> See Niall McCarthy, *Oil and Gas Giants Spend Millions Lobbying To Block Climate Change Policies [Infographic]*, FORBES (Mar. 25, 2019, 8:06 AM), [forbes.com/sites/niallmccarthy/2019/03/25/oil-and-gas-giants-spend-millions-lobbying-to-block-climate-change-policies-infographic](https://forbes.com/sites/niallmccarthy/2019/03/25/oil-and-gas-giants-spend-millions-lobbying-to-block-climate-change-policies-infographic) (describing fossil fuel companies' massive annual lobbying expenditures).

<sup>50</sup> See *infra* notes 139-48, 155-59 and accompanying text.

<sup>51</sup> Maire Geoghegan-Quinn, Keynote Speech at the Science in Dialogue Conference Odense 1-2 (Apr. 23-25, 2012), [ec.europa.eu/archives/commission\\_2010-2014/geoghegan-quinn/headlines/speeches/2012/documents/20120423-dialogue-conference-speech\\_en.pdf](https://ec.europa.eu/archives/commission_2010-2014/geoghegan-quinn/headlines/speeches/2012/documents/20120423-dialogue-conference-speech_en.pdf) [perma.cc/XLW5-ZTAS]; see also Richard Owen, Phil Macnaghten & Jack Stilgoe, *Responsible Research and Innovation: From Science and Society to Science for Society, with Society*, 39 SCI. & PUB. POL'Y 751, 753 (2012) (noting "growing momentum in both academic and EU policy contexts" in support of responsible innovation).

<sup>52</sup> Daron Acemoglu & Pascual Restrepo, *Robots and Jobs: Evidence from US Labor Markets*, 128 J. POL. ECON. 2188, 2241 (2020); Erik Brynjolfsson, *The Turing Trap: The Promise & Peril of Human-Like Artificial Intelligence*, DAEDALUS, Spring 2022, at 272, 273; Steve Lohr, *Economists Pin More Blame on Tech for Rising Inequality*, N.Y. TIMES (June 22, 2023), [nytimes.com/2022/01/11/technology/income-inequality-technology.html](https://nytimes.com/2022/01/11/technology/income-inequality-technology.html).

<sup>53</sup> *Understanding the Opioid Overdose Epidemic*, CTRS. FOR DISEASE CONTROL & PREVENTION, [cdc.gov/opioids/basics/epidemic.html](https://cdc.gov/opioids/basics/epidemic.html) [perma.cc/8TXE-NR5Y] (last updated Aug. 8, 2023) (describing increase in opioid overdose deaths from 1999-2021); see Daniel J. Hemel & Lisa Larrimore Ouellette, *Innovation Institutions and the Opioid Crisis*, J.L. & BIOSCIENCES, Jan.-June, 2020, at 1, 1 (arguing that U.S. intellectual property law and general policies toward innovation played a significant role in the opioid crisis).

exacerbates ideological polarization and spreads misinformation.<sup>54</sup> Surveillance technologies undermine privacy and individual liberty.<sup>55</sup> Technologies that burn fossil fuels produce greenhouse gas emissions that have created a climate change disaster.<sup>56</sup> Leading experts fear that AI poses an existential threat to humanity.<sup>57</sup> In a Pew Research Center survey, numerous technologists, academics, and policymakers warned that digital technologies would cause more problems than they would solve.<sup>58</sup> Across numerous contexts, well-intentioned research and technological development have generated significant negative externalities.<sup>59</sup> The harms arising from science and technology represent a pressing public

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<sup>54</sup> See YOCHAI BENKLER, ROBERT FARIS & HAL ROBERTS, NETWORK PROPAGANDA: MANIPULATION, DISINFORMATION, AND RADICALIZATION IN AMERICAN POLITICS 4 (2018) (“[T]he convergence of social media, algorithmic news curation, bots, artificial intelligence, and big data analysis—were creating echo chambers that reinforced our biases, were removing indicia of trustworthiness, and were generally overwhelming our capacity to make sense of the world, and with it our capacity to govern ourselves as reasonable democracies.”); Mark Harris, *How Patents Made Facebook’s Filter Bubble: The Social Network’s Public Filings Portray an Echo-Chamber Factory*, IEEE SPECTRUM (Jan. 28, 2021), [spectrum.ieee.org/computing/networks/the-careful-engineering-of-facebooks-filter-bubble](https://spectrum.ieee.org/computing/networks/the-careful-engineering-of-facebooks-filter-bubble) [perma.cc/NE8B-25X2] (“Algorithms create intensely personal ‘filter bubbles,’ which are powerfully addictive to users, irresistible to advertisers, and a welcoming environment for rampant misinformation and disinformation such as QAnon, antivaxxer propaganda, and election conspiracy theories.”); Lam Thuy Vo, *How the Internet Created Multiple Publics*, 4 GEO. L. TECH. REV. 399, 400 (2020) (“[The Internet] is optimized for the virality of one-punch headlines, not stories with nuance. And this pushes political information universes further apart than they may otherwise naturally be.”).

<sup>55</sup> See Timothy T. Takahashi, *Drones and Privacy*, 14 COLUM. SCI. & TECH. L. REV. 72, 76 (2012) (describing law enforcement’s use of surveillance drones, which raise constitutional concerns about searches); Ray Purdy, *Attitudes of UK and Australian Farmers Towards Monitoring Activity with Satellite Technologies: Lessons To Be Learnt*, 27 SPACE POL’Y 202, 205 (2011) (discussing privacy threats from satellites).

<sup>56</sup> See Zachary Liscow & Quentin Karpilow, *Innovation Snowballing and Climate Law*, 95 WASH. U. L. REV. 387, 405 (2017) (positing that because innovations build on each other and “snowball,” it continues to be more efficient to invest in well-established “dirtytech” compared to cleantech).

<sup>57</sup> Kevin Roose, *Inside the White-Hot Center of A.I. Doomerism*, N.Y. TIMES (July 11, 2023), [nytimes.com/2023/07/11/technology/anthropic-ai-claude-chatbot.html](https://www.nytimes.com/2023/07/11/technology/anthropic-ai-claude-chatbot.html) (describing deep anxiety AI developers feel about their technologies).

<sup>58</sup> EMILY A. VOGELS, LEE RAINIE & JANNA ANDERSON, EXPERTS PREDICT MORE DIGITAL INNOVATION BY 2030 AIMED AT ENHANCING DEMOCRACY (2020), [pewresearch.org/internet/2020/06/30/experts-predict-more-digital-innovation-by-2030-aimed-at-enhancing-democracy/](https://www.pewresearch.org/internet/2020/06/30/experts-predict-more-digital-innovation-by-2030-aimed-at-enhancing-democracy/) [https://perma.cc/L6RP-HYCE].

<sup>59</sup> See Arti Kaur Rai, *Regulating Scientific Research: Intellectual Property Rights and the Norms of Science*, 94 NW. U. L. REV. 77, 146 (1999) (“One basis for questioning the efficiency of current research norms is the problem of negative externalities.”); Lee, *Externality Asymmetry*, *supra* note 7, at 1939-49 (describing negative externalities from technologies such as social media, autonomous vehicles, and big data analytics).

policy challenge, particularly given the significant role of government support in developing many of these innovations.<sup>60</sup>

A third set of critiques focuses on distributive and democratic deficiencies of contemporary science and technology. Commentators argue that enormous expenditures on science and technology are disproportionately benefitting monied, privileged interests rather than poor and marginalized communities. This critique has several dimensions. First, the increasingly commercial nature of science “shifts science away from the preferences of those unable to pay for commercial solutions.”<sup>61</sup> Relatedly, the pull of market demand favors technologies that serve the interests of those with greater purchasing power.<sup>62</sup> Additionally, the benefits of massive investment in science and technology—which include public support—disproportionately accrue to well-resourced individuals.<sup>63</sup> For instance, economists warn that automation technologies are increasing economic inequality by displacing low-wage jobs.<sup>64</sup> Additionally, critics decry a lack of representation among not only the beneficiaries but also the participants of research and development.<sup>65</sup> It is widely recognized that women, certain marginalized communities, and persons with disabilities are underrepresented in science and engineering compared to the general population.<sup>66</sup> Furthermore, the distribution of patents is highly unequal, with the top 1% of patentees receiving more than half of newly issued patents.<sup>67</sup> As political scientist Darrell West argues, “[W]e . . . need R&D spending that sees

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<sup>60</sup> See Lee, *Externality Asymmetry*, *supra* note 7 at 1941-49 (describing several patented inventions that produce significant negative externalities).

<sup>61</sup> Drahos, *supra* note 6, at 336.

<sup>62</sup> Cf. George Packer, *Change the World*, *NEW YORKER*, May 27, 2013, at 44, 51 (“It suddenly occurred to me that the hottest tech start-ups are solving all the problems of being twenty years old, with cash on hand, because that’s who thinks them up.”).

<sup>63</sup> See Elizabeth MacBride, *Why Venture Capital Doesn’t Build the Things We Really Need*, *MIT TECH. REV.* (June 17, 2020), [technologyreview.com/2020/06/17/1003318/why-venture-capital-doesnt-build-the-things-we-really-need/](https://technologyreview.com/2020/06/17/1003318/why-venture-capital-doesnt-build-the-things-we-really-need/) (“This largely white, largely male corner of finance has backed software companies that grow fast and generate large amounts of money for a shrinking number of Americans—companies like Google, Facebook, Uber, and Airbnb.”).

<sup>64</sup> Lohr, *supra* note 52 (“Half or more of the increasing gap in wages among American workers over the last 40 years is attributable to the automation of tasks formerly done by human workers, especially men without college degrees . . .”).

<sup>65</sup> See, e.g., Colleen V. Chien, *The Inequalities of Innovation*, 72 *EMORY L.J.* 1, 13 (2022) (noting the “extreme underrepresentation of women among inventors”).

<sup>66</sup> Julia R. Kamenetzky, *Opportunities for Impact: Statistical Analysis of the National Science Foundation’s Broader Impacts Criterion*, 40 *SCI. & PUB. POL’Y* 72, 74 (2013).

<sup>67</sup> Chien, *supra* note 65, at 8 (“[M]ore than half of newly granted patents went to the top 1% of patentees, and over three-quarters to the top 10%, up from 39% and 64%, respectively. Five states, all coastal, captured over 50% of all U.S. patents. Women accounted for only 12.8% of inventors on 2019 U.S.-origin patents.” (footnotes omitted)).

equity as an important societal goal and prioritizes new knowledge, products, and processes that are fair and equitable.”<sup>68</sup>

More broadly, critics decry a democratic deficit in science. Commentators warn of a disconnect between contemporary science and the needs and input of everyday individuals. As Drahos further observes, “Science emerges as a compromised client-centered institution, one that has broken with its obligation of fidelity to communities of people.”<sup>69</sup> Taken together, these deficiencies define a need for more socially responsive science and technology.<sup>70</sup>

## II. THE CHALLENGES OF GOVERNING INNOVATION

Due to its complexity, unpredictability, and tremendous capacity to both benefit and harm society, innovation presents difficult governance challenges for policymakers. As this Article explores, governments regulate scientific and technological activity in myriad ways. Among them, the objective of increasing the benefits and mitigating the harms of innovation informs several so-called “centralized” governance approaches. These interventions rely on centralized policymakers setting policy agendas to either promote or constrain certain types of innovative activity. This Part explores two prominent centralized approaches: mission-based science funding and ex post regulation. It further explores several limitations of centralized innovation governance, which can impair scientific autonomy, overly politicize innovation policy, and rely on a relatively narrow information base. As we shall later see, distributed innovation governance can compensate for these limitations by supplementing centralized approaches.

### A. *Centralized Innovation Funding and Regulation*

First, toward the upstream end of the R&D lifecycle, the objective of maximizing the social benefit of public innovation investments has motivated mission-oriented science funding.<sup>71</sup> Unlike open, curiosity-based research grants, mission-oriented funding entails policymakers defining priorities for scientific and technological development and directing funds toward those priorities.<sup>72</sup> Early examples of mission-oriented funding focused on achieving discrete technological objectives, often on a short timeline. The archetypical example is the Manhattan Project, in which the U.S. government spent \$2.2

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<sup>68</sup> West, *supra* note 43.

<sup>69</sup> Drahos, *supra* note 6, at 335.

<sup>70</sup> *Id.* at 334 (noting that responsiveness demands that an institution both maintain integrity and learn from its broader social environment).

<sup>71</sup> See generally Foray et al., *supra* note 40 (describing mission-oriented R&D programs).

<sup>72</sup> See Mariana Mazzucato, *Mission-Oriented Innovation Policies: Challenges and Opportunities*, 27 *INDUS. & CORP. CHANGE* 803, 804 (2018) (defining mission-oriented approaches as “systemic public policies that draw on frontier knowledge to attain specific goals”).

billion to develop nuclear weapons during World War II.<sup>73</sup> Other examples include the Apollo Program,<sup>74</sup> War on Cancer,<sup>75</sup> Human Genome Project,<sup>76</sup> and Cancer Moonshot.<sup>77</sup> A recent, highly visible example of mission-oriented R&D funding was Operation Warp Speed. The Trump Administration launched Operation Warp Speed in 2020 with the ambitious goal of producing 300 million doses of safe and effective COVID-19 vaccine.<sup>78</sup> This initiative provided about \$18 billion to eight vaccine developers and was by most accounts highly successful.<sup>79</sup> As illustrated by Operation Warp Speed, mission-oriented science funding also includes government procurement, in which the government contracts with suppliers to deliver a certain technological output to achieve a specified policy objective.<sup>80</sup>

Contemporary models of mission-oriented funding focus on not just developing key innovations but also mobilizing technological, political, and economic resources to address social priorities.<sup>81</sup> These initiatives are

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<sup>73</sup> Off. of Legacy Mgmt., *Manhattan Project Background Information and Preservation Work*, ENERGY.GOV, [energy.gov/lm/doe-history/manhattan-project-background-information-and-preservation-work#](https://energy.gov/lm/doe-history/manhattan-project-background-information-and-preservation-work#) [perma.cc/7SWN-XZ4T] (last Mar. 28, 2024).

<sup>74</sup> Monika Gisler & Didier Sornette, *Exuberant Innovations: The Apollo Program*, 46 SOC. SCI. & PUB. POL'Y 55, 57 (2009).

<sup>75</sup> National Cancer Act of 1971, Pub. L. No. 92-918, 85 Stat. 778 (enacting a new medical research program targeting cancer); see Bhaven N. Sampat, *Mission-Oriented Biomedical Research at the NIH*, 41 RES. POL'Y 1729, 1737-38 (2012) (describing NIH's role in the War on Cancer).

<sup>76</sup> Robert Mullan Cook-Deegan, *Origins of the Human Genome Project*, 5 RISK: HEALTH, SAFETY & ENV'T 97, 100-03 (1994).

<sup>77</sup> 21st Century Cures Act, Pub. L. No. 144-255, 130 Stat. 1033 (2016); see Jacob S. Sherkow, *Cancer's IP*, 96 N.C. L. REV. 297, 318-20 (2018) (contextualizing the Cancer Moonshot project within United States' history of similar programs supporting health research through large, singular grants).

<sup>78</sup> U.S. GOV'T ACCOUNTABILITY OFF., GAO-21-319, OPERATION WARP SPEED: ACCELERATED COVID-19 VACCINE DEVELOPMENT STATUS AND EFFORTS TO ADDRESS MANUFACTURING CHALLENGES I (2021).

<sup>79</sup> Stephanie Baker & Cynthia Koons, *Inside Operation Warp Speed's \$18 Billion Sprint for a Vaccine*, BLOOMBERG: BUSINESSWEEK (Oct. 29, 2020, 4:00 AM), [bloomberg.com/news/features/2020-10-29/inside-operation-warp-speed-s-18-billion-sprint-for-a-vaccine](https://www.bloomberg.com/news/features/2020-10-29/inside-operation-warp-speed-s-18-billion-sprint-for-a-vaccine).

<sup>80</sup> See Charles Edquist & Jon Mikel Zabala-Iturriagoitia, *Public Procurement for Innovation as Mission-Oriented Innovation Policy*, 41 RSCH. POL'Y 1757, 1758 (2012) (defining public procurement for innovation as government procurement projects whose end goal is to solve a human need or social problem rather than to develop a specific product).

<sup>81</sup> See Matthijs J. Janssen, Jonas Torrens, Joeri H. Wesseling & Iris Wanzenböck, *The Promises and Premises of Mission-Oriented Innovation Policy—A Reflection and Ways Forward*, 48 SOC. & PUB. POL'Y 438, 439 (2021) (“[M]issions matter because of the promise of engendering dynamics of mobilisation (of resources, actors, and institutions) and innovation around a goal . . . .”); Marko P. Hekkert, Matthijs J. Janssen, Joeri H. Wesseling & Simona O. Negro, *Mission-Oriented Innovation Systems*, 34 ENV'T INNOVATION & SOCIETAL TRANSITIONS 76, 76 (2020) (“Policy makers promoting third generation

sometimes organized under “grand challenges,” such as combating climate change or promoting sustainable development.<sup>82</sup> This generation of mission-oriented innovation policies addresses “wicked” problems that are “complex, systemic, interconnected, and urgent.”<sup>83</sup> As such, rather than simply push technological innovations, these policies address societal challenges in a more holistic fashion.<sup>84</sup> Although this model is more decentralized than technology-focused funding,<sup>85</sup> it ultimately arises from and is subject to centralized political control.<sup>86</sup>

Second, toward the downstream end of the R&D lifecycle, another form of centralized innovation governance is ex post technology regulation. Such regulation also represents a means to enhance the social responsiveness of science and technology. However, while ex ante mission-based funding focuses on increasing the social benefits of innovation, ex post regulation generally seeks to reduce the social harms of technologies. Much of this regulation falls under the ambit of “techlaw,” which can include adapting existing laws to address novel technologies or establishing new laws.<sup>87</sup> Modalities of governance include enforcing command-and-control regulations, establishing technological standards, creating economic incentives, and requiring permits.<sup>88</sup>

Recently, governments have engaged in several high-profile instances of ex post regulation to address technological harms. The Biden Administration recently released the Blueprint for an AI Bill of Rights, which delineates numerous regulations that curb the harms of automated systems.<sup>89</sup> The European Parliament recently adopted the AI Act to regulate various aspects of AI

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‘transformative’ innovation policy acknowledge the importance of tackling societal problems, as well as the difficulty in changing innovation direction in innovation systems marked by path dependencies.” (citation omitted)).

<sup>82</sup> See Mazzucato, *supra* note 72, at 803 (reviewing lessons learned from mission-oriented policies addressing grand challenges).

<sup>83</sup> *Id.*; see Marchant, *supra* note 14, at 1862-63 (arguing that the “wicked problem” approach, which integrates several necessarily imperfect tools, constitutes the most effective governance model for emerging technologies).

<sup>84</sup> Hekkert et al., *supra* note 81, at 77.

<sup>85</sup> See Mazzucato, *supra* note 72, at 805 (“To have highest impact, missions should embrace actors across an entire economy, not just in one sector and not just in the private or public realm.”).

<sup>86</sup> See Janssen et al., *supra* note 81, at 440-41 (proposing questions to consider for ensuring multi-actor missions are governed effectively); Hekkert et al., *supra* note 81, at 78 (arguing for strong central governance over missions because they involve normative, political choices).

<sup>87</sup> Rebecca Crotoof & BJ Ard, *Structuring Techlaw*, 34 HARV. J.L. & TECH. 347, 395-416 (2021).

<sup>88</sup> Lin, *Herdling Cats*, *supra* note 26, at 964-73.

<sup>89</sup> See BLUEPRINT FOR AI, *supra* note 15, at 21-22.

systems.<sup>90</sup> At the subnational level, numerous U.S. states have enacted or are considering legislation to regulate AI.<sup>91</sup> In the realm of privacy, the most influential legislation has been the European Union's GDPR, which creates a broad range of individual rights and obligations to safeguard data processing.<sup>92</sup> In this country, states have taken the lead in regulating data privacy. For instance, in 2018 the California legislature enacted the CCPA.<sup>93</sup> Similar in some respects to the GDPR, the CCPA grants consumers greater control over their personal data.<sup>94</sup> Other states have also enacted data privacy laws,<sup>95</sup> and Congress may weigh in soon. Turning to other technological harms, Congress has been debating reforms to Section 230 of the Communications Decency Act to impose greater liability on social media companies for content posted on their platforms.<sup>96</sup>

More broadly, many general laws that do not necessarily target specific technologies also regulate technological harms.<sup>97</sup> Environmental laws internalize negative externalities from a vast array of activities that produce

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<sup>90</sup> Artificial Intelligence Act: MEPs Adopt Landmark Law, EUROPEAN PARLIAMENT (Mar. 13, 2024), <https://www.europarl.europa.eu/news/en/press-room/20240308IPR19015/artificial-intelligence-act-meps-adopt-landmark-law> [<https://perma.cc/K8DH-P8F3>].

<sup>91</sup> See *Legislation Related to Artificial Intelligence*, NAT'L CONF. STATE LEGISLATURES (Jan. 31, 2023), [ncsl.org/research/telecommunications-and-information-technology/2020-legislation-related-to-artificial-intelligence.aspx](https://ncsl.org/research/telecommunications-and-information-technology/2020-legislation-related-to-artificial-intelligence.aspx) [[perma.cc/79WS-FRA7](https://perma.cc/79WS-FRA7)] ("General artificial intelligence bills or resolutions were introduced in at least 17 states in 2022, and were enacted in Colorado, Florida, Idaho, Maine, Maryland, Rhode Island, Vermont and Washington.").

<sup>92</sup> Council Regulation 2016/679, of the European Parliament and of the Council of 27 April 2016 on the Protection of Natural Persons with Regard to the Processing of Personal Data and on the Free Movement of Such Data, and Repealing Directive 95/46/EC, 2016 O.J. (L 119) 3-4; see Margot E. Kaminski, *Binary Governance: Lessons from the GDPR's Approach to Algorithmic Accountability*, 92 S. CAL. L. REV. 1529, 1585 (2019) ("The GDPR thus contains a broad assortment of individual rights and company obligations that apply beyond algorithmic decision-making, to personal data processing in general."); Katherine J. Strandburg, *Rulemaking and Inscrutable Automated Decision Tools*, 119 COLUM. L. REV. 1851, 1853 (2019) (describing the right of an individual subject to an algorithm to have an explanation of how it works, as provided by the GDPR).

<sup>93</sup> CAL. CIV. CODE §§ 1798.100-1798.199.10 (West 2023).

<sup>94</sup> Joanna Kessler, Note, *Data Protection in the Wake of the GDPR: California's Solution for Protecting "The World's Most Valuable Resource,"* 93 S. CAL. L. REV. 99, 106 (2019) (describing CCPA and its similarities to GDPR in giving consumers more control over data); Mary D. Fan, *The Right To Benefit from Big Data as a Public Resource*, 96 N.Y.U. L. REV. 1438, 1455-59 (2021) (same).

<sup>95</sup> See Fan, *supra* note 94, at 1458 (describing data privacy laws enacted in Maine and Nevada).

<sup>96</sup> Meghan Anand et al., *All the Ways Congress Wants To Change Section 230*, SLATE (Mar. 23, 2021, 5:45 AM), [slate.com/technology/2021/03/section-230-reform-legislative-tracker.html](https://slate.com/technology/2021/03/section-230-reform-legislative-tracker.html) [[perma.cc/SV9U-2MLY](https://perma.cc/SV9U-2MLY)] (tracking several bills that would amend Section 230).

<sup>97</sup> See Crootof & Ard, *supra* note 87, at 408-13 (arguing that techlaw can comprise technology-neutral rules, technology-specific rules, or approaches that completely reassess existing regimes).

greenhouse gas emissions,<sup>98</sup> pesticides,<sup>99</sup> and toxic chemicals.<sup>100</sup> Regulations from the Occupational Safety and Health Administration (“OSHA”) can also constrain technologies that adversely affect human health.<sup>101</sup> Tort law, particularly products liability law, can impose liability on producers of technologies.<sup>102</sup> For instance, plaintiffs are suing Tesla for tort liability for vehicular deaths caused by Tesla automobiles operating in Autopilot Mode.<sup>103</sup> Such laws also represent centralized governance mechanisms to mitigate technological harms.

### B. *Shortcomings of Centralized Innovation Governance*

While centralized governance is highly valuable, it also suffers from several shortcomings. The remainder of this section explores three limitations that, in various ways, are intrinsic to centralized, political governance of innovation.

#### 1. *Impairing Scientific Autonomy*

Focusing first on mission-oriented science funding, such funding can impair scientific autonomy and undermine the robustness of research efforts. This dynamic is best illustrated by influential debates over science policy from the early- to mid-twentieth century. On one side of the debate, left-leaning commentators argued that governments should proactively direct publicly funded science to serve social ends.<sup>104</sup> For example, in *The Social Function of*

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<sup>98</sup> Clean Air Act, 42 U.S.C. § 7521(a)(1) (regulating emission standards for new motor vehicles); see *Massachusetts v. EPA*, 549 U.S. 497, 528 (2007) (holding that the EPA has authority to regulate gas emissions from new motor vehicles).

<sup>99</sup> Federal Insecticide, Fungicide, and Rodenticide Act, 7 U.S.C. § 136 (regulating pesticides throughout production and use).

<sup>100</sup> Toxic Substances Control Act, 15 U.S.C. § 2601 (enacting a range of policies to regulate chemical substances posing risks to human health and the environment).

<sup>101</sup> See, e.g., James M. Andris, Jr., Note, *Adopting Proactive Standards To Protect Americans in Indoor Environments: Volatile Organic Compound Emissions Regulation*, 56 WM. & MARY L. REV. 1947, 1961-62 (2015) (discussing how OSHA regulates and limits use of workplace technologies that emit harmful chemicals).

<sup>102</sup> See Lin, *Herding Cats*, *supra* note 26, at 970 (noting tort law imposes strict liability on producers of “defective products”); Marchant, *supra* note 14, at 1872 (“If an emerging technology harms people, the entities responsible for unleashing that technology could be held liable for the resultant injuries.”).

<sup>103</sup> See Neal E. Boudette, *Tesla Says Autopilot Makes Its Cars Safer. Crash Victims Say It Kills.*, N.Y. TIMES (Sept. 1, 2021), [nytimes.com/2021/07/05/business/tesla-autopilot-lawsuits-safety.html](https://www.nytimes.com/2021/07/05/business/tesla-autopilot-lawsuits-safety.html); Jason Murdock, *Tesla Faces Lawsuit After Model X on Autopilot with ‘Dozing Driver’ Blamed for Fatal Crash*, NEWSWEEK (Apr. 30, 2020, 4:45 AM), [newsweek.com/tesla-lawsuit-model-x-autopilot-fatal-crash-japan-yoshihiro-unmeda-1501114](https://www.newsweek.com/tesla-lawsuit-model-x-autopilot-fatal-crash-japan-yoshihiro-unmeda-1501114) [perma.cc/AY38-YFHX]; Jamin Xu, *Liability of Tesla’s Autopilot System Under California Tort Law*, B.C. INTELL. PROP. & TECH. F., June 5, 2017, at 1, 5-17.

<sup>104</sup> The philosophy of conscientiously planning scientific efforts drew from a long intellectual history, including logical empiricism and John Dewey’s writings on pragmatism.

*Science*, British crystallographer and communist J. D. Bernal rejected the normative ideal of scientific autonomy, in which scientists are insulated from political and market forces and pursue research based solely on scientific curiosity.<sup>105</sup> He argued instead that governments should actively “plan” scientific research to serve social ends.<sup>106</sup> Influenced by the Soviet Union,<sup>107</sup> Bernal argued that the primary objective of science was not simply to understand nature but to improve human welfare.<sup>108</sup> Consistent with his embrace of the proletariat, he railed against the authority of scientific elites—what he called the “gerontocracy”—to direct scientific activity without regard to social benefit.<sup>109</sup>

On the other side of the debate, conservatives like philosopher and scientist Michael Polanyi argued against state encroachment into what Polanyi termed the “Republic of Science.”<sup>110</sup> He argued that the scientific community represented an autonomous, self-governing system, similar to a political body or market economy,<sup>111</sup> thus obviating the need for external governmental regulation.<sup>112</sup> He advocated robust public funding for science but with limited political control over what research scientists pursued. Polanyi contended that rather than serving immediate, practical ends, the overarching goal of science was scientific progress itself.<sup>113</sup> Polanyi argued that robust support for basic science would yield enormous social benefits, but that centralized planning would stifle science—and ultimately fail—given the inherent unpredictability of

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Erik Baker, *From Planning to Entrepreneurship: On the Political Economy of Scientific Pursuit*, 92 *STUD. HIST. & PHIL. SCI.* 27, 28-29 (2022).

<sup>105</sup> BERNAL, *supra* note 34, at 385-86 (“The task of the future is to make the work of the scientist more conscious, more organized, and more effective; to create a proper appreciation of that work by the mass of the people and to link both together in a common effort to realize, in practice, the possibilities that science offers.”); Baker, *supra* note 104, at 29 (noting Bernal’s belief that science is intrinsically shaped by economic and political forces and his advocacy of planning efforts suited for a socialist society).

<sup>106</sup> Baker, *supra* note 104, at 28.

<sup>107</sup> BERNAL, *supra* note 34, at 393 (“[O]rganization of science in the Soviet Union and the relatively vast sums of money spent for its development and for scientific education showed the world that at last there was one State where the proper function of science was being realized . . .”); Baker, *supra* note 104, at 29 (describing how presentations by a Soviet delegation “and other Soviet papers” heavily influenced Bernal’s views on planning and science).

<sup>108</sup> BERNAL, *supra* note 34, at 322 (“The full development of science is only possible if it can play a positive and not merely contemplative part in social life.”).

<sup>109</sup> Baker, *supra* note 104, at 30.

<sup>110</sup> Polanyi, *supra* note 1, at 54.

<sup>111</sup> *Id.*

<sup>112</sup> *Id.* at 56 (“[A]ny authority which would undertake to direct the work of the scientist centrally would bring the progress of science virtually to a standstill.”).

<sup>113</sup> *Id.* at 62 (“Any attempt at guiding scientific research towards a purpose other than its own is an attempt to deflect it from the advancement of science.”); Philip Mirowski, *On Playing the Economics Trump Card in the Philosophy of Science: Why It Did Not Work for Michael Polanyi*, 64 *PHIL. SCI.* S127, S135 (1997) (describing Polanyi’s argument that advancement of science was not concerned with public welfare).

scientific progress.<sup>114</sup> Resisting influence from the state and market, Polanyi argued that prevailing scientific authority should determine research agendas and inform the allocation of public research funds.<sup>115</sup> In sharp opposition to the science planning movement of Bernal and others, Polanyi staunchly advocated autonomy and “freedom in science.”<sup>116</sup>

Polanyi’s conception of an autonomous scientific community that flourishes without governmental regulation found support in sociological accounts of scientific norms. In the early twentieth century, sociologist of science Robert Merton famously articulated several “normative pillars” of science. Notably, he did so to defend scientific autonomy against attempts at greater government regulation.<sup>117</sup> Merton articulated four norms that govern scientific practice: universalism, communism, disinterestedness, and organized skepticism.<sup>118</sup> Universalism emphasized objectivity and the “international, impersonal, virtually anonymous character of science.”<sup>119</sup> Communism underscored the lack of individual ownership over scientific knowledge and the dedication of scientific findings to the community at large.<sup>120</sup> Disinterestedness referred to the pursuit of science for collective benefit rather than personal gain, as enforced by institutional controls and peer policing.<sup>121</sup> Finally, organized skepticism denoted suspension of judgment and commitment to logic and empiricism.<sup>122</sup> Although not exactly on all fours with Polanyi’s Republic of Science,<sup>123</sup> Merton’s account of scientific norms supported a vision of science as autonomous and self-

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<sup>114</sup> Polanyi, *supra* note 1, at 62.

<sup>115</sup> *Id.* at 61.

<sup>116</sup> MARY JO NYE, MICHAEL POLANYI AND HIS GENERATION: ORIGINS OF THE SOCIAL CONSTRUCTION OF SCIENCE, at xviii (2011). The debate between Polanyi and Bernal reflects a tension between so-called Mode 1 science, which is evaluated with respect to scientific merit, and Mode 2 science, which is assessed with respect to social utility. Lutz Bornmann, *What Is Societal Impact of Research and How Can It Be Assessed? A Literature Survey*, 64 J. AM. SOC’Y FOR INFO. SCI. & TECH. 217, 218 (2013).

<sup>117</sup> Robert K. Merton, *A Note on Science and Democracy*, 1 J. LEGAL & POL. SOC. 115, 115 (1942) (“Manifestos and pronouncements by associations of scientists are devoted to the relations of science and society. An institution under attack must reexamine its foundations, restate its objectives, seek out its rationale.”); see Laura G. Pedraza-Fariña, *Patent Law and the Sociology of Innovation*, 2013 WIS. L. REV. 813, 835 (describing Merton’s norms and their historical and political context).

<sup>118</sup> Merton, *supra* note 117, at 118.

<sup>119</sup> *Id.* at 118-19.

<sup>120</sup> *Id.* at 121 (“The substantive findings of science are a product of social collaboration and are assigned to the community.”).

<sup>121</sup> *Id.* at 124-25.

<sup>122</sup> *Id.* at 126.

<sup>123</sup> Compare Polanyi, *supra* note 1, at 19 (comparing the scientific community to a market economy), with Merton, *supra* note 117, at 121 (espousing the communist character of the scientific community).

regulating.<sup>124</sup> In so doing, it provided further intellectual ammunition against efforts to control science through governmental regulation.

Early on, the Bernalist ideal of science planning held significant political sway. For example, it informed legislation introduced by Senator Harley Kilgore, a New Deal Democrat, to create an Office of Science and Technology Mobilization to unify military research under civilian control.<sup>125</sup> Kilgore's plan also sought to establish a "National Science Foundation," which would both allocate grants to outside researchers and operate a vast network of government laboratories.<sup>126</sup>

Ultimately, however, the conception that science is most robust when subject to minimal regulation won out.<sup>127</sup> Opposing Kilgore was Vannevar Bush, the conservative director of the Office of Scientific Research and Development during World War II.<sup>128</sup> Bush authored an influential report, *Science: The Endless Frontier*, which argued that the federal government should generously fund science but minimally oversee individual researchers.<sup>129</sup> Rather than entrust funding decisions to government bureaucrats, Bush advocated funding research projects proposed by individual scientists and subjected to peer review.<sup>130</sup> Bush helped push NSF through Congress, but it bore little resemblance to the institution that Kilgore originally proposed.<sup>131</sup> NSF would primarily be a grant-making organization that gave extramural funding to outside scientists based on peer-review evaluations.<sup>132</sup> It would not operate a large network of government laboratories; instead, NSF would focus on basic research, and it would be administered by scientists.<sup>133</sup> Over the ensuing decades, NSF has granted billions of dollars, and its model of funding curiosity-

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<sup>124</sup> Merton, *supra* note 117, at 124-25 (discussing how peer policing has ensured "virtual absence of fraud in the annals of science").

<sup>125</sup> Baker, *supra* note 104, at 31.

<sup>126</sup> *Id.*

<sup>127</sup> *Id.* at 28 ("[C]onservative proponents of science as entrepreneurship ultimately succeeded in beating back advocates of the planning of science in postwar debates about the future of federal science policy.").

<sup>128</sup> *Id.* at 32.

<sup>129</sup> VANNEVAR BUSH, *SCIENCE: THE ENDLESS FRONTIER* 118-22 (1945); Baker, *supra* note 104, at 32 (describing the core premise of *Science: The Endless Frontier* as the view that scientific progress results from "free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity for exploration of the unknown" (quoting BUSH, *supra*, at 10)).

<sup>130</sup> Baker, *supra* note 104, at 33.

<sup>131</sup> *Id.*

<sup>132</sup> *Id.* (stating that NSF would administer funding to scientists with "few mechanisms for external oversight").

<sup>133</sup> *Id.* (noting that NSF would not "administer[] the elaborate system of government-run laboratories the Kilgore bill suggested," and that "its grants would focus on basic research" and "be administered solely by scientists").

based research has been a valuable complement to more centralized, mission-oriented funding.<sup>134</sup>

It is, of course, an empirical question as to whether decentralized, autonomous science is more robust than centralized, mission-oriented science. They both play important roles in different contexts. However, Polanyi, Merton, and Bush provide solid theoretical arguments that too much centralized control may stifle science. Many structural features of science, some of which are embodied in law, further suggest that the absence of centralized control contributes to scientific robustness. For instance, the inability of scientists (or any other parties) to patent natural laws, physical phenomena, and abstract ideas ensures that these “infrastructural” resources remain in the public domain.<sup>135</sup> Such “basic tools of scientific and technological work” are freely available to all.<sup>136</sup> Relatedly, a wide literature on the scientific commons attests to the highly generative potential of a decentralized ecosystem in which knowledge, resources, and tools are freely available to scientists to use as they see fit.<sup>137</sup> Finally, the institutional structure of university research, which emphasizes academic freedom, peer review, and curiosity-based research, further suggests that decentralization contributes meaningfully to robust science.<sup>138</sup>

## 2. Politicizing Science and Technology Governance

A second, and related, challenge of centralized innovation governance is the risk of politicizing science and technology policy. Politicization may affect both

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<sup>134</sup> See *About NSF*, NAT'L SCI. FOUND., new.nsf.gov/about [perma.cc/77Q4-RLTT] (last visited Apr. 3, 2024) (noting that NSF is a grant-making organization whose “investments account for about 25% of federal support to America’s colleges and universities for basic research”).

<sup>135</sup> See *Mayo Collaborative Servs. v. Prometheus Lab’ys, Inc.*, 566 U.S. 66, 71 (2012).

<sup>136</sup> *Id.* at 71 (quoting *Gottschalk v. Benson*, 409 U.S. 63, 67 (1972)).

<sup>137</sup> See, e.g., Peter Lee, *Contracting To Preserve Open Science: Consideration-Based Regulation in Patent Law*, 58 EMORY L.J. 889, 919-62 (2009) [hereinafter Lee, *Open Science*] (discussing efforts by government, academic, and nonprofit entities to promote scientific progress by ensuring wide access to patented technologies needed for research); Jorge L. Contreras, *Bermuda’s Legacy: Policy, Patents, and the Design of the Genome Commons*, 12 MINN. J.L. SCI. & TECH. 61, 63-65 (2011) (outlining how the Human Genome Project’s policy of releasing DNA sequence data within twenty-four hours of generation accelerated genome sequencing and became an effective model for other endeavors); YOCHAI BENKLER, *THE WEALTH OF NETWORKS: HOW SOCIAL PRODUCTION TRANSFORMS MARKETS AND FREEDOM* 14 (2006) (discussing societal benefits of scientific decentralization, including “commons-based strategies to publish important sources of information in a way that makes the outputs freely available in poorer countries”).

<sup>138</sup> See Michael J. Madison, Brett M. Frischmann & Katherine J. Strandburg, *The University as Constructed Cultural Commons*, 30 WASH. U. J.L. & POL’Y 365, 390 (2009) (discussing how “[k]nowledge in the university setting is often assumed to be an inherently open thing,” grounded on informal norms that include “presentation of a new piece of research by one scholar to a workshop of colleagues, the prioritization of new research initiatives based on inherent rather than market worth, and the subscription to the overarching premise and goal known as academic freedom”).

the funding and regulation of innovation. An extreme example of politicization is the spectacular failure of the Soviet Union's support of Lysenkoism in the face of Mendelian genetics.<sup>139</sup> Indeed, this fiasco contributed to the demise of the science planning movement and the vindication of decentralized, peer-reviewed science funding models championed by Polanyi and Bush.<sup>140</sup>

More recent examples of the politicization of federal science funding abound. Based on moral and political concerns, President George W. Bush famously withdrew federal research funds for new lines of human embryonic stem cells.<sup>141</sup> This move drew harsh criticism from the research community.<sup>142</sup> Furthermore, it was part of a broader politicization of science that even included NIH subjecting research proposals mentioning the word "gay" to extra scrutiny.<sup>143</sup> Following the election of President Barack Obama, Congress enacted the American Recovery and Reinvestment Act of 2009,<sup>144</sup> which included \$21 billion in research funding for several agencies.<sup>145</sup> Massive investment in science was part of President Obama's pledge to "restore science to its rightful place."<sup>146</sup> More recently, President Donald Trump's first proposed budget drastically cut science funding, though Congress successfully reversed most of

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<sup>139</sup> Baker, *supra* note 104, at 32 ("[C]ritics of science planning could hardly have asked for better ammunition than the Stalin regime's suppression of opposition to the spurious anti-Mendelian biology of Trofim Lysenko.").

<sup>140</sup> *Id.*

<sup>141</sup> See Press Release, Off. of the Press Sec'y, President George W. Bush Discusses Stem Cell Research (Aug. 9, 2001, 8:01 PM CDT), [georgewbush-whitehouse.archives.gov/news/releases/2001/08/print/20010809-2.html](http://georgewbush-whitehouse.archives.gov/news/releases/2001/08/print/20010809-2.html) [<https://perma.cc/SGA9-BBNC>] (describing decision to limit federal support for stem cell research to existing cell lines as motivated not only by scientific concerns, but also belief that "human life is a sacred gift from our Creator"); Press Release, Nat'l Inst. of Health Comm'ns Office, NIH Statement on the President's Stem Cell Address (Aug. 9, 2001), [web.archive.org/web/20011103102414/http://www.nih.gov/news/pr/aug2001/od-09.htm](http://web.archive.org/web/20011103102414/http://www.nih.gov/news/pr/aug2001/od-09.htm) (stating that NIH is "pleased with the President's decision to allow the use of Federal funds for important basic research on human embryonic stem cells," and that it "understand[s] the President's clear desire to move forward with care").

<sup>142</sup> See, e.g., Martin McKee & Thomas E. Novotny, *Political Interference in American Science: Why Europe Should Be Concerned About the Actions of the Bush Administration*, 13 EUR. J. PUB. HEALTH 289, 289 (2003) (describing the Bush Administration as engaging in "distortion and suppression of scientific information," including a statement "that over 60 useable stem cell lines already existed" at the time of the funding decision when this was "simply wrong").

<sup>143</sup> *Id.* at 290.

<sup>144</sup> Pub. L. No. 111-5, 123 Stat. 115.

<sup>145</sup> *Id.*; Jeffrey Mervis, *Scientists Start To Parse a Trump Presidency*, 354 SCIENCE 811, 812 (2016).

<sup>146</sup> See *Science Scorned*, Editorial, 467 NATURE 133, 133 (2010).

the cuts.<sup>147</sup> Additionally, climate change scientists feared they would receive decreased funding due to Trump's hostility to such research.<sup>148</sup>

Centralized political control over innovation is also subject to classic rent-seeking problems. As public choice theory predicts, powerful lobbies can assert their political influence over government actors to receive outsized public support.<sup>149</sup> The potential for government capture is illustrated by the Obama Administration's disastrous support for solar panel manufacturer Solyndra. In 2009, the Obama Administration famously guaranteed \$535 million in loans to Solyndra, which filed for bankruptcy two years later.<sup>150</sup> The administration maintained that its support for Solyndra arose from a merit-based review by experts from the DOE.<sup>151</sup> However, an investigation revealed that "high-level maneuvering by politically connected clean-technology investors" influenced public support.<sup>152</sup> Not surprisingly, powerful technology interests routinely seek to influence federal innovation laws and regulations. To take one example, during one recent two-year congressional election cycle, internet service providers ("ISPs") spent \$235 million on lobbying, much of it aimed at opposing net neutrality rules.<sup>153</sup> Troublingly, if an innovation harms a diffuse and broad population while benefiting a concentrated interest group, collective action problems may inhibit attempts at regulation.<sup>154</sup>

Politicization of innovation policy, which centralized governance exacerbates, can destabilize public support for science and technology. While popular sentiment views Democratic administrations as more supportive of

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<sup>147</sup> Joel Achenbach, *Trump's Budget Calls for Seismic Disruption in Medical and Science Research*, WASH. POST (Mar. 16, 2017, 12:01 AM), [washingtonpost.com/national/health-science/trumps-budget-would-slash-scientific-and-medical-research/2017/03/15/d3261f98-0998-11e7-a15f-a58d4a988474\\_story.html](https://www.washingtonpost.com/national/health-science/trumps-budget-would-slash-scientific-and-medical-research/2017/03/15/d3261f98-0998-11e7-a15f-a58d4a988474_story.html) (outlining the Trump Administration's proposed cuts to science funding, including a nearly 20% cut to NIH, nearly 18% cut to DOE, and more than 31% cut to EPA).

<sup>148</sup> See Eric Niiler, *Scientists Prepare To Fight for Their Funding Under Trump*, WIRED (Nov. 15, 2016, 3:00 PM), [www.wired.com/2016/11/scientists-preparing-defend-research-funding/](http://www.wired.com/2016/11/scientists-preparing-defend-research-funding/).

<sup>149</sup> See generally MANCUR OLSON, JR., *THE LOGIC OF COLLECTIVE ACTION: PUBLIC GOODS AND THE THEORY OF GROUPS* (1965) (arguing that concentrated minority interests can be overrepresented relative to diffuse majority interests).

<sup>150</sup> Ronald D. White, *Solar Panel Firm Solyndra To Cease Operations*, L.A. TIMES (Sept. 1, 2011, 12:00 AM PT), [latimes.com/business/la-xpm-2011-sep-01-la-fi-solar-shutdown-20110901-story.html](http://latimes.com/business/la-xpm-2011-sep-01-la-fi-solar-shutdown-20110901-story.html) [perma.cc/A97W-AC6Y].

<sup>151</sup> Joe Stephens & Carol D. Leonnig, *Solyndra: Politics Infused Obama Energy Programs*, WASH. POST (Dec. 25, 2011, 6:27 PM), [washingtonpost.com/solyndra-politics-infused-obama-energy-programs/2011/12/14/gIQA4HIIHP\\_story.html](https://www.washingtonpost.com/solyndra-politics-infused-obama-energy-programs/2011/12/14/gIQA4HIIHP_story.html).

<sup>152</sup> *Id.*

<sup>153</sup> Jon Brodtkin, *ISPs Spent \$235 Million on Lobbying and Donations, "More Than \$320,000 a Day,"* ARS TECHNICA (July 20, 2021, 2:50 PM), [arstechnica.com/tech-policy/2021/07/isps-spent-235-million-on-lobbying-and-donations-more-than-320000-a-day/](https://arstechnica.com/tech-policy/2021/07/isps-spent-235-million-on-lobbying-and-donations-more-than-320000-a-day/) [perma.cc/RN9S-ZQE2].

<sup>154</sup> Crootof & Ard, *supra* note 87, at 382; see generally OLSON, JR., *supra* note 149.

science than Republican ones, that is not necessarily the case. Rather, different administrations tend to favor different kinds of science.<sup>155</sup> Democratic administrations favor agencies like NASA, the EPA, the Department of Commerce, and the Department of Transportation.<sup>156</sup> However, Republican administrations favor agencies such as NSF, the Department of Agriculture, and NIH.<sup>157</sup> Indeed, overall science funding may increase under Republican administrations due to increased defense-related R&D spending.<sup>158</sup> While politics are unavoidable in innovation policy, centralized governance can produce an unsettling degree of politicization. At a minimum, centralization elevates the views of policymakers (and politically connected lobbies) over scientists themselves in defining research priorities. Additionally, politicization destabilizes research (particularly long-term projects) because priorities and funding can change dramatically with changing political administrations.<sup>159</sup>

### 3. Information Deficiencies and the Problem of Timing

Third, another disadvantage of centralized innovation governance is that it does not exploit enormous amounts of information distributed outside of central decisionmakers.<sup>160</sup> As proponents of scientific autonomy argue, mission-based science funding diminishes the tremendous generative potential of individual scientists determining their own research agendas. The wide community of scientists may identify scientific opportunities that legislators and regulators do not recognize. Additionally, centralized regulation does not exploit tremendous amounts of information distributed among scientists and engineers related to anticipating and mitigating technological harms. This information asymmetry, in which policymakers have lower-quality information than researchers and inventors, informs broader technical competence limitations on the part of legislators.<sup>161</sup> Such limitations are particularly stark in light of the demise of the

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<sup>155</sup> Sidita Kushi, *Breaking Science Stereotypes: Examining the Effects of Party Politics on Federal R&D Funding*, J. SCI. POL'Y & GOVERNANCE, Aug. 2015, at 1, 11.

<sup>156</sup> *Id.*

<sup>157</sup> *Id.*

<sup>158</sup> *Id.*

<sup>159</sup> See Laura Díaz Anadón, *Missions-Oriented RD&D Institutions in Energy Between 2000 and 2010: A Comparative Analysis of China, the United Kingdom, and the United States*, 41 RSCH. POL'Y 1742, 1751 n.39 (2012) (finding that some firms in the energy sector avoid government R&D funds because of the political instability of such funding).

<sup>160</sup> Cf. Marchant, *supra* note 14, at 1862 (noting that regulatory agencies lack the expertise and resources to regulate emerging technologies comprehensively).

<sup>161</sup> See, e.g., Cecilia Kang & Adam Satariano, *As A.I. Booms, Lawmakers Struggle To Understand the Technology*, N.Y. TIMES (Mar. 3, 2023), [nytimes.com/2023/03/03/technology/artificial-intelligence-regulation-congress.html](https://www.nytimes.com/2023/03/03/technology/artificial-intelligence-regulation-congress.html).

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Office of Technology Assessment, a now-defunct entity that previously provided advice to Congress on science and technology issues.<sup>162</sup>

Relatedly, centralized regulation suffers from lags in timing. Such regulation tends to be ex post, reacting after the harms of some technology have manifested. This is evident, for example, in the flurry of legislative activity aimed at stemming the harms of AI. However, scientists and engineers developing these technologies can anticipate problems and solutions far before legislatures can act. Exploiting private information from these scientists and engineers can address the pacing problem: the typically large time lag between possibly disruptive innovation and adequate regulatory responses.<sup>163</sup>

The information deficiencies of centralized innovation governance are particularly striking when comparing this approach to two decentralized governance systems: the market and the commons. First, as economist and political philosopher Friedrich Hayek famously argued, markets enjoy significant advantages over centralized planning in harnessing broadly distributed information to allocate resources.<sup>164</sup> It would be exceedingly difficult, for example, for central policymakers to determine the number and kinds of shoes to produce in a society in a given year. According to Hayek, however, one of the great advantages of markets is that they distill private information from millions of consumers and producers about preferred resource allocations.<sup>165</sup> By harnessing distributed information in this fashion, markets can (in theory) allocate resources more efficiently than central planning. Reflecting this insight, Polanyi famously compared the scientific community to a market economy. Like Adam Smith's invisible hand, in which consumers and producers exploit gaps and opportunities in the market, individual scientists view the work of the collective and adjust their efforts accordingly.<sup>166</sup> The market-like ability of the scientific community to mobilize distributed information offers another argument against central science planning.

Second, the information disadvantages of centralized governance are evident when comparing central planning to the commons. As articulated in

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<sup>162</sup> See ZACH GRAVES & DANIEL SCHUMAN, SCIENCE, TECHNOLOGY, AND DEMOCRACY: BUILDING A MODERN CONGRESSIONAL TECHNOLOGY ASSESSMENT OFFICE 4-7 (2020) (describing the Office of Technology Assessment's function as a think tank within Congress, providing authoritative, nonpartisan advice on a broad range of science and technology issues); Albert C. Lin, *Technology Assessment 2.0: Revamping Our Approach to Emerging Technologies*, 76 BROOK. L. REV. 1309, 1330-32 (2011) (same).

<sup>163</sup> See Gary E. Marchant, *The Growing Gap Between Emerging Technologies and the Law*, in THE GROWING GAP BETWEEN EMERGING TECHNOLOGIES AND LEGAL-ETHICAL OVERSIGHT: THE PACING PROBLEM 19, 19 (Gary E. Marchant, Braden R. Allenby & Joseph R. Herkert eds., 2011).

<sup>164</sup> See F. A. Hayek, *The Use of Knowledge in Society*, 35 AM. ECON. REV. 519, 524-25 (1945).

<sup>165</sup> See *id.*; see also Demsetz, *supra* note 41, at 12 (noting that markets have advantages over governments in producing information "on the desired directions of investment and on the quantities of resources that should be committed to invention").

<sup>166</sup> See Polanyi, *supra* note 1, at 54-55.

foundational work by political economist Elinor Ostrom and others, a commons refers to resources that are openly available to a given population.<sup>167</sup> A commons can apply to both physical resources, such as an open park, and intangible, intellectual resources. As noted, the scientific commons represent an open repository of knowledge, information, and tools that greatly accelerates scientific progress. Legal scholar Yochai Benkler has influentially explored the related phenomenon of commons-based peer production.<sup>168</sup> Like markets, one of the principal virtues of a commons is its ability to mobilize information distributed among large numbers of people.<sup>169</sup> For instance, in the context of open-source software, influential software developer Eric Raymond famously observed that “[g]iven enough eyeballs, all bugs are shallow.”<sup>170</sup> In other words, open-source projects benefit from a wide, decentralized community of programmers identifying and correcting software errors. The advantages of the commons in mobilizing distributed information further underscore the informational deficiencies of centralized regulation.

The inability of centralized governance to exploit wide swaths of private information leads to several shortcomings of timing. Legislative processes are very slow,<sup>171</sup> and centralized regulation does not exploit the real-time knowledge of millions of scientists and engineers about new innovations and their harms. Relatedly, legislative activity tends to be ex post and reactive, arising after technological harms have manifested. Tapping into private information distributed among scientists and engineers can provide policymakers with a “heads up” of likely harms that warrant intervention. The inability of centralized innovation governance to mobilize distributed information quickly is a significant disadvantage, given that policymakers may only have a short window to act decisively before path dependence, lock-in, and stabilization render regulation much more difficult.<sup>172</sup>

### III. A MODEL OF DISTRIBUTED INNOVATION GOVERNANCE

While centralized governance to promote socially responsive innovation has several shortcomings, this Article does not disclaim its importance. Mission-based science funding has achieved many notable successes, such as the Human Genome Project and Operation Warp Speed. Furthermore, there is sometimes

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<sup>167</sup> See generally ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION (1990) (presenting empirical studies illustrating practical arrangements for effectively governing and managing common resources).

<sup>168</sup> See BENKLER, *supra* note 137, at 24-25.

<sup>169</sup> This is somewhat ironic given that commons, which eschew private property rights, are generally seen as diametrically opposed to markets, which are predicated on private property rights.

<sup>170</sup> ERIC S. RAYMOND, THE CATHEDRAL & THE BAZAAR: MUSINGS ON LINUX AND OPEN SOURCE BY AN ACCIDENTAL REVOLUTIONARY 30 (1999).

<sup>171</sup> See Marchant, *supra* note 14, at 1863 (suggesting that traditional governmental regulation is becoming even slower due to increasing bureaucracy and politicization).

<sup>172</sup> See Crootof & Ard, *supra* note 87, at 355.

no substitute for ex post regulation to address technological harms. While centralized funding and regulation are susceptible to politicization, such politicization also fosters democratic accountability.<sup>173</sup> In theory, centralized governance allows members of the polity to express their policy preferences in the electoral system rather than externalizing regulatory functions to nondemocratically accountable entities, such as private firms or the “scientific community.” Finally, legislatures and agencies possess mechanisms to access knowledge distributed throughout the scientific community to inform laws and regulations.<sup>174</sup>

The shortcomings of centralized innovation governance, however, suggest the value of supplementing it with decentralized approaches.<sup>175</sup> Accordingly, the balance of this Article explores a distributed model of innovation governance to promote socially responsive science and technology. While decentralized mechanisms to promote innovation have long existed alongside centralized approaches, unlike the latter, they have tended to focus on “neutral” technical criteria rather than orienting innovations toward serving broader social, economic, and political objectives. This Article proposes such a shift in orientation. Extending beyond central policymakers, this model would confer greater authority and responsibility to promote socially responsive innovation on a wide array of public and private entities, including scientists and engineers themselves. The essential model involves reorienting various gatekeepers toward considering the broader social impacts of innovative projects when granting valuable resources to scientists and engineers. These gatekeepers would operate across the lifecycle of a typical R&D project. Thus, this Article proposes that federal funding agencies, scientific journals and conferences, and the PTO consider the broader impacts—not just technical merit—of innovative work when allocating research funds, publication and presentation offers, and patents.

“Broader impacts” is, of course, a rather capacious term that is deliberately flexible and subject to interpretation. This Article proposes three factors to structure the broader impacts analysis and respond to the most serious critiques of contemporary science and technology.<sup>176</sup> The first factor would assess the social benefit of the research or technology. The emphasis here is not so much technical merit but the potential for the innovation to improve social welfare. For instance, a federal funding agency would rate research aimed at mitigating climate change high on this factor. A second factor in the broader impacts analysis would consider the potential social harms of the research or technology and any mechanisms disclosed to mitigate those harms. Thus, for instance, AI

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<sup>173</sup> See Lin, *Herding Cats*, *supra* note 26, at 985.

<sup>174</sup> See, e.g., Graves & Schuman, *supra* note 162, at 16; Wendy E. Wagner, *A Place for Agency Expertise: Reconciling Agency Expertise with Presidential Power*, 115 COLUM. L. REV. 2019, 2027 (2015) (“[M]any agencies have instituted formal and often extensive expert peer review processes to solicit feedback on their science-intensive analyses.”).

<sup>175</sup> Cf. Marchant, *supra* note 14, at 1874 (suggesting combining various approaches to regulate emerging technologies).

<sup>176</sup> See *supra* Part I.

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researchers applying to present a paper at a scientific conference should disclose the potential for their research to undermine privacy and any technical (or other) mechanisms to reduce that risk. A third factor in the broader impacts analysis would consider the distributional effects of the research or technology and whether it serves the needs of marginalized groups. Here, for instance, the PTO could prioritize the examination of a patent application on a drug that treats a neglected disease prevalent among low-income populations. By considering these factors as part of “broader impacts,” gatekeepers would promote a norm of socially responsive science and technology.

This model of innovation governance is distributed or decentralized in multiple senses of the term. First, as noted, it distributes responsibility to promote socially responsive innovation beyond core policymakers to a wider population of actors.<sup>177</sup> While policymakers could articulate general social objectives to be achieved, a wide array of public and private gatekeepers, such as federal funding agencies, scientific journals and conferences, and the PTO would play important roles in interpreting and applying “broader impacts” when reviewing submissions. More importantly, the onus would ultimately fall on legions of scientists and engineers applying for funds, submitting manuscripts to journals and conferences, and filing patent applications to consider the wider social implications of their work, communicate these impacts to relevant gatekeepers, and, in some cases, modify their projects accordingly.

Second, in some contexts, this model is further distributed by mobilizing communal processes of peer review. Federal funding agencies, scientific journals, and academic conferences routinely outsource a portion of their review processes to peer reviewers unaffiliated with those institutions. The participation of independent peer reviewers, who would consider the social implications of research in recommending whether to grant research funds, publication offers, or presentation opportunities, further decentralizes this governance model. Additionally, mobilizing academic peer review would help strengthen the communal norm of considering the social impacts of innovation. Scientists and engineers would consider broader impacts both as applicants (submitting funding proposals and manuscripts) and as reviewers of others’ funding proposals and manuscripts.

Finally, this model is distributed in that it would apply to several stages across the lifecycle of a typical R&D project. At the beginning of a project, when a researcher is applying for funds, a federal funding agency would consider the social implications of the proposed research. Later, when the scientist or engineer seeks to publish or present research findings, scientific journals and conferences would also weigh the social implications of the research when reviewing submissions. Toward the end of the R&D lifecycle, when a scientist

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<sup>177</sup> The distributed nature of this approach shores up its character as a governance rather than traditional regulatory regime. *Cf.* Marchant, *supra* note 14, at 1865 (noting that governance regimes extend beyond governmental entities and enforceable government regulations).

or engineer seeks to patent a technology, the PTO would consider the social implications of the technology when prioritizing applications for review. By continuously reinforcing the importance of social impacts throughout the R&D lifecycle, this distributed model would further strengthen the norm of socially responsive innovation.

It bears emphasizing that this distributed model comprises a *governance* approach, in contradistinction to traditional command-and-control regulation. As legal scholar Albert Lin describes, governance comprises “the making and implementation of norms by public actors as well as businesses, nonprofit organizations, and other private actors.”<sup>178</sup> Unlike “hard” legislation, these approaches have a “soft” character.<sup>179</sup> They neither require nor prohibit any kind of innovative activity. Rather, they partially condition resources—funds, publication and presentation opportunities, and patents—on a project’s potential to promote social welfare, broadly construed. As such, they operate as “nudges” rather than hard “shoves”: they seek to shape people’s behavior “without forbidding any options or significantly changing their economic incentives.”<sup>180</sup> As we have seen, communal norms play a particularly important role in governing scientific and technological communities.<sup>181</sup> Rather than operate solely as external regulation, such distributed approaches seek to cultivate a norm of socially responsive innovation within the innovative community itself.

Accordingly, it is helpful to both situate this proposal within a regulatory trend of self-disclosure regimes and to distinguish it from approaches in other fields. At a conceptual level, this proposal resembles other disclosure frameworks, such as the National Environmental Policy Act’s requirement that federal agencies submit Environmental Impact Statements (“EISs”) for “major Federal actions significantly affecting the quality of the human environment.”<sup>182</sup>

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<sup>178</sup> Lin, *Herding Cats*, supra note 26, at 981.

<sup>179</sup> See *id.* at 980 (describing “soft law” approaches that tend to “shy away from complex regulation, strive to educate rather than coerce, and devolve power away from central government to local or private entities”); Marchant, supra note 14, at 1866 (“Soft law instruments set forth substantive requirements that are not directly enforceable by government regulators.”).

<sup>180</sup> RICHARD H. THALER & CASS R. SUNSTEIN, *NUDGE: IMPROVING DECISIONS ABOUT HEALTH, WEALTH, AND HAPPINESS* 6 (2008). While some of these approaches would change the economic incentives of scientists and engineers, their influence would be tempered by the fact that broader impacts would be just one of several criteria used to evaluate grant proposals, manuscripts, presentation requests, and patent applications.

<sup>181</sup> See supra notes 110-24 and accompanying text; see also Pedraza-Fariña, supra note 117, at 838-39 (describing the importance of “communities of practice” in shaping scientific norms and activity).

<sup>182</sup> National Environmental Policy Act of 1969, Pub. L. No. 91-190, § 102(2)(C), 83 Stat. 852 (codified at 42 U.S.C. § 4332(2)(C)). Another influential disclosure regime is the requirement for public companies to disclose various risks to potential investors. See Virginia Harper Ho, *Disclosure Overload? Lessons for Risk Disclosure & ESG Reporting Reform from the Regulation S-K Concept Release*, 65 VILL. L. REV. 67, 76-80 (2020) (discussing disclosure requirement reform and challenging objections of overdisclosure).

By analogy, scientists and engineers applying for research grants, presentation and publication slots, or patents would have to disclose the broader social impacts of their innovations. The comparison to EISs is simultaneously sobering and encouraging. On the one hand, EISs and the broader phenomenon of environmental impact assessments (“EIAs”) have received criticism as theoretically infirm, procedurally deficient, and substantively ineffective.<sup>183</sup> On the other hand, EIAs has been widely influential and effectuated deep cultural change. Virtually all countries, and several international treaties, have adopted an EIA requirement in some fashion.<sup>184</sup> Additionally, beyond the environmental sphere, EISs have inspired numerous actual and proposed self-disclosure regimes, such as racial impact statements,<sup>185</sup> privacy impact notices,<sup>186</sup> and algorithmic impact statements.<sup>187</sup> It is useful to note that many of the technicalities and limitations of EISs are not germane to the present proposal, which in some ways is quite modest. For instance, while it is important for EISs to anticipate environmental harms with a high degree of accuracy, some leeway is more acceptable when projecting the broader social impacts of an emerging technology. Rather than aim for stringent accuracy, if this proposal contributes to a cultural shift in encouraging scientists and engineers to think more about the social implications of their work, it will have accomplished an important objective.

This distributed model of governance offers several benefits relative to centralized innovation governance. First, it preserves wider room for scientific and technological autonomy, which has enormous generative potential. Rather than central bureaucrats determining what kinds of research or innovations to pursue, scientists and engineers can consider whether and how to shape their research to serve broad social objectives. Returning to the classic debates between Bernal and Polanyi, this approach seeks to integrate the Bernalist project of applying innovation to enhance social welfare with Polanyi-esque scientific autonomy and communal, norm-based governance. Second, while no

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<sup>183</sup> See Richard K. Morgan, *Environmental Impact Assessment: The State of the Art*, 30 *IMPACT ASSESSMENT & PROJECT APPRAISAL* 5, 7-11 (2012); see also Gerald G. Singh et al., *Scientific Shortcomings in Environmental Impact Statements Internationally*, 2 *PEOPLE & NATURE* 369, 376-77 (2020) (finding that analyses in EISs sometimes do not meet research standards in particular fields).

<sup>184</sup> See Morgan, *supra* note 183, at 6.

<sup>185</sup> See Jessica Erickson, *Racial Impact Statements: Considering the Consequences of Racial Disproportionalities in the Criminal Justice System*, 89 *WASH. L. REV.* 1425, 1444-45 (2014) (advocating for improvements to racial impact statements and drawing lessons from EISs).

<sup>186</sup> See A. Michael Froomkin, *Regulating Mass Surveillance as Privacy Pollution: Learning from Environmental Impact Statements*, 2015 *U. ILL. L. REV.* 1713, 1745-46 (advocating for requiring entities conducting mass surveillance in and through public spaces to disclose plans publicly via an updated form of EISs).

<sup>187</sup> See Andrew D. Selbst, *Disparate Impact in Big Data Policing*, 52 *GA. L. REV.* 109, 118-19 (2017) (advocating for algorithmic impact statements modeled on EISs); see also Morgan, *supra* note 183, at 7 (discussing further offshoots of EIAs).

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governance regime is immune from politics, distributed innovation governance would distribute control over ensuring socially responsive innovation throughout a far-flung network of public and private institutions, peer reviewers, scientists, and engineers. Third, distributed innovation governance would exploit massive amounts of real-time information distributed among scientists and engineers. This approach enhances regulatory efficiency by exploiting information asymmetries between innovators and policymakers, accelerating the pace and nimbleness of governance, and encouraging frontline scientists and engineers to prevent problems before path dependence and settled expectations complicate attempts at regulation.

The next three Parts elaborate this distributed model of innovation governance, starting first with leveraging federal research funds to encourage more socially responsive science.

#### IV. BROADER IMPACTS: TYING FEDERAL RESEARCH FUNDS TO SOCIALLY RESPONSIVE SCIENCE

A central prong in this distributed model is to leverage federal research funds to encourage curiosity-based research that serves important social needs. While this may seem far-fetched, this approach builds upon existing practice by NSF. With an annual budget of almost \$10 billion, NSF funds about 25% of all federally supported basic research at U.S. colleges and universities.<sup>188</sup> It receives about 43,000 grant proposals a year, funding about 11,000 of them (25%).<sup>189</sup> Not surprisingly, NSF receives more worthy proposals that it can fund, and it has adopted two review criteria to select proposals for funding: intellectual merit and broader impacts. Intellectual merit refers to the scientific value of proposed research and its “potential to advance knowledge.”<sup>190</sup> The broader impacts criterion, on the other hand, “encompasses the potential [of proposed research] to benefit society and contribute to the achievement of specific, desired societal outcomes.”<sup>191</sup>

This Article argues that considering broader impacts when awarding research funds to scientists and engineers represents a valuable model of distributed innovation governance. This Part first explores the evolution of NSF’s broader impacts criterion, focusing on recent reforms in the CHIPS and Science Act of 2022. It then addresses some of the principal critiques of the broader impacts criterion, and it offers suggestions to improve its implementation. Relatedly, it suggests reforming the factors informing the broader impacts requirement, and

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<sup>188</sup> *About NSF*, *supra* note 134.

<sup>189</sup> Gopal Ratnam, *NSF Director: Funding Boost Can Steer Research Monday to More States*, ROLL CALL (Aug. 2, 2022, 6:00 AM), [rollcall.com/2022/08/02/nsf-director-funding-boost-can-steer-research-money-to-more-states/](https://rollcall.com/2022/08/02/nsf-director-funding-boost-can-steer-research-money-to-more-states/) [perma.cc/NE39-KKBL].

<sup>190</sup> NAT’L SCI. FOUND., PROPOSAL & AWARD POLICIES & PROCEDURES GUIDE, at ch. III (2021).

<sup>191</sup> *Id.*

it argues for extending the consideration of broader impacts to other federal funding agencies beyond NSF.

A. *The Evolution of the National Science Foundation's Broader Impacts Criterion*

While NSF funds research to advance scientific knowledge, it has long considered the social, economic, and political effects of proposed research when awarding grants. This multivalent approach is consistent with its mission to “Promote the progress of science,” “Advance the national health, prosperity, and welfare,” and “Secure the national defense.”<sup>192</sup> In its first call for grants in 1951, NSF stated that it would subject applications to peer review and focus on the “scientific merit of the suggested research.”<sup>193</sup> However, NSF program officers also considered “the proposed research’s relation to the national effort, as well as issues of geographic and institutional distribution.”<sup>194</sup> Thus, from the very outset, NSF considered nonscientific, social and economic factors when awarding research grants.

The NSF’s consideration of broader social impacts expanded in subsequent decades. In part, these developments paralleled the increasing proportion of NSF funding devoted to applied rather than “pure” basic research.<sup>195</sup> In 1967, NSF issued new review criteria for national centers and research institutes that considered the degree to which a laboratory’s work resulted in “tangible social benefits.”<sup>196</sup> In 1971, NSF established a new program called Research Applied to National Needs, which had an explicitly goal-oriented character.<sup>197</sup> In 1974, NSF issued new review criteria grouped into four categories: the researcher’s technical competence, the scientific merit of the proposed project, the utility or potential application of the research, and contributions to scientific institutions and infrastructure.<sup>198</sup> Notably, the third category—utility—considered tangible technological applications of proposed research. In 1981, NSF reconsolidated its review criteria.<sup>199</sup> In so doing, it clarified that the fourth criterion—effect of the research on the infrastructure of science and engineering—considered the participation of women, marginalized communities, and individuals with disabilities in research projects and the institutional and geographic distribution

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<sup>192</sup> *About NSF*, *supra* note 134 (emphasis omitted).

<sup>193</sup> NAT’L SCI. FOUND., THE SECOND ANNUAL REPORT OF THE NATIONAL SCIENCE FOUNDATION: FISCAL YEAR 1952, at 51 (1952).

<sup>194</sup> Marc Rothenberg, *Making Judgments About Grant Proposals: A Brief History of the Merit Review Criteria at the National Science Foundation*, 12 TECH. & INNOVATION 189, 190 (2010).

<sup>195</sup> *See id.* at 190-91.

<sup>196</sup> NAT’L SCI. FOUND., SEVENTEENTH ANNUAL REPORT FOR THE FISCAL YEAR ENDED JUNE 30, 1967, at 218-19 (1967).

<sup>197</sup> Rothenberg, *supra* note 194, at 191.

<sup>198</sup> NAT’L SCI. FOUND., TWENTY-FOURTH ANNUAL REPORT FOR FISCAL YEAR 1974, at 131 (1974).

<sup>199</sup> NAT’L SCI. FOUND., GRANT PROPOSAL GUIDE 13, 15 (1995).

of research grants.<sup>200</sup> Thus, for decades, social considerations and distributional impacts—not just scientific merit—have informed NSF’s funding decisions.

In 1997, NSF officially adopted a “broader impacts” review criterion.<sup>201</sup> It consolidated its four review criteria to two factors: “(1) What is the intellectual merit and quality of the proposed activity? and (2) What are the broader impacts of the proposed activity?”<sup>202</sup> Since then, NSF has relied on these two criteria to allocate billions of dollars in federal research funds every year.

Although it started as an internal rule, NSF’s consideration of broader impacts ultimately became codified in statute. The America COMPETES Reauthorization Act of 2010 required NSF to apply a broader impacts review criterion when awarding research funds.<sup>203</sup> Furthermore, the legislation articulated several public policy goals that this criterion was intended to advance, including increased economic growth and greater participation of women and underrepresented minorities in STEM.<sup>204</sup> In debates leading to the legislation, Representative Danny K. Davis (D-Ill) argued, “Such a policy is long overdue. We spend billions of federal dollars for science advancements but have limited requirements for the institutions receiving these dollars to give back to the nation in terms of helping institutions or students beyond their walls improve their access to quality science.”<sup>205</sup>

Congress further bolstered NSF’s consideration of broader impacts in 2017 with the American Innovation and Competitiveness Act.<sup>206</sup> The Act reaffirmed both the intellectual merit and broader impacts review criteria.<sup>207</sup> In a far cry from Polanyi’s autonomous Republic of Science, the statute states that NSF research grants should “address societal needs through basic research findings or through related activities.”<sup>208</sup> The legislation further requires NSF to submit a report to Congress if it changes its merit review process.<sup>209</sup> The Act also

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<sup>200</sup> *Id.* at 15.

<sup>201</sup> Press Release, Nat’l Sci. Found., NSF to Adopt New Merit Review Criteria, (Apr. 8, 1997), [www.nsf.gov/pubs/1997/pr9728/pr9728.txt](http://www.nsf.gov/pubs/1997/pr9728/pr9728.txt) [perma.cc/L356-GA8K].

<sup>202</sup> *Id.*

<sup>203</sup> America COMPETES Reauthorization Act of 2010 Pub. L. 111-358, § 526(a), 124 Stat. 3982, 4019 (codified at 42 U.S.C. § 1862p-14(a)).

<sup>204</sup> The statute states:

Goals. The Foundation shall apply a Broader Impacts Review Criterion to achieve the following goals: (1) Increased economic competitiveness of the United States. (2) Development of a globally competitive STEM workforce. (3) Increased participation of women and underrepresented minorities in STEM. (4) Increased partnerships between academia and industry. (5) Improved pre-K-12 STEM education and teacher development. (6) Improved undergraduate STEM education. (7) Increased public scientific literacy. (8) Increased national security.

*Id.*

<sup>205</sup> 156 CONG. REC. E2238 (Daily Ed. Dec. 22, 2010) (statement of Rep. Danny K. Davis).

<sup>206</sup> Pub. L. 114-329, 130 Stat. 2969 (2017).

<sup>207</sup> *Id.* § 101(a)(2), 130 Stat. at 2971.

<sup>208</sup> *Id.* § 101(a)(3)(B), 130 Stat. at 2971.

<sup>209</sup> *Id.* § 101(c), 130 Stat. at 2971.

updated the broader impacts provision from the America COMPETES Reauthorization Act of 2010 by modifying the goals to be advanced by the broader impacts criterion.<sup>210</sup> The legislation continued a theme of greater legislative oversight and democratic accountability for NSF and its grant-making functions. Arguing in favor of the legislation, Representative Lamar Smith (R-TX) stated, “Each public NSF award announcement must make clear, in non-technical language, how at least one of these goals is met, affirming that the project is worthy of taxpayer support, based on scientific merit and national interest.”<sup>211</sup>

The CHIPS and Science Act of 2022 further expands NSF’s consideration of broader social impacts when evaluating grant proposals. The Act requires the Director of NSF to assess the broader impacts criterion and allocate funds to train program officers, reviewers, and researchers to better apply it.<sup>212</sup> Notably, beyond the formal broader impacts criterion itself, the Act recognizes that emerging areas of research raise “potential ethical, social, safety, and security implications” and that considering these implications in research design can mitigate possible harms.<sup>213</sup> Accordingly, the Act requires grant proposals to discuss “ethical and societal considerations” of proposed research.<sup>214</sup> The Act further stipulates that grant applicants may disclose, as appropriate, “any readily foreseeable or quantifiable risks to society” and address “how technical or social solutions can mitigate such risks.”<sup>215</sup> Thus, in addition to the formal broader impacts criterion, which focuses on a research proposal’s social benefits, grant applicants are now required to address ethical and societal considerations, which in many cases will include potential harms from their research and ways to mitigate them.

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<sup>210</sup> The statute states:

(a) Goals. The Foundation shall apply a broader impacts review criterion to identify and demonstrate project support of the following goals: (1) Increasing the economic competitiveness of the United States. (2) Advancing of the health and welfare of the American public. (3) Supporting the national defense of the United States. (4) Enhancing partnerships between academia and industry in the United States. (5) Developing an American STEM workforce that is globally competitive through improved pre-kindergarten through grade 12 STEM education and teacher development, and improved undergraduate STEM education and instruction. (6) Improving public scientific literacy and engagement with science and technology in the United States. (7) Expanding participation of women and individuals from underrepresented groups in STEM.

*Id.* § 102(c), 130 Stat. at 2972.

<sup>211</sup> 162 CONG. REC. 16816 (2016) (statement of Rep. Lamar Smith).

<sup>212</sup> CHIPS and Science Act of 2022, Pub. L. No. 117-167, § 10341(a)-(b), 136 Stat. 1366, 1557.

<sup>213</sup> *Id.* § 10343(a)(1)-(2), 136 Stat. at 1557-58 (stating the Congressional intent to utilize the assessment and reward criteria for NSF grants to mitigate potential harms in developing fields before those harms manifest).

<sup>214</sup> *Id.* § 10343(b), 136 Stat. at 1557-58.

<sup>215</sup> *Id.* § 10343(b)(1)-(2), 136 Stat. at 1558.

Although NSF emerged from a Polanyi-esque commitment to scientific autonomy, for decades it has considered the broader social impacts—not just scientific merit—of research projects when awarding billions of dollars of research funds. The CHIPS and Science Act strengthens and expands this practice. This trend, moreover, creates an enormous opportunity to leverage public funding to encourage more socially responsive science and technology. It bears mentioning that the United States is not alone in deploying science funding to advance social objectives. Harkening back to the debate between Bernal and Polanyi, it is now quite clear that governments seek some social return on massive investments in science.<sup>216</sup> For example, UK Research and Innovation and the European Commission’s Horizon 2020 program require applicants to include indicators of the social impact of proposed research.<sup>217</sup> Commentators note that “articulat[ion of] societal and economic ‘impact’ has become a condition of funding [of] even ‘blue skies’ . . . research in many countries.”<sup>218</sup>

B. *Strengthening the Consideration of Broader Impacts in National Science Foundation Research Funding*

This Article argues for strengthening and expanding the consideration of broader impacts when awarding federal research funds. In so doing, it must contend with the challenge that, as presently structured, the broader impacts criterion has delivered mixed results and received significant criticism. In one 2013 study, only 65% of abstracts in a sample of NSF research proposals mentioned broader impacts.<sup>219</sup> This study further found that the broader impacts criterion has primarily encouraged NSF grant applicants to include teaching, training, and dissemination of research results in their grant proposals rather than steering them to pursue research projects of high intrinsic social benefit.<sup>220</sup> Notably, however, these findings arose prior to NSF implementing reforms to

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<sup>216</sup> See Daniel Sarewitz, *The Dubious Benefits of Broader Impact*, 475 NATURE 141, 141 (2011) (“Politicians worldwide no longer accept that public investments in science automatically bring social benefits.”); Robert Frodeman & J. Britt Holbrook, *Science’s Social Effects*, 23 ISSUES SCI. & TECH. 28, 29 (2007) (“[I]t is no longer accepted that scientific progress automatically leads to societal progress.”).

<sup>217</sup> See *Framework for Responsible Research and Innovation*, *supra* note 9 (recommending a four-step “AREA” approach in which researchers anticipate impacts of their research, reflect on the purposes of conducting the research, engage with others in discussion, and act to influence the research).

<sup>218</sup> Owen et al., *supra* note 51, at 754.

<sup>219</sup> Nalini M. Nadkarni & Amy E. Stasch, *How Broad Are Our Broader Impacts? An Analysis of the National Science Foundation’s Ecosystem Studies Program and the Broader Impacts Requirement*, 11 FRONTIERS ECOLOGY & ENV’T 13, 15 (2013).

<sup>220</sup> *Cf. id.* at 15-17 (noting that of active grants addressing broader impacts reviewed in a study, 37% mentioned teaching, training, and learning, while only 13% mentioned benefits to society).

bolster compliance with the broader impacts criterion among researchers.<sup>221</sup> This Section explores several criticisms of the broader impacts criterion and proposals to improve its implementation.

First, commentators express procedural concerns over the ability of researchers and peer reviewers to assess the broader impacts of research projects.<sup>222</sup> Part of the problem is a lack of clarity around the criterion itself.<sup>223</sup> Various stakeholders in NSF-sponsored studies observed that the criterion is unclear and highly subjective, and its weight relative to intellectual merit in grant evaluations is uncertain.<sup>224</sup> More fundamentally, commentators argue that researchers and peer reviewers lack the expertise to assess the broader social implications of research proposals.<sup>225</sup> Scientists, after all, are experts in their technical fields, not in evaluating the social impacts of research.<sup>226</sup> More generally, NSF's application of the broader impacts criterion is subject to all of the usual critiques of peer review, including inconsistency, bias, and the potential for abuse.<sup>227</sup>

Second, commentators have substantive doubts as to whether the broader impacts criterion actually induces researchers to pursue more socially responsive science. To begin, many scientists have deprioritized the broader impacts criterion and delegated satisfying the criterion to outside "education and public outreach" professionals.<sup>228</sup> Additionally, anecdotal evidence suggests that proposals rated highly for broader impacts do not enjoy significant advantages in obtaining funding over proposals that do not.<sup>229</sup> Rather, it seems that reviewers often use broader impacts as a sort of tiebreaker, thus diminishing the incentive effect of this review criterion.<sup>230</sup> As such, NSF grant applicants may

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<sup>221</sup> *Id.* at 18.

<sup>222</sup> Rothenberg, *supra* note 194, at 194 ("The peer review community does not necessarily apply the criteria in the manner the NSF wishes.").

<sup>223</sup> The charge for the 2011 NSB Merit Review Task Force stated, "Anecdotal evidence suggests that this requirement can be very confusing to the research community, which continues to express frustration in interpreting and thus responding effectively to the Broader Impacts criterion when creating a proposal." *Task Force on Merit Review: Charge*, NAT'L SCI. BD. (2010), nsf.gov/nsb/committees/archive/task\_force/tskforce\_mr.jsp [perma.cc/5G5H-JKQL].

<sup>224</sup> NAT'L ALLIANCE FOR BROADER IMPACTS, *THE CURRENT STATE OF BROADER IMPACTS: ADVANCING SCIENCE AND BENEFITING SOCIETY* 4 (2018) [hereinafter *CURRENT STATE*].

<sup>225</sup> Sarewitz, *supra* note 216, at 141; Barry Bozeman & Daniel Sarewitz, *Public Values and Public Failure in US Science Policy*, 32 *SCI. & PUB. POL'Y* 119, 124 (2005).

<sup>226</sup> See Rothenberg, *supra* note 194, at 193 (noting that, before the change to broader impacts, reviewers were most likely to ignore the criteria of utility and infrastructure because they "did not deal with the more technical aspects of the proposal").

<sup>227</sup> Richard Smith, *Peer Review: A Flawed Process at the Heart of Science and Journals*, 99 *J. ROYAL SOC'Y MED.* 178, 179-80 (2006).

<sup>228</sup> Frodeman & Holbrook, *supra* note 216, at 28.

<sup>229</sup> *Id.* at 30 (stating broader impacts ratings are not typically used in determining funding for proposals, except in instances where there is a tie between two similar proposals).

<sup>230</sup> *Id.*

simply blow off this requirement or include unconsidered, boilerplate statements.<sup>231</sup> The broader impacts criterion has elicited “skepticism or even outright opposition on the part of reviewers,” which further suggests that its ability to impact the behavior of researchers is rather limited.<sup>232</sup>

Third, commentators warn that considering social impacts when awarding general, curiosity-based grants will allow policymakers to pass the buck and forgo other, more targeted ways to promote socially responsive science.<sup>233</sup> In a 2001 survey, peer reviewers and stakeholders preferred targeted programs (such as directly increasing funding for underrepresented minorities) to achieve policy goals rather than integrating social considerations in general research grants.<sup>234</sup> Relatedly, commentators suggest that assessing the social value of science at the individual-project level is less useful than doing so at a macroscopic, holistic level, where tradeoffs between different resource allocations are more explicit.<sup>235</sup>

While some of these criticisms are quite valid, this Article argues that they are all, in some way, surmountable. First, NSF and Congress can do much to improve the application of the broader impacts criterion. A valuable start would be to clarify the criterion itself, and this Article discusses revisions to the criterion below.<sup>236</sup> Additionally, while the broader impacts criterion should remain flexible, an illustrative guide with examples (or case studies) of broader impacts that count favorably in the merit review process would be helpful.<sup>237</sup> Additionally, NSF or Congress should clarify the relative weight of broader impacts compared to intellectual merit in the review process. NSF has already made useful strides by requiring all Project Summaries to separately address intellectual merit and broader impacts.<sup>238</sup> However, while merit-review systems must maintain flexibility, some range of relative weight, such as 30-50%, would indicate that the broader impacts criterion is an important part of merit review

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<sup>231</sup> Brent Hecht et al., *It’s Time To Do Something: Mitigating the Negative Impacts of Computing Through a Change to the Peer Review Process* 4 (2018), [arxiv.org/pdf/2112.09544](https://arxiv.org/pdf/2112.09544) [perma.cc/W464-QQBB].

<sup>232</sup> Bozeman & Sarewitz, *supra* note 225, at 124.

<sup>233</sup> *Cf.* Sarewitz, *supra* note 216, at 141 (arguing that rather than assess proposals for broader impacts, “NSF’s capacity to meet broad national goals is best pursued through strategic design and implementation of its programmes, and best assessed at the programme-performance level”).

<sup>234</sup> NAT’L SCI. BD., NSB-05-119, REPORT OF THE NATIONAL SCIENCE BOARD ON THE NATIONAL SCIENCE FOUNDATION’S MERIT REVIEW SYSTEM 19 (2005) [hereinafter NAT’L SCI. BD., REPORT ON MERIT REVIEW].

<sup>235</sup> Bozeman & Sarewitz, *supra* note 225, at 125.

<sup>236</sup> *See infra* Section IV.C.

<sup>237</sup> *See* Peter Lee, *Patent Law and the Two Cultures*, 120 YALE L.J. 2, 69-71 (2010) (arguing that examples and explanations provide useful guidance for parties charged with applying broad standards).

<sup>238</sup> NAT’L SCI. BD., NSB-2021-45, MERIT REVIEW PROCESS: FISCAL YEAR 2020 DIGEST 28 (2020) [hereinafter NAT’L SCI. BD., MERIT REVIEW PROCESS].

and not simply window dressing. Assigning a range of weights would encourage grant applicants and reviewers to take this criterion more seriously.

Additionally, greater technical assistance and training can help NSF, peer reviewers, and grant applicants apply the broader impacts criterion more effectively.<sup>239</sup> NSF has offered significant guidance on broader impacts and funded resources to help researchers articulate the social benefits of their research.<sup>240</sup> Indeed, the NSF-funded National Alliance for Broader Impacts (“NABI”) was founded “to build institutional capacity, advance [broader impacts], and demonstrate the societal benefits of research.”<sup>241</sup> Among other functions, NABI curates best practices for broader impacts and trains researchers.<sup>242</sup> NSF stakeholders have even suggested a broader impacts-themed journal to disseminate best practices.<sup>243</sup> Recent legislative developments are encouraging. The CHIPS and Science Act directs NSF to allocate grants for: (1) training program officers, peer reviewers, and researchers; (2) establishing repositories and clearinghouses to share best practices and facilitate collaborations; and (3) creating tools for assessing and documenting “societal impacts of research.”<sup>244</sup> In February 2021, the National Science Board (“NSB”) recommended mandatory training on the broader impacts criterion for all reviewers.<sup>245</sup>

Additionally, NSF should incorporate more nonscientists with expertise in research evaluation in review panels. The NSB has recommended adding at least one broader impacts expert to all Committees of Visitors, which are external panels that evaluate the NSF merit review process every four to five years.<sup>246</sup>

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<sup>239</sup> See CURRENT STATE, *supra* note 224, at 4 (finding surveyed stakeholder groups needed greater support from NSF to implement the broader impacts criterion).

<sup>240</sup> J. Britt Holbrook, *Assessing the Science-Society Relation: The Case of the US National Science Foundation’s Second Merit Review Criterion*, 27 TECH. SOC’Y 437, 443-44 (2005) (noting that NSF has produced examples of activities that satisfy the broader impacts criterion, revised its Grant Proposal Guide, and designed activities to increase attention to the criterion by program officers); ARIS, *ARIS Broader Impacts Toolkit*, aris.marine.rutgers.edu/index.php (providing NSF-funded resources to help researchers satisfy the broader impacts criterion).

<sup>241</sup> Oludurotimi O. Adetunji & Susan D. Renoe, *Assessing Broader Impacts*, 2 MRS ADVANCES 1681, 1681 (2017).

<sup>242</sup> *Id.* at 1682-84.

<sup>243</sup> CURRENT STATE, *supra* note 224, at 5-6.

<sup>244</sup> CHIPS and Science Act of 2022, Pub. L. No. 117-167, § 10341(b)(1)-(3), 136 Stat. 1366, 1558.

<sup>245</sup> NAT’L SCI. BD., MERIT REVIEW PROCESS, *supra* note 238, at ii.

<sup>246</sup> *Id.* at 3-4; NAT’L SCI. BD., NSB-2021-9, NSB STATEMENT IN SUPPORT OF BROADER IMPACTS EXPERTS TO SERVE ON COMMITTEES OF VISITORS (2021) (“NSB therefore strongly supports an NSF policy to include at least one expert in the broader impacts criterion on COV panels.”); NAT’L SCI. BD., NSB-2021-11, RESOLUTION: NATIONAL SCIENCE BOARD: BROADER IMPACTS EXPERTS TO SERVE ON COMMITTEES OF VISITORS (2021) (“[T]he Director shall, at his discretion, develop a plan to ensure that there is appropriate broader impacts expertise on COV panels . . .”).

Including economists, sociologists, and historians with expertise on the social impacts of scientific research would improve NSF's application of the broader impacts criterion.<sup>247</sup> It would also help scientists serving on review panels to understand and apply the criterion.

Second, these procedural improvements would help the broader impacts criterion achieve its substantive goal of encouraging scientists to pursue research that serves broader social interests. As noted, assigning relative weights to the broader impacts criterion would encourage researchers competing for scarce federal funds to take this criterion seriously. The broader impacts criterion can benefit from a virtuous cycle in which greater clarification, technical assistance, and external appraisal would lead researchers and reviewers to apply it more conscientiously, which in turn would spawn more best practices. While a 2001 review identified several problems with the criterion, a subsequent NSF study concluded that "[r]eviewer and applicant attention to the 'broader impact' criterion has improved over time."<sup>248</sup> Empirical research suggests that the proportion of grant proposals that address broader impacts is increasing.<sup>249</sup>

Third, the political process argument that a broader impacts criterion allows policymakers to pass the buck on promoting socially responsive science seems like a red herring. Cultivating social responsiveness through the peer review process is not mutually exclusive with (and is indeed supportive of) advancing socially responsive science through more direct programs. This Article argues for governmental (and nongovernmental) entities to advance social objectives through both centralized innovation governance and decentralized approaches, such as by considering broader impacts in extramural funding. Indeed, developing a culture where researchers and peer reviewers are expected to consider the social implications of research will support more centralized programs, and vice versa.

### C. *Reforming and Extending the Broader Impacts Criterion*

In addition to these largely procedural prescriptions, this Article also suggests substantively reforming the broader impacts criterion itself. As noted, Congress has enumerated several objectives that the broader impacts criterion is supposed to advance.<sup>250</sup> While these are worthy goals, this Article suggests abstracting from these objectives to articulate three general factors to drive the broader impacts analysis. Drawing on the discussion above, this Article suggests structuring the broader impacts analysis to focus on the social benefits, social

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<sup>247</sup> Cf. Frodeman & Holbrook, *supra* note 216, at 29 (calling on humanists and social scientists to be more engaged with assessing the broader impacts of scientific research); Bornmann, *supra* note 116, at 231 (arguing the inclusion of experts in nonscientific disciplines will allow NSF to better assess social and economic effects of proposed research).

<sup>248</sup> NAT'L SCI. BD., REPORT ON MERIT REVIEW, *supra* note 234, at 5.

<sup>249</sup> Nadkarni & Stasch, *supra* note 219, at 15 (finding a higher percentage of proposals discussing broader impacts in active rather than expired grants).

<sup>250</sup> See *supra* note 210 and accompanying text.

harms, and distributional effects of proposed research. This reform could come about through legislative change or by NSF adopting these factors in revised merit review policies.

First, NSF's broader impacts criterion should include a factor addressing the general positive social impact of a proposed research project. The current list of statutorily enumerated factors, which includes the contributions of proposed research to economic competitiveness, health and welfare, and national defense, clearly indicates a desire to translate publicly funded science into tangible social benefits. However, the current mix of policy objectives has struck some commentators (and undoubtedly some researchers) as arbitrary and overly politicized.<sup>251</sup> Additionally, the current factors do not clearly address certain pressing concerns, such as climate change.<sup>252</sup> This Article suggests including within the broader impacts criterion a general factor addressing the social benefits of proposed research. The open-ended nature of this factor would afford flexibility to researchers to interpret and apply it. As mentioned, however, this Article also suggests that Congress or NSF provide specific examples of research projects that would score high on positive social impact. While some researchers may seek to satisfy the broader impacts criterion by appending education and outreach initiatives to their proposals,<sup>253</sup> this factor would clarify that the broader impacts of the research *itself* would be the central issue for review.

While social benefit is notoriously difficult to measure, economic principles offer some guidance. As a rough cut, some kind of utilitarian cost-benefit analysis, a principle well established in administrative law,<sup>254</sup> may indicate that some research proposals offer greater bang for the buck and are thus more deserving of public investment.<sup>255</sup> Additionally, this social benefit factor would favor research projects that produce public goods, which may generate significant social welfare yet be underproduced in markets. Similarly, proposals that produce significant positive externalities would rate high on this factor. While a "social benefit" factor seems to favor applied rather than basic research, this is not necessarily the case. Rather, the onus would fall on researchers to consider and articulate the wide potential implications of basic research, which may generate enormous social benefit.

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<sup>251</sup> Sarewitz, *supra* note 216, at 141.

<sup>252</sup> *See id.* (highlighting how current broader impacts criteria represents a value judgment and does not include all major policy issues).

<sup>253</sup> *See* Frodeman & Holbrook, *supra* note 216, at 28 (noting the practice of scientists satisfying the broader impacts criterion by hiring education and public outreach ("EPO") professionals, which "allows scientists to conduct their research on their own while the EPO professionals take care of education and outreach").

<sup>254</sup> *See* Jonathan S. Masur, *CBA at the PTO*, 65 DUKE L.J. 1701, 1702 (2016) (describing longstanding mandate that administrative agencies must "perform cost-benefit analysis . . . of all 'economically significant' regulations that they issue").

<sup>255</sup> *See id.* at 1705 ("[C]ost-benefit analysis provides substantial information regarding whether a given policy will increase or decrease social welfare.").

Second, NSF's broader impacts criterion should also include a factor considering the potential *negative* impacts of a proposed research project and ways to mitigate those harms. The current broader impacts criterion focuses solely on the benefits of proposed research.<sup>256</sup> As noted, however, R&D can produce social harms as well.<sup>257</sup> Public support has contributed to advances in big data that undermine privacy, automation technologies that increase unemployment, and social media networks that spread misinformation. All of these effects are "broader impacts" of publicly supported innovation. Research that generates high negative externalities should raise warning flags and face greater obstacles to funding. While researchers may be reluctant to disclose potential social harms, this factor would also consider measures disclosed by researchers to mitigate those risks. This factor would thus provide a powerful incentive for researchers to find solutions for negative broader impacts.

While this factor seems like a radical change, it would simply strengthen and integrate provisions of the CHIPS and Science Act into NSF's existing broader impacts framework. The Act directs NSF to require grant applicants to submit an ethics statement, which may include disclosing "any foreseeable or quantifiable risks to society" from their research and to address "how technical or social solutions can mitigate such risks."<sup>258</sup> The Act presents this as a standalone requirement, and it is not clear how peer reviewers should assess it and what weight it should receive. This Article proposes formally integrating potential harms and their solution as a factor within the broader impacts criterion. In this fashion, training and infrastructure around the broader impacts criterion can also help researchers and reviewers identify and mitigate the risks of proposed research.

Third, this Article proposes a factor addressing the distributional impacts of proposed research. In many ways, the existing broader impacts criterion is already sensitive to distributional concerns. For example, as defined by statute, the criterion considers how a proposed research project "expand[s] the] participation of women and individuals from underrepresented groups in STEM."<sup>259</sup> This Article builds on this existing sensitivity to argue that the broader impacts criterion should more generally consider how a proposed research project would benefit marginalized communities. Consistent with current practice, this factor would consider a research project's plans to include underrepresented researchers and expand education, training, and outreach functions. However, this new factor would go further, inquiring into how the research itself would yield applications that serve underrepresented communities. Thus, for instance, research on vaccines for malaria and other

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<sup>256</sup> *About NSF*, *supra* note 134 (describing beneficial broader impacts of proposal as factors considered in merit review).

<sup>257</sup> *See supra* notes 52-60 and accompanying text.

<sup>258</sup> H.R. 2225, 117th Cong. § 7(e)(2)(A)-(B) (2021).

<sup>259</sup> American Innovation and Competitiveness Act, Pub. L. 114-389, § 102(c), 130 Stat. 2969, 2972 (2017) (codified at 42 U.S.C. § 1862p-14(a)).

neglected diseases would rate highly on this factor. This factor would be consistent with other provisions of the CHIPS and Science Act seeking to ensure that the benefits of publicly funded science extend to underserved communities.<sup>260</sup>

These procedural and substantive reforms would strengthen a system of distributed innovation governance that offers several key benefits. First, rather than requiring or prohibiting any type of research, this approach preserves significant scientific autonomy. Social benefits, social harms, and distributional effects are just three factors that would inform the broader impacts criterion, which itself is only one of two criteria (alongside intellectual merit) that determine the award of funds. Grant applicants would be free to emphasize (or not emphasize) these factors as they see fit. While these factors would reflect political determinations of the objectives of publicly funded research, their interpretation and application would be diffused among NSB, NSF program officers, peer reviewers, and individual grant applicants. Such distributed decision making among largely technical experts would dilute overtly political applications of these factors. Finally, embedding these factors in the broader impacts criterion exploits information distributed among thousands of scientists and engineers applying for NSF grants. Such technical experts likely have ideas for research projects to enhance social welfare that would never occur to centralized policymakers.

With these reforms in place, this Article argues for extending the broader impacts criterion beyond NSF to other federal agencies that fund extramural research. Although the broader impacts criterion is unique to NSF, the imperative to demonstrate social benefit from public research funding extends to all federal funding agencies.<sup>261</sup> Furthermore, NSF plays an influential role in setting standards and influencing trends in general research funding.<sup>262</sup> Notably, several agencies already consider factors beyond scientific merit when evaluating grant proposals.<sup>263</sup> Commentators and NSF stakeholders have

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<sup>260</sup> See CHIPS and Science Act of 2022, Pub. L. 117-167, § 10402(a)(7) (codified at 42 U.S.C. § 19132(a)(7)) (noting the goal of expanding researchers with training in engineering biology, “including [those] from traditionally underrepresented and underserved populations”); *Id.* at § 10621(b)(1)(C) (codified at 15 U.S.C. § 3722a) (amending the Stevenson-Wydler Technology Innovation Act of 1980 to include regional innovation hubs that “promote the benefits of technology development and innovation for all Americans, including underserved communities and vulnerable communities”).

<sup>261</sup> See Adetunji & Renoe, *supra* note 241, at 1681 (“Although the term broader impacts is specific to NSF, other funding organizations such as the National Institutes of Health, and the United States Department of Agriculture are requiring principal investigators to justify the relevance or impact of their work in certain capacities.”).

<sup>262</sup> Nadkarni & Stasch, *supra* note 219, at 14 (“[T]he NSF is—for those carrying out basic research in the US and to some extent internationally—the research funding agency that sets standards and influences trends in general research funding.”).

<sup>263</sup> See J. Britt Holbrook, *The Use of Societal Impacts Considerations in Grant Proposal Peer Review: A Comparison of Five Models*, 12 TECH. & INNOVATION 213, 218-22 (2010)

recommended extending something like a broader impacts criterion to other funding agencies, including DOE, NIH, the National Institute of Standards and Technology, and the Department of Agriculture.<sup>264</sup> Relatedly, the Federation of Academic Scientists has recommended that NIH adopt a broader impacts review criterion modeled on NSF's practices.<sup>265</sup> Beyond just NSF, linking federal funding to the social benefits, social harms, and distributional effects of proposed research would be a meaningful step toward ensuring that massive public science investments serve important social priorities.

#### V. THE BROADER IMPACTS OF BROADER IMPACTS: CONSIDERING SOCIAL IMPACTS IN PEER REVIEWS FOR SCIENTIFIC JOURNALS AND CONFERENCES

This Article elaborates a distributed model of innovation governance in which various gatekeepers consider the social impact of research when granting resources to scientists and engineers. While researchers certainly value funding, they also highly value opportunities to publish and present their work.<sup>266</sup> As such, scientific journals and conferences are also important gatekeepers in the research community.<sup>267</sup> After all, publications are the currency of academic science, and prestigious journals and conferences—which routinely enlist peer reviewers to screen submissions—can significantly impact the behavior of researchers. As such, this Part argues for orienting scientific journals and conferences toward considering the positive, negative, and distributional impacts of research when reviewing submissions.

At first glance, this prescription may seem odd for a law review article, given that scientific journals and conferences are private entities not subject to government regulation. However, this Part argues that governmental practices can indirectly influence such private institutions by shaping prevailing scientific norms. This Part first draws on the law-and-norms literature to show how government action, which is often seen as the opposite of norm-based governance, can help define, strengthen, and promulgate scientific norms. Indeed, one of the “broader impacts” of NSF’s broader impacts review criterion is to cultivate a norm in the scientific community of greater sensitivity to the social implications of research. To illustrate this dynamic, this Part presents a case study of recent developments in the AI academic community. AI

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(noting peer review models at four national and international agencies include considerations such as relevance and necessity of research to the program’s mission, impact on greater public, educational value, and sometimes public feedback).

<sup>264</sup> CURRENT STATE, *supra* note 224, at 8.

<sup>265</sup> Andrew Sosanya, *Supercharging Biomedical Science at the National Institutes of Health*, FED’N AM. SCIENTISTS (Apr. 19, 2022), [fas.org/publication/supercharging-biomedical-science-at-the-national-institutes-of-health/](https://fas.org/publication/supercharging-biomedical-science-at-the-national-institutes-of-health/) [perma.cc/374S-3585].

<sup>266</sup> Warren Chan, *What Is the Value of Publishing?*, 12 ACS NANO 6345, 6346 (2018) (noting that despite an evolving landscape, “[p]ublishing remains the bedrock of an academic career”).

<sup>267</sup> *See id.* (“In the current paradigm, the editors of many journals control the academic fate of many researchers.”).

researchers are pushing scientific journals and conferences to consider broader impacts in peer-reviewed selection of manuscripts for publication and presentation. These activities reveal that scientific journals and conferences can play a vital role in encouraging researchers to pursue more socially responsive science.

A. *The Government as Norm Entrepreneur*

Since legal scholar Robert Ellickson's pioneering study of farmers and ranchers in Shasta County, California, legal scholars have examined the role of norms in shaping behavior.<sup>268</sup> Norms represent "rules or expectations that are socially enforced."<sup>269</sup> They encompass "patterns of behavior and internalized values"<sup>270</sup> that people follow out of a sense of obligation.<sup>271</sup> At first glance, norms seem an odd subject for legal study. As the title of Ellickson's book, *Order Without Law*, suggests, early commentators viewed informal norms as functioning outside the domain of formal law.<sup>272</sup> However, norms play an important, law-like role in governing individual and group behavior.<sup>273</sup>

Norms play a particularly prominent role in governing scientific activities. As noted, Polanyi conceived of a "Republic of Science" governed not by formal law but by communal norms based on scientific authority and peer review.<sup>274</sup> Merton was even more explicit in arguing that norms of universalism, communism, disinterestedness, and organized skepticism govern the scientific community.<sup>275</sup> Norms of "open science" continue to exert significant influence in contemporary science.<sup>276</sup>

The importance of norms to governance—including scientific governance—raises the question of where norms originate. One obvious answer is that many

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<sup>268</sup> See ROBERT C. ELICKSON, *ORDER WITHOUT LAW: HOW NEIGHBORS SETTLE DISPUTES* 10-11 (1991) ("Informal norms serve, among other functions, to create property rights, to govern the use of remedial violence, and to punish persons who wrongly invoke the legal system."); see, e.g., David Charny, *Illusions of a Spontaneous Order: "Norms" in Contractual Relationships*, 144 U. PA. L. REV. 1841, 1841 (1996) (describing a process by which industry actors develop a norm, which a centralized agency then codifies and enforces); Rai, *supra* note 59, at 78-79 (noting numerous examples of norm-based governance); *id.* at 81-88 (summarizing literature).

<sup>269</sup> Christine Horne, *Norms*, OXFORD BIBLIOGRAPHIES (Jan. 11, 2018), oxfordbibliographies.com/display/document/obo-9780199756384/obo-9780199756384-0091.xml [perma.cc/JW8R-4ZGE].

<sup>270</sup> *Id.*

<sup>271</sup> Rai, *supra* note 59, at 81.

<sup>272</sup> See ELICKSON, *supra* note 268, at 10.

<sup>273</sup> See, e.g., Lin, *Herding Cats*, *supra* note 26, at 975-77 (discussing the role of social and personal norms in shaping behavior).

<sup>274</sup> See *supra* notes 110-16 and accompanying text.

<sup>275</sup> See *supra* notes 117-24 and accompanying text.

<sup>276</sup> See e.g., Amy Kapczynski, *Order Without Intellectual Property Law: Open Science in Influenza*, 102 CORNELL L. REV. 1539, 1548 (2017) (describing "open science" in the influenza research community).

norms arise from members of a community themselves. Thus, for instance, norms arise in a distributed fashion from interactions between farmers and ranchers or between transacting parties in the marketplace.<sup>277</sup> While norms can bubble up from community members, in other cases norms emerge in a more centralized fashion from institutions, such as firms and universities.<sup>278</sup> In some instances, prevailing norms emerge from the interaction of centralized institutions and decentralized community members, a dynamic aptly illustrated by the scientific community itself. As legal scholar Arti Rai observes, “[C]entralized norms often have an interdependent relationship with less centralized ones. For example, in the context of scientific research, the centralized policies of research universities and professional organizations influence, and are influenced by, the practices of individual researchers.”<sup>279</sup>

Somewhat surprisingly, the government is another centralized institution that participates in norm-based governance. While early law-and-norms scholarship viewed law and norms as operating in different spheres, later commentators recognized that “they typically operate either to reinforce or to subvert each other.”<sup>280</sup> In some cases, “nonlegal systems both displace in part, yet rest upon, the extant legal regime.”<sup>281</sup> The role of law in supporting norm-based governance can be fairly modest, such as establishing a baseline of enforceable contracts to enable private ordering.<sup>282</sup> Additionally, government institutions can strengthen existing norms by using legal tools. For instance, if the government prohibits smoking on airplanes, this legal change reinforces social norms against smoking.<sup>283</sup>

More aggressively, government institutions can function as “norm entrepreneurs” by actively defining and promulgating communal norms. Legal scholar Cass Sunstein coined the term “norm entrepreneur” to refer to a party seeking to change social norms.<sup>284</sup> While norm entrepreneurs can be individuals, nongovernmental organizations, or for-profit firms, the government itself also functions as a norm entrepreneur.<sup>285</sup> This represents almost a complete inversion of the traditional view that norms operate outside of the domain of government regulation. In some contexts, a government agency may select among several

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<sup>277</sup> See, e.g., Charny, *supra* note 268, at 1850 (noting that, in the case of the National Grain and Feed Association (“NGFA”), “norms in a sense emerge ‘spontaneously’ as a result of the conduct of dispersed transactors”).

<sup>278</sup> See Rai, *supra* note 59, at 81-82 (explaining centralized institutions’ use of norms to promote cooperative behavior).

<sup>279</sup> *Id.* at 81.

<sup>280</sup> *Id.* at 84.

<sup>281</sup> Charny, *supra* note 268, at 1841.

<sup>282</sup> *Id.* at 1841-42.

<sup>283</sup> Rai, *supra* note 59, at 84.

<sup>284</sup> Cass R. Sunstein, *Social Norms and Social Roles*, 96 COLUM. L. REV. 903, 909 (1996).

<sup>285</sup> See *id.*

competing norms that have bubbled up from a community.<sup>286</sup> Additionally, by convening community stakeholders and reporting consensus, the government can shape communal norms in a desired direction. More intensively, the government can take the lead in defining a new norm, which it then promulgates throughout a community.

Thus, in addition to enacting and enforcing positive law, the government also shapes behavior through selecting, promulgating, and creating norms. As the following case studies reveal, the government has been particularly influential in shaping norms in the scientific community.<sup>287</sup> The government's ability to shape scientific norms, moreover, provides a lever for cultivating a norm of socially responsive science and technology. As we will see, members of the scientific community have acted on this norm to press private scientific institutions—including scientific journals and conferences—to integrate this norm in their practices.

#### B. *Government Action to Shape, Create, and Promulgate Scientific Norms*

The advent of recombinant DNA technology illustrates the government's ability to shape scientific norms. In the early 1970s, scientists began manipulating DNA from different organisms to create novel combinations.<sup>288</sup> While so-called recombinant DNA technology had great potential benefits, it also raised significant health concerns.<sup>289</sup> Several leading scientists called for an immediate, worldwide stop to certain forms of recombinant DNA experimentation.<sup>290</sup> They further called for an international conference to assess the risks of this technology and formulate research guidelines.<sup>291</sup> Eight months later, various government entities convened this conference. The National Academy of Sciences, in conjunction with NIH and NSF,<sup>292</sup> organized a gathering of 140 scientists, policymakers, lawyers, and journalists at the

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<sup>286</sup> See, e.g., Charny, *supra* note 268, at 1850 (“NGFA selects some of these norms for codification and/or arbitral enforcement.”).

<sup>287</sup> Of course, government action has helped shape norms in numerous contexts. See, e.g., Morgan, *supra* note 183, at 6 (discussing how private-sector financial institutions have adopted the norm of requiring environmental impact assessments when funding major projects).

<sup>288</sup> Paul Berg, *Asilomar 1975: DNA Modification Secured*, 455 NATURE 290, 290 (2008) [hereinafter Berg, *Asilomar 1975*] (explaining the origins of recombinant DNA technology).

<sup>289</sup> *Id.* (highlighting concerns that recombinant DNA technology could spread cancer and pose other risks).

<sup>290</sup> Paul Berg et al., *Potential Biohazards of Recombinant DNA Molecules*, 185 SCIENCE 303, 303 (1974).

<sup>291</sup> *Id.*

<sup>292</sup> *Recombinant DNA Research: Guidelines*, 41 Fed. Reg. 27902, 27903 (proposed July 7, 1976) [hereinafter DNA Guidelines] (describing the National Academy of Sciences, NIH, and NSF's joint hosting of an international meeting about the dangers of recombinant DNA molecules).

Asilomar Conference Center in California.<sup>293</sup> Attendees ultimately agreed that recombinant DNA research should continue but be subject to stringent regulations.<sup>294</sup> In the immediate aftermath, NIH adopted the so-called Asilomar Recommendations as interim guidance for NIH grantees and contractors.<sup>295</sup> Ultimately, the NIH drew upon the Asilomar recommendations to issue slightly more stringent guidelines for DNA research, which have been widely influential.<sup>296</sup> In this context, the government catalyzed consensus around a research norm and helped promulgate it.

The government's role in shaping scientific norms is also evident in reforms to government patent policy. In the late 1970s, concerns grew that significant public investments in R&D were not being translated to tangible products benefiting society.<sup>297</sup> Policymakers were particularly concerned that the inability of many federal grantees to own patents from federally funded research discouraged them from developing commercial technologies.<sup>298</sup> Accordingly, in 1980, Congress enacted the Bayh-Dole Act.<sup>299</sup> The legislation allowed federal grant recipients, such as universities, to take title to patents arising from federally funded research.<sup>300</sup> As such, it created an explicit incentive for scientists and universities to patent the outputs of publicly financed research. Along with other legal changes,<sup>301</sup> the Bayh-Dole Act led to a significant shift in scientific

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<sup>293</sup> Berg, *Asilomar 1975*, *supra* note 288, at 290.

<sup>294</sup> Paul Berg et al., *Asilomar Conference on Recombinant DNA Molecules*, 188 SCIENCE 991, 991 (1975) (reporting consensus from the Asilomar conference that most recombinant DNA research should proceed, subject to appropriate containment measures); Berg, *Asilomar 1975*, *supra* note 288, at 290 (elaborating a framework that assigned different levels of risk to different kinds of experiments and applied varying safety guidelines accordingly).

<sup>295</sup> DNA Guidelines, *supra* note 292, at 27903.

<sup>296</sup> *Id.* (chronicling various multicommitee meetings, draft guidelines, and feedback before releasing final "Guidelines for Research on Recombinant DNA Molecules" on June 25, 1976).

<sup>297</sup> Rebecca S. Eisenberg, *Public Research and Private Development: Patents and Technology Transfer in Government-Sponsored Research*, 82 VA. L. REV. 1663, 1663-64 (1996).

<sup>298</sup> Prior to the Bayh-Dole Act, some federal funding agencies allowed grantees to own patents on research outputs, while other agencies took ownership of patents or dedicated technologies to the public. *See* S. REP. NO. 96-480, at 2 (1980); Eisenberg, *supra* note 297, at 1671-95 (providing a history of the Bayh-Dole Act and related legislation).

<sup>299</sup> Pub. L. No. 96-517, 94 Stat. 3015 (1980) (codified at 35 U.S.C. §§ 200-12).

<sup>300</sup> *See generally* DAVID C. MOWERY, RICHARD R. NELSON, BHAVEN N. SAMPAT & ARVIDS A. ZIEDONIS, *IVORY TOWER AND INDUSTRIAL INNOVATION: UNIVERSITY-INDUSTRY TECHNOLOGY TRANSFER BEFORE AND AFTER THE BAYH-DOLE ACT* (2004) (describing the Bayh-Dole Act and presenting research on U.S. universities' patenting and licensing activities before and after the Act).

<sup>301</sup> *See* Rai, *supra* note 59, at 100-09 (discussing several factors, including expansive patentability doctrine, the establishment of the Court of Appeals for the Federal Circuit, increased patenting by NIH, and PTO guidelines adopting a broad conception of utility).

norms.<sup>302</sup> Traditionally, academic science was characterized by the Mertonian norm of communalism, which eschewed individual property rights in scientific discoveries.<sup>303</sup> Relatedly, academic scientists historically viewed patents with disdain.<sup>304</sup> However, “[a]s might be predicted by law-and-norms theory . . . universities and individual researchers soon began to respond to the financial incentives of Bayh-Dole by rejecting communalism and increasing efforts to seek patents.”<sup>305</sup> While vestiges of traditional norms persist,<sup>306</sup> academic researchers and universities responded to this policy change by embracing a norm of patenting and commercializing their research outputs.<sup>307</sup>

Pointing in an opposite direction, the government’s support of the so-called Bermuda Principles has contributed to a norm of rapid release of scientific data. In 1990, NIH and DOE launched the Human Genome Project (“HGP”), an ambitious initiative to map the human genome.<sup>308</sup> Early in the project, debate emerged over how quickly HGP scientists should deposit gene sequence data in public databases.<sup>309</sup> Genome researchers—with the prodding of federal funding agencies—ultimately coalesced around a norm of rapid data release. In 1996, a group of publicly funded genome researchers meeting in Bermuda agreed to release data for DNA sequence assemblies of more than one kilobase in publicly accessible databases within *twenty-four hours* of generation.<sup>310</sup> Although the so-

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<sup>302</sup> See *id.* at 109-15 (explaining how legal change effectuated norm breakdown, which, in turn, changed the social meaning of patents for researchers and universities); Peter Lee, *Patents and the University*, 63 DUKE L.J. 1, 36 (2013) [hereinafter Lee, *University*] (noting the Bayh-Dole Act’s contribution to “a long (and still ongoing) process of norm contestation,” in which “academic culture has become much more receptive to exclusive rights and the commercial exploitation of scientific knowledge”).

<sup>303</sup> See *supra* notes 117-24 and accompanying text.

<sup>304</sup> Lee, *University*, *supra* note 302, at 12 (“[A]cademic norms of open disclosure and communal sharing informed [scientists’ and] universities’ early resistance to patenting.”).

<sup>305</sup> Rai, *supra* note 59, at 109.

<sup>306</sup> Illustrating these traditional norms, Stanford and UCSF researchers Stanley Cohen and Herbert Boyer, who invented recombinant DNA technology in 1973, only agreed to patent their technology “after strenuous urging by the university’s patent counsel.” *Id.* at 93. Furthermore, they insisted that the patent be broadly licensed and that the university be the exclusive beneficiary of royalties. *Id.*

<sup>307</sup> See MOWERY ET AL., *supra* note 300, at 104 (suggesting that the Bayh-Dole Act accelerated a trend of increased academic patenting that was already in place at the time of its enactment).

<sup>308</sup> Contreras, *supra* note 137, at 70-71; *The Human Genome Project*, NAT’L HUM. GENOME RSCH. INST., [www.genome.gov/human-genome-project](http://www.genome.gov/human-genome-project) [perma.cc/3PR9-JNT7] (last visited Apr. 3, 2024).

<sup>309</sup> See Contreras, *supra* note 137, at 81-84.

<sup>310</sup> Rai, *supra* note 59, at 113 n.200; see Eliot Marshall, *Genome Researchers Take the Pledge*, 272 SCIENCE 477, 478 (1996) (“[T]he Bermuda meeting . . . ‘passed a unanimous resolution that “all human genomic DNA sequence information generated by centers funded for large-scale human sequencing should be freely available and in the public domain in order to encourage research and development . . . .””).

called Bermuda Principles represented private ordering,<sup>311</sup> the federal government helped catalyze and formalize this norm. Similar to codification of the Asilomar agreement, federal funding agencies also formalized the Bermuda Principles. In 1996, the National Human Genome Research Institute adopted the Bermuda Principles as official policy.<sup>312</sup> The Bermuda Principles were widely influential and helped to establish a norm of rapid data release in other fields.<sup>313</sup>

Across numerous contexts, government action has promoted scientific norms to constrain recombinant DNA research, encourage patenting and commercialization of federally funded inventions, and accelerate the sharing of scientific data.<sup>314</sup> The next Section shows how government action can lead to a norm of socially responsive science among researchers and scientific institutions.

C. *From Top-Down to Bottom-Up: A Case Study of Broader Impacts in Scientific Journals and Conferences in the Artificial Intelligence Community*

As we have seen, the federal government influences innovative activity in several ways. The government directly impacts researchers through centralized governance, including mission-oriented funding and ex post regulation of technologies. Additionally, the government indirectly shapes the behavior of researchers through altering the incentives they face. This is evident, for example, in NSF's consideration of broader impacts when evaluating grant proposals. In both cases, government action can also have longer-term effects by creating, strengthening, and promulgating scientific norms. This norm-shaping function, moreover, creates opportunities to mobilize additional gatekeepers to promote socially responsive science that do not fall within the direct regulatory ambit of government. This Section presents a case study of a grassroots movement among AI researchers to push scientific journals and

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<sup>311</sup> Contreras, *supra* note 137, at 65.

<sup>312</sup> *NHGRI Policy Regarding Intellectual Property of Human Genomic Sequence*, NAT'L HUM. GENOME RSCH. INST. (Apr. 9, 1996), <https://web.archive.org/web/20030420213244/http://www.genome.gov:80/10000926>.

<sup>313</sup> Contreras, *supra* note 137, at 65.

<sup>314</sup> Legal and policy developments have shaped scientific norms in other areas as well, for example in research ethics. The Nuremberg trials following World War II established the Nuremberg Code, which articulated basic requirements for research on human subjects. See Todd W. Rice, *The Historical, Ethical, and Legal Background of Human-Subjects Research*, 53 RESPIRATORY CARE 1325, 1326 (2008). The Code served as the foundation for subsequent ethical principles and federal research regulations, most visibly manifested in ubiquitous Institutional Review Boards ("IRBs") at universities and research institutes that review research supported by the federal government. *Id.* The requirement of obtaining IRB approval for qualifying research is now firmly entrenched in scientific norms, even beyond federally funded research. For example, most biomedical journals require IRB approval as a condition of publication. A. Rowan-Legg, C. Weijer, J. Gao & C. Fernandez, *A Comparison of Journal Instructions Regarding Institutional Review Board Approval and Conflict-of-Interest Disclosure Between 1995 and 2005*, 35 J. MED. ETHICS 74, 75-76 (2009).

conferences to consider the broader impacts of research projects when reviewing submissions. In this fashion, a norm of socially responsive innovation that originated in government policy can lead private institutions to participate in a distributed model of innovation governance.

In addition to central policymakers, researchers themselves are concerned about the broader social implications of scientific and technological advances. Rapid developments in AI have been particularly troubling.<sup>315</sup> In an influential blog post from 2018, a group of computer scientists working in AI sounded the alarm that innovations from their research could cause significant social harm.<sup>316</sup> For example, advances in AI threatened to undermine privacy, spread misinformation, and fuel unemployment through increased automation.<sup>317</sup> While computer scientists traditionally extol the benefits of their research, these scientists urged their peers to “more deeply consider the negative impacts of their work.”<sup>318</sup>

To force greater scrutiny of AI research, the authors proposed “leverag[ing] the gatekeeping functionality of the peer review process.”<sup>319</sup> Peer-reviewed journal articles are the traditional means by which researchers disseminate their findings to the scientific community. Additionally, many academic conferences use peer review to screen presentation papers, which may be published in conference proceedings. The quantity and quality of publications in large part determine the success of academic scientists,<sup>320</sup> thus rendering publishing an important lever for shaping researcher behavior. The computer scientists proposed integrating consideration of the broader social impact of research in peer reviews to select articles for publication and presentation.<sup>321</sup> Proposers of this initiative argued that modifying peer review in this fashion would encourage researchers to “change the technologies they create to tilt the scales towards more positive outcomes.”<sup>322</sup> In essence, the authors sought to use the valuable

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<sup>315</sup> Developments in AI have led to a flurry of governmental responses, a full accounting of which exceeds the scope of this Article. *See, e.g.*, BLUEPRINT FOR AI, *supra* note 15, at 5-7 (outlining the Biden Administration’s AI policy guidelines); Michael D. Shear, Cecilia Kang & David E. Sanger, *Pressured by Biden, A.I. Companies Agree to Guardrails on New Tools*, N.Y. TIMES (July 21, 2023), [nytimes.com/2023/07/21/us/politics/ai-regulation-biden.html](https://www.nytimes.com/2023/07/21/us/politics/ai-regulation-biden.html) (describing commitments made by private AI companies following a White House meeting); *United States v. Kurbo Inc.*, No. 3:22-cv-00946 (N.D. Cal. Mar. 3, 2022) (forcing parties to destroy data and AI algorithms derived from such data due to privacy violations); Lina Khan, *Opinion, Lina Khan: We Must Regulate A.I. Here’s How.*, N.Y. TIMES (May 3, 2023), [nytimes.com/2023/05/03/opinion/ai-lina-khan-ftc-technology.html](https://www.nytimes.com/2023/05/03/opinion/ai-lina-khan-ftc-technology.html).

<sup>316</sup> *See generally* Hecht et al., *supra* note 231.

<sup>317</sup> *Id.* at 1; *see* Metz, *supra* note 9 (claiming certain workers will become more productive with AI while others will be replaced).

<sup>318</sup> Hecht et al., *supra* note 231, at 1.

<sup>319</sup> *Id.* at 2 (emphasis omitted).

<sup>320</sup> Contreras, *supra* note 137, at 73-74.

<sup>321</sup> Hecht et al., *supra* note 231, at 1.

<sup>322</sup> *Id.* at 3.

resources of academic publications and presentations to encourage more socially responsive research.

In 2020, a variant of this proposal became a reality. That year, NeurIPS, one of the world's largest AI conferences, began integrating social considerations into its peer review process.<sup>323</sup> The conference announced that submitting authors would be required to address the "ethical aspects and future societal consequences" of their research.<sup>324</sup> Peer reviewers would consider such ethical and societal factors while selecting articles for presentation. Furthermore, because NeurIPS also publishes papers, social considerations also serve as a gatekeeper for publication. In announcing this requirement, the conference organizers stated the need to "think more broadly about what it means to develop new methods and systems, and to consider not only the beneficial applications and products enabled by our research, but also potential nefarious uses and consequences of failure."<sup>325</sup> Peer reviewers could flag submissions for ethical concerns; submissions with poor technical qualities would be denied, and those with strong technical qualities would be referred to ethics advisors for additional review.<sup>326</sup>

While ostensibly a grassroots movement, this development drew significantly from NSF's practice of considering the broader impacts of research proposals when granting federal research funds. The original blog post represented a movement among computer scientists to push peer reviewers to consider the social impacts—positive and negative—of research projects. Harkening back to Polanyi's self-governing Republic of Science, commentators characterized this movement as "governance from within."<sup>327</sup> However, the authors explicitly modeled their proposal on NSF's broader impacts review criterion for research grants.<sup>328</sup> Furthermore, they justified their proposal in terms strikingly similar to the motivation behind NSF's broader impacts criterion—to ensure that publicly funded science translates to social gain.<sup>329</sup> To be sure, researchers slightly adapted NSF's practice. Unlike NSF's formal broader impacts criterion, the

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<sup>323</sup> Carina E. A. Prunkl et al., *Institutionalizing Ethics in AI Through Broader Impact Requirements*, 3 NATURE MACH. INTEL. 104, 104 (2021).

<sup>324</sup> *Call for Papers*, NEURIPS (2020), nips.cc/Conferences/2020/CallForPapers [perma.cc/72BE-737M].

<sup>325</sup> Neural Info. Processing Sys. Conference, *Getting Started with NeurIPS 2020*, MEDIUM (Feb. 9, 2020), medium.com/@NeurIPSCnf/getting-started-with-neurips-2020-e350f9b39c28 [perma.cc/5UCW-Q9CY].

<sup>326</sup> Prunkl et al., *supra* note 323, at 105.

<sup>327</sup> *Id.* at 104 (quoting Erik Fisher, Roop L. Mahajan & Carl Mitcham, *Midstream Modulation of Technology: Governance from Within*, BULL. SCI., TECH. & SOC'Y, Dec. 2006, at 485, 485).

<sup>328</sup> Hecht et al., *supra* note 231, at 2.

<sup>329</sup> *See id.* at 3 ("[I]t is unlikely that government agencies will want to use taxpayer dollars for research that is, on balance, going to hurt the taxpayers who paid for the grant. No matter how intellectually interesting an idea, computing researchers are by no means entitled to public money to explore the idea if that idea is not in the public interest." (emphasis omitted)).

researchers argued that peer reviewers should explicitly consider the negative implications of a research project—an innovation that this Article argues should be integrated into NSF’s broader impacts criterion itself.<sup>330</sup> Nonetheless, this ostensibly “bottom-up” movement was based on “top-down” government policy, further illustrating the ability of government practice to shape scientific norms.

The experience of NeurIPS thus reveals a double dividend from strengthening NSF’s broader impacts criterion and extending it to other federal funding agencies. In addition to encouraging scientists to consider the social impacts of their research when applying for federal funds, this selection criterion can help shape the norms of the scientific community and scientific institutions, including academic journals and conferences.

Of course, integrating social considerations in peer review processes at scientific journals and conferences is subject to many of the critiques that apply to NSF’s broader impacts criterion. For example, it is unclear what effects are “reasonably” foreseeable from a line of research, and there will undoubtedly be significant uncertainty.<sup>331</sup> Relatedly, there are persistent doubts about the ability of scientists and peer reviewers to anticipate the ethical and social consequences of research.<sup>332</sup> Broader impacts requirements could foster a backlash by researchers who feel that such statements are “burdensome, confusing or punitive.”<sup>333</sup> Finally, researchers working in industrial settings may be particularly unwilling to disclose negative impacts to maintain commercial value and avoid legal liability.<sup>334</sup>

The early experience of NeurIPS, however, reveals several best practices that can improve the assessment of broader impacts. Commentators suggest several principles that should guide broader impacts requirements: transparency, guidance, incentives, and deliberation.<sup>335</sup> Journals and conference organizers should be transparent about the “[p]urpose, motivation, and expectations” for “broader impact statement[s]” from researchers.<sup>336</sup> Additionally, organizers should also clarify how peer reviewers and decisionmakers will assess these statements.<sup>337</sup> Organizers should also provide technical assistance to researchers and reviewers.<sup>338</sup> It may be particularly helpful to include outside experts in the peer-review process.<sup>339</sup>

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<sup>330</sup> *Id.* at 1.

<sup>331</sup> *Id.* at 2.

<sup>332</sup> See Prunkl et al., *supra* note 323, at 106 (noting that broader impact statements could improve the anticipation of societal impacts of AI technologies but that they risk quality deficits).

<sup>333</sup> *Id.* at 107.

<sup>334</sup> *Id.*

<sup>335</sup> *Id.* at 108-09.

<sup>336</sup> *Id.* at 108.

<sup>337</sup> *Id.*

<sup>338</sup> *Id.*

<sup>339</sup> *Id.* at 106, 108.

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In addition to these procedural reforms, this Article argues for the same substantive reform of the broader impacts criterion offered above.<sup>340</sup> To structure the broader impacts inquiry, this Article proposes deconstructing this criterion into three factors: the positive social impact of the research project, its potential social harms and ways to address those harms, and its distributional effects. Doing so would encourage researchers and reviewers to conduct a thorough examination of the social implications of a research project.

It bears highlighting that considering the social impacts of a research project during manuscript review offers some timing advantages compared to doing so when reviewing a funding proposal. At the point of manuscript submission, scientists are not merely proposing research; they have completed research, obtained findings, and drafted a report of those findings. At this later, more downstream stage, positive, negative, and distributional effects are more concrete than at the grant-proposal stage.<sup>341</sup> Given that more information emerges as a research project matures, considering the broader social impact of research is likely to be more fruitful at the point of publication or presentation than during initial funding.

Ultimately, considering the social implications of research in peer reviews for publications and presentations offers several distinct benefits. Unlike centralized innovation governance, this distributed approach maintains a high level of scientific autonomy, diffuses political control over scientific affairs, and exploits private information held by individual researchers.<sup>342</sup> If widely adopted, this practice can usher in a valuable cultural shift:

By inviting researchers to reflect on the impacts of their own research, the requirement can contribute to raising awareness about issues associated with particular research or the field more generally, among both readers and authors. In time, this could produce a generation of researchers who have grappled with thinking about impacts and who chose to steer their research agendas towards opportunities to benefit society as a result.<sup>343</sup>

Policymakers can help effectuate this cultural shift without directly regulating academic journals and conferences themselves. Rather, by influencing scientific norms—most notably through a robust broader impacts criterion for federal research grants—policymakers can expand a distributed model of innovation governance.

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<sup>340</sup> See *supra* Section IV.C.

<sup>341</sup> Prunkl et al., *supra* note 323, at 105 (“At the time of conference submission, research projects will have been completed and so any intervention will take place *ex post*, whereas interventions from IRBs and funding applications take place at a much earlier stage in the research cycle.”).

<sup>342</sup> See *supra* Part III.

<sup>343</sup> Prunkl et al., *supra* note 323, at 106.

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VI. EXTENDING BROADER IMPACTS: CONSIDERING SOCIAL IMPACTS OF INVENTIONS IN THE PATENT SYSTEM

Toward the end of a typical R&D lifecycle—perhaps after a researcher has applied for grants and published and presented research findings—the patent system represents another gatekeeper that can encourage socially responsive innovation.<sup>344</sup> At this downstream stage, scientists or engineers have translated their research into a tangible invention.<sup>345</sup> Obtaining a patent, which confers twenty years of exclusive rights over an invention, can be critical to commercializing that invention.<sup>346</sup> To obtain a patent, an inventor must submit an application to the PTO that satisfies several technical requirements.<sup>347</sup> This Part argues that in addition to these requirements, the PTO should also consider the broader positive, negative, and distributional effects of inventions when reviewing patent applications.<sup>348</sup> In this manner, the patent system can play an important role in promoting socially responsive technology.

A. *Rethinking the U.S. Patent System's Nonconsideration of the Social*

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<sup>344</sup> This Article does not suggest that all or even a substantial proportion of patents arise from federal funding or academic research. Many patents fit this pattern, particularly in science-based fields like biotechnology. *See, e.g.*, Tom Magerman, Bart Van Looy & Koenraad Debackere, *Does Involvement in Patenting Jeopardize One's Academic Footprint? An Analysis of Patent-Paper Pairs in Biotechnology*, 44 RES. POL'Y 1702, 1702-03 (2015). However, many do not, and this Part's analysis also applies to patents that have no connection to federal funding or academic research, such as those from industrial research and independent inventors.

<sup>345</sup> This may be achieved by creating a physical prototype or submitting a patent disclosure that teaches a technical artisan how to make and use the invention. *See* 35 U.S.C. § 112.

<sup>346</sup> Of course, parties obtain patents for reasons other than commercialization, such as to signal technical prowess to funders, assert exclusive rights against potential infringers, or contribute to a defensive patent portfolio. *See* Stuart J.H. Graham, Robert P. Merges, Pam Samuelson & Ted Sichelman, *High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey*, 24 BERKELEY TECH. L.J. 1255, 1261-63 (2009) (discussing patent incentives and usage among early-stage technology companies); Colleen V. Chien, *Of Trolls, Davids, Goliaths, and Kings: Narratives and Evidence in the Litigation of High-Tech Patents*, 87 N.C. L. REV. 1571, 1579-89 (2009) (detailing ways firms weaponize patents to achieve goals unrelated to innovation).

<sup>347</sup> *See, e.g.*, 35 U.S.C. §§ 101-03, 112.

<sup>348</sup> This proposal focuses on assessing the social utility of an invention when granting a patent. A separate and important question, which this Article does not address, would focus on considering the social utility of a *patent* on an invention when granting exclusive rights. A wide literature suggests that social utility considerations should limit patents on, for example, critical health technologies or infrastructural technologies that enable broad swaths of downstream productivity. *See generally* Peter Lee, *Toward a Distributive Commons in Patent Law*, 2009 WIS. L. REV. 917 (discussing benefits of limiting exclusive rights for health technologies); Peter Lee, *The Evolution of Intellectual Infrastructure*, 83 WASH. L. REV. 39 (2008) (proposing liberalizing access to patented inventions that serve an infrastructural function); Lee, *Open Science*, *supra* note 137 (describing contractual provisions to increase access to patented inventions to promote scientific research).

*Impacts of Technology*

As conventionally understood, the U.S. patent system does not consider the broader social impacts of inventions when evaluating patentability. The technical criteria of patentability, which include patentable subject matter, utility, novelty, nonobviousness, enablement, and description,<sup>349</sup> largely evaluate the innovativeness of an invention and how thoroughly a patent application discloses it. In this sense, these criteria are technological analogs to NSF's "intellectual merit" criterion when evaluating grant proposals. However, unlike NSF, the patent system possesses no analog for considering broader impacts as a formal criterion of patentability. Put differently, technical considerations, rather than broader social impacts, dominate the determination of patentability. Of course, a significant caveat applies: the patent system reflects Congress's view that granting patents on inventions satisfying these technical criteria advances technological progress,<sup>350</sup> which may in turn significantly increase social welfare. Beyond this general principle, however, the patent system rarely inquires into the specific social impacts of particular inventions.<sup>351</sup>

While the requirement that patented inventions must be "useful" seems a natural place to consider the broader social impacts of an invention,<sup>352</sup> this requirement rarely serves this function. An early influential case advocated a very low requirement of utility: inventions need not be better than the prior art to be considered useful, and the market—rather than courts—should determine the value of patented inventions.<sup>353</sup> This "market mantra" reflects patent doctrine's general reluctance to place value judgments on inventions.<sup>354</sup> The court's opinion, however, also articulated a "moral utility" doctrine, which holds that inventions that offend prevailing public morals should not be patentable.<sup>355</sup>

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<sup>349</sup> 35 U.S.C. § 101 (patentable subject matter, utility); § 102 (novelty); § 103 (nonobviousness); § 112 (enablement, written description, best mode, utility).

<sup>350</sup> U.S. CONST. art. I, § 8, cl. 8.

<sup>351</sup> Indeed, international patent law hampers any such inquiry that would favor or disfavor patents in particular technological fields. *See* Agreement on Trade-Related Aspects of Intellectual Property Rights, Marrakesh Agreement Establishing the World Trade Organization, Apr. 15, 1994, 1869 U.N.T.S. 299, Annex 1C, art. 27 ("[P]atents shall be available for any inventions, whether products or processes, in all fields of technology, provided that they are new, involve an inventive step and are capable of industrial application.").

<sup>352</sup> 35 U.S.C. § 101.

<sup>353</sup> *Lowell v. Lewis*, 15 F. Cas. 1018, 1019 (C.C.D. Mass. 1817) (No. 8,568) ("[W]hether [an invention] be more or less useful is a circumstance very material to the interests of the patentee, but of no importance to the public. If it not be extensively useful, it will silently sink into contempt and disregard.").

<sup>354</sup> Andrew C. Michaels, *Benefits of the Invention and Social Value in Patent Law*, 29 GEO. MASON L. REV. 827, 836 (2022).

<sup>355</sup> *See Lowell*, 15 F. Cas. at 1019 ("All that the law requires is, that the invention should not be frivolous or injurious to the well-being, good policy, or sound morals of society. The word 'useful,' therefore, is incorporated into the act in contradistinction to mischievous or immoral.").

For example, “a new invention to poison people, or to promote debauchery, or to facilitate private assassination” would fail the moral utility doctrine and not receive a patent.<sup>356</sup> While the moral utility doctrine considers the wider social impacts (including harms) of inventions, this doctrine has largely fallen into desuetude. In contemporary times, neither the PTO nor courts see themselves as arbiters of public morality,<sup>357</sup> and the moral utility doctrine is rarely the basis for denying patentability.

Similarly, the requirement of patentable subject matter seldom considers the wider social impacts of an invention. The doctrine of patentable subject matter defines the types of things that, as a threshold matter, are eligible for patenting.<sup>358</sup> On rare occasions, the PTO has invoked patent eligibility doctrine to deny patents on morally objectionable inventions. In the late 1990s, for example, the PTO rejected a patent application claiming a human-animal chimera on the ground that it did not comprise patentable subject matter.<sup>359</sup> While doctrinally based on patent eligibility, the denial was motivated by ethical concerns about this technology. Unease about human cloning led to a statutory carveout in the 2011 America Invents Act establishing that claims directed to or encompassing a human organism are not patentable subject matter.<sup>360</sup> Restrictions on patentable subject matter could, in theory, deny patents on immoral inventions likely to produce significant social harms. However, moral concerns play a very small role in narrowing patent eligibility in U.S. patent law, particularly compared to other jurisdictions.<sup>361</sup> As patent scholar Margo Bagley has described, U.S. patent law follows a mantra of “patent first, ask questions later,” regarding the moral and ethical dimensions of new technologies.<sup>362</sup> This technological neutrality further reflects patent doctrine’s reluctance to weigh social impacts when determining patentability.

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<sup>356</sup> *Id.*; see generally Laura A. Keay, *Morality’s Move Within U.S. Patent Law: From Moral Utility to Subject Matter*, 40 AIPLA Q.J. 409 (2012) (discussing U.S. patent law’s consideration of morality over time).

<sup>357</sup> See *Juicy Whip, Inc. v. Orange Bang, Inc.*, 185 F.3d 1364, 1366-68 (Fed. Cir. 1999) (“The requirement of ‘utility’ in patent law is not a directive to the Patent and Trademark Office or the courts to serve as arbiters of deceptive trade practices. Other agencies, such as the Federal Trade Commission and the Food and Drug Administration, are assigned the task of protecting consumers from fraud and deception in the sale of food products.”); Keay, *supra* note 356, at 415-16 (discussing *Juicy Whip*). Indeed, evolving norms now suggest that the deceptive nature of some inventions actually constitutes their utility. *Juicy Whip*, 185 F.3d at 1367.

<sup>358</sup> See 35 U.S.C. § 101.

<sup>359</sup> *Patent Application Is Disallowed as “Embracing” Human Being*, PAT. TRADEMARK & COPYRIGHT J., June 17, 1999, at 203, 203.

<sup>360</sup> See Leahy-Smith America Invents Act, Pub. L. No. 112-29, § 33(a), 125 Stat. 284, 340 (2011).

<sup>361</sup> See Margo A. Bagley, *Patent First, Ask Questions Later: Morality and Biotechnology in Patent Law*, 45 WM. & MARY L. REV. 469, 479-80 (2003).

<sup>362</sup> *Id.* at 474.

Challenging this view on normative grounds, legal scholars have argued that patent law should more stringently consider the broader social impacts of inventions when granting exclusive rights. For example, Professor Michael Risch proposes requiring that inventions must have both practical and commercial usefulness to be patentable.<sup>363</sup> More broadly, Professor Ofer Tur-Sinai argues for reorienting the patent system away from satisfying market-based preferences and toward promoting objective wellbeing.<sup>364</sup> Doing so would better correlate incentives to innovate with maximizing social value.<sup>365</sup> Professor Andrew Michaels argues that courts should more explicitly consider the social value of inventions when determining patent validity and scope.<sup>366</sup> Courts could do so by reinvigorating the moral utility doctrine or the pioneer patents doctrine, which confers wider scope to patents on groundbreaking, pioneer inventions of high social value.<sup>367</sup>

Buttressing these normative arguments, a close examination reveals that the patent system is far from neutral, and it routinely advances social objectives beyond simply promoting technological progress. For instance, the patent system is sensitive to distributive concerns and seeks to increase diversity and inclusiveness among inventors.<sup>368</sup> By regulation, the PTO charges lower fees to small and micro entities, some of which include independent inventors.<sup>369</sup> The PTO also offers technical assistance to small entities and inventors lacking legal representation.<sup>370</sup> The patent system operates numerous programs to enhance gender, racial, and geographic diversity among inventors.<sup>371</sup> In this sense, the patent system already considers certain “broader impacts” when conferring valuable exclusive rights on technologies.

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<sup>363</sup> Michael Risch, *Reinventing Usefulness*, 2010 BYU L. REV. 1195, 1196.

<sup>364</sup> Tur-Sinai, *supra* note 43, at 145.

<sup>365</sup> *See id.* at 194 (promoting alternative schemes to replace current market-focused approach).

<sup>366</sup> Michaels, *supra* note 354, at 827.

<sup>367</sup> *Id.* at 864-67.

<sup>368</sup> *See* Peter Lee, *Toward a Distributive Agenda for U.S. Patent Law*, 55 Hous. L. Rev. 321, 331-52 (2017) [hereinafter Lee, *Distributive*] (describing several ways in which the U.S. patent system and related bodies of law seek to advance distributive considerations).

<sup>369</sup> 37 C.F.R. § 1.16 (2022); Lee, *Distributive*, *supra* note 368, at 350; *USPTO Alert: Patent Fees for Small and Micro Entities Reduced*, U.S. PAT. & TRADEMARK OFF. (Dec. 30, 2022, 10:35 AM), [uspto.gov/subscription-center/2022/patent-fees-small-and-micro-entities-reduced](https://www.uspto.gov/subscription-center/2022/patent-fees-small-and-micro-entities-reduced) [perma.cc/DX98-7Y2U] (increasing discounts to small entities from 50% to 60% and increasing discounts for micro entities from 75% to 80%).

<sup>370</sup> Lee, *Distributive*, *supra* note 368, at 350 (listing pro se and pro bono programs offered by the PTO to aid small entities and unrepresented inventors).

<sup>371</sup> *See* Kathi Vidal, *The Unleashing American Innovators Act: Promoting Inclusive Innovation Under the New Law*, U.S. PAT. & TRADEMARK OFF.: DIRECTOR'S BLOG (Jan. 10, 2023), [uspto.gov/blog/director/entry/the-unleashing-american-innovators-act](https://www.uspto.gov/blog/director/entry/the-unleashing-american-innovators-act) [perma.cc/HW2L-E6M6] (discussing efforts to lower the cost of entry into the patent system to allow more diverse participation in the innovation economy).

Even more striking, the patent system also departs from technological neutrality by encouraging innovation in particular areas of high social value. For example, the PTO's Patents for Humanity program rewards, and thereby encourages, "innovators who use game-changing technology to meet global humanitarian challenges."<sup>372</sup> The program recognizes patent holders that "provide affordable, scalable, and sustainable solutions for the less fortunate."<sup>373</sup> Program winners receive a certificate to accelerate certain administrative matters at the PTO.<sup>374</sup> The recently completed Green Technology Pilot Program allowed patent applicants claiming certain green technologies to request accelerated examination.<sup>375</sup> The PTO also operates the Cancer Moonshot Expedited Examination Pilot Program to accelerate review of patent applications related to the Cancer Moonshot initiative.<sup>376</sup> Recently, the PTO initiated the Semiconductor Technology Pilot Program, which supports the CHIPS and Science Act by expediting the examination of semiconductor-related patents.<sup>377</sup> In sum, the patent system is not nearly as neutral as commonly perceived. Seeking to maximize the broader societal impacts of the patent system, the PTO promotes certain kinds of innovation of high social value. And the way it does so—by accelerating the examination of certain patent applications—provides a template for expanding and formalizing this practice.

B. *Reforming Patent Law To Require Disclosure of Broader Impacts*

Building on this analysis, this Section argues that the PTO should more generally consider the broader social impacts of inventions when evaluating patentability. This Article modifies a prior proposal requiring inventors to disclose certain social impacts of their inventions when applying for a patent.<sup>378</sup> According to that proposal, PTO examiners could flag patent applications covering inventions with significant potential to generate negative externalities. If flagged, the patent applicant would have to submit a "Societal Impacts" statement that would disclose all reasonably foreseeable harms from the invention.<sup>379</sup> In this proposal, the disclosure obligation would be purely procedural.<sup>380</sup> While a patent examiner could deny an application based on an

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<sup>372</sup> *Patents for Humanity*, U.S. PAT. & TRADEMARK OFF., [uspto.gov/ip-policy/patent-policy/patents-humanity#p4hsupport](https://uspto.gov/ip-policy/patent-policy/patents-humanity#p4hsupport) [perma.cc/749Z-JJU7] (last visited Apr. 3, 2024).

<sup>373</sup> *Id.*

<sup>374</sup> *Id.*

<sup>375</sup> Pilot Program for Green Technologies Including Greenhouse Gas Reduction, 74 Fed. Reg. 64666 (effective Dec. 8, 2009).

<sup>376</sup> Cancer Moonshot Expedited Examination Pilot Program, 87 Fed. Reg. 75608 (proposed Dec. 9, 2022).

<sup>377</sup> Semiconductor Technology Pilot Program, 88 Fed. Reg. 83926 (Dec. 1, 2023).

<sup>378</sup> Lee, *Externality Asymmetry*, *supra* note 7, at 1990-93.

<sup>379</sup> *Id.* at 1991.

<sup>380</sup> *Id.*

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incomplete or bad-faith Societal Impacts statement, substantive harms disclosed in the statement would rarely be the basis for rejecting an application.

This Article builds upon this previous proposal to recommend a more muscular social-impacts disclosure requirement for patent applications. To differentiate this “strong” version of the proposal from the previous one, and to use language consistent with other prescriptions in this Article, it proposes that patent applicants include a “Broader Impacts Statement” in all patent applications. A general requirement would eliminate the need for patent examiners to make difficult decisions as to which inventions merit such disclosure and which do not. Furthermore, it would encourage a greater share of inventors (all those applying for patents) to contemplate the social ramifications of their inventions. As such, it has the most potential to shift norms within the inventive community toward socially responsive innovation.

This proposal also expands the scope of the disclosure requirement to include the positive, negative, and distributional impacts of a new invention.<sup>381</sup> First, the Broader Impacts Statement would have to articulate the social benefits of the invention under examination. This should be fairly easy given that patent applicants already have an incentive to disclose the benefits of their technology to satisfy the existing utility requirement.<sup>382</sup> However, the Broader Impacts Statement would afford patent applicants an opportunity to discuss the wider social benefits of their inventions, including any positive externalities accruing to society at large.

Second, the Broader Impacts Statement would require patent applicants to disclose reasonably foreseeable social harms from their inventions and ways to mitigate them. For instance, inventors of AI technologies could discuss the potential for their inventions to spread misinformation, undermine privacy, or exacerbate unemployment through automation. This factor would also encourage patent applicants to disclose technical means for addressing such harms.

Third, patent applicants would be required to disclose the distributive effects of their inventions and how, if at all, they serve marginalized communities. This factor is particularly important given that, as a market-based system of technological development, the patent system is likely to overlook the needs of smaller and less-resourced populations.<sup>383</sup> In addressing this factor, patent applicants could also, if relevant, include plans to increase access to a technology for underserved populations. For example, a patent application for a pharmaceutical drug could include, as part of its Broader Impacts Statement, any

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<sup>381</sup> See *supra* Section IV.C. This further differentiates this “strong” proposal from the previous one, in which Societal Impacts statements would only require patent applicants to disclose any reasonably foreseeable negative externalities arising from their inventions. Lee, *Externality Asymmetry*, *supra* note 7, at 1990.

<sup>382</sup> See 35 U.S.C. §§ 101, 112.

<sup>383</sup> See Drahos, *supra* note 6, at 336 (discussing how commercialization shifts the focus of science away from the preferences of those with low ability to pay).

plans by the patentee to increase access to the drug for low-income populations, perhaps through patient assistance programs.

The appropriate substantive effect of broader impacts disclosed by a patent applicant represents a challenging issue of institutional design. Consistent with this Article's recommendation to consider broader impacts when awarding grants, publication offers, and presentation opportunities, one option would be for PTO examiners to weigh these factors in the substantive decision of whether to grant a patent. Under this approach, for instance, if an invention poses significant social risks (and the inventor did not disclose adequate mitigation measures), a PTO examiner could deny patentability. However, weighing broader impacts so heavily in the patent system poses several difficulties. Similar to other contexts, there are doubts about the ability of PTO examiners to assess broader impacts accurately. Furthermore, there are concerns that weighing negative impacts so heavily might chill disclosure by inventors. In addition to these general concerns, there are specific concerns unique to the patent system. The patent system does not have an established history of explicitly considering the social value of inventions when determining patentability.<sup>384</sup> By analogy, this diverges considerably from NSF, which for decades has considered broader impacts in determining whether to award research grants.

Given this unique posture, this Section proposes an intermediate approach to weighing broader impacts that is consistent with the practice and history of the PTO. As a procedural matter, patent examiners could reject applications with cursory Broader Impacts Statements or where the patent examiner has reason to believe that an applicant has not disclosed broader impacts in good faith.<sup>385</sup> This is consistent with other procedural requirements in the patent system, such as the obligation of an inventor to submit an oath or declaration attesting to inventorship.<sup>386</sup> Such a procedural requirement would encourage patent applicants to take disclosure seriously. As a substantive matter, however, the potential social harms of an invention would rarely be a reason to deny patentability. Rejection would only be appropriate in extreme cases where such harms failed the existing (watered-down) moral utility standard.<sup>387</sup>

While Broader Impacts Statements would rarely affect patentability, their principal effect would be to determine the *timing* of patent examination. Prosecuting a patent is a lengthy process that routinely takes about three years.<sup>388</sup> Time is money, and inventors certainly value faster prosecution. As such, if a

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<sup>384</sup> See *supra* notes 352-62 and accompanying text.

<sup>385</sup> Cf. Lee, *Externality Asymmetry*, *supra* note 7, at 1991 (proposing that patent examiners deny patent applications on procedural grounds for not disclosing foreseeable societal risks in good faith).

<sup>386</sup> See 37 C.F.R. § 1.63 (2024).

<sup>387</sup> See *Juicy Whip, Inc. v. Orange Bang, Inc.*, 185 F.3d 1364, 1368 (Fed. Cir. 1999).

<sup>388</sup> *Patents Pendency Data February 2024*, U.S. PAT. & TRADEMARK OFF., [uspto.gov/dashboards/patents/pendency.html](https://dashboards.uspto.gov/dashboards/patents/pendency.html) [https://perma.cc/2LJ9-7PWU] (last visited Apr. 3, 2024).

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PTO examiner deemed that an invention scored high on factors such as social benefit or serving marginalized communities, the examiner could recommend accelerating examination of that patent application. This is consistent with current and past PTO programs that accelerate patent examination for inventions that serve substantial social needs. This approach is evident, for example, in the Patents for Humanity Program, Green Technology Pilot Program, Cancer Moonshot Expedited Examination Pilot Program, and Semiconductor Technology Pilot Program.<sup>389</sup> As a novel proposal, if a patent application disclosed significant harms without countervailing social benefit or means to mitigate those harms, a PTO examiner could recommend *delaying* examination of that application.

Of course, anticipating the broader social impacts of a novel invention is exceedingly difficult. Furthermore, trying to weigh those impacts to ascertain whether the invention will be a net social positive or negative can be a highly indeterminate exercise. For instance, when Rudolf Diesel patented an internal combustion engine in 1898,<sup>390</sup> it would have been difficult for him (or anyone else) to anticipate the sweeping social changes that his invention would facilitate, from vastly increasing personal mobility to contributing to urban sprawl, racial segregation, and climate change. While difficult, this Article contends that there is substantial value to patent applicants engaging in such wide-ranging assessments. Nonetheless, to render this proposal more manageable, this Article suggests limiting Broader Impacts Statements to an invention's "reasonably foreseeable" social harms, social benefits, and distributive effects in a manner analogous to other disclosure regimes.<sup>391</sup>

While this proposal seems like a dramatic shift from existing practice, it would likely be relatively modest in operation. For the vast majority of inventions—such as an improved hinge for a cabinet—social benefits and harms are small in scale and do not point strongly in one direction or another. Such patent applications would likely be neither accelerated nor delayed. However, for a minority of inventions explicitly addressing high-priority social challenges—such as neglected diseases or climate change—social benefits are likely to strongly outweigh harms, thus favoring accelerated examination. For another minority of inventions where the potential social harms are substantial—such as for artificial general intelligence ("AGI")—or where social harms are likely to significantly outweigh benefits—such as for improved firearms and explosives—delaying examination may be appropriate. In some ways, this latter approach represents an adaptation of the precautionary principle by delaying the

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<sup>389</sup> See *supra* notes 372-77 and accompanying text. It should be noted that the Patents for Humanity Program does not expedite examination of the subject invention per se, but awards acceleration certificates to the winners.

<sup>390</sup> U.S. Patent No. 608,845 (issued Aug. 9, 1898).

<sup>391</sup> Cf. 40 CFR § 1502.15 (2024) (indicating EISs shall describe "reasonably foreseeable" environmental trends and planned actions arising from various alternatives).

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examination of patents on inventions that are particularly risky or poorly understood.<sup>392</sup>

This proposal raises the obvious question of why a patent applicant would disclose social harms that could delay examination. This Article offers some general observations on this phenomenon below,<sup>393</sup> but a few thoughts related to the patent context are useful here. First, as noted, purely boilerplate, cursory Broader Impacts Statements that do not adequately address social harms could warrant rejection. Second, the PTO does not simply have to take patent applicants at their word; the examiner can exercise discretion to request more information regarding the social risks (as well as benefits and distributive effects) of an invention. Third, even if a relatively small percentage of patent applicants disclose social harms for their inventions, such disclosure are highly valuable, a point elaborated further below.<sup>394</sup> Finally, even if no patent applicants disclosed social harms for their inventions (which is highly unlikely), this proposal would still have value. Patent applicants would still have strong incentives to disclose the social benefits and positive distributive effects of their inventions, and accelerating examination of inventions of high predicted value would have the effect of delaying examination of inventions of lower predicted value.

Utilizing social impacts to inform the timing of patent prosecution would have two salutary effects. First, it would provide a significant incentive for inventors to develop technologies that served significant social interests, including addressing the needs of underserved communities. As a corollary, it would also encourage inventors of potentially harmful technologies to engineer solutions for those harms. Second, this arrangement would accelerate the introduction of socially beneficial inventions while delaying the introduction (via the patent system) of inventions of high social risk. Such delay would provide more time for inventors to engineer solutions for those harms or simply encourage them to abandon such inventions if they did not seem worthwhile.

While this appears to be a radical departure from the technological neutrality of the patent system, it simply formalizes and expands existing practice. As we have seen, in a variety of contexts, the patent system does not treat all technologies equally. It already puts a thumb on the scale to advance certain kinds of innovation of high social importance. This proposal simply abstracts from existing programs rewarding patents that serve marginalized communities, improve environmental outcomes, treat cancer, and advance the production of valuable semiconductors. Drawing on these programs, it generalizes a broader principle of allowing the social implications of inventions to influence the timing of patent examination.

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<sup>392</sup> See discussion *supra* note 14.

<sup>393</sup> See *infra* Section VII.A.

<sup>394</sup> *Id.*

## VII. OBJECTIONS AND COUNTERARGUMENTS

This Article has sketched the contours of a distributed model of innovation governance to promote socially responsive innovation. The key concept involves conditioning the grant of valuable resources in part on an evaluation of the positive, negative, and distributive effects of an innovative project. Of course, this model is subject to several objections. Some of these objections have been mentioned earlier, but this Part addresses them more comprehensively. Additionally, this Part highlights some of the key benefits of considering broader impacts in the award of research funds, publication and presentation opportunities, and patents.

A. *Objections and Responses*

First, this proposal raises technical competence concerns about the ability of scientists and engineers (as well as funding agency staff, peer reviewers, and PTO examiners) to evaluate the social impacts of research projects and inventions. Even with a wide range of expertise, predicting the broader impacts of emerging technologies is difficult.<sup>395</sup> Scientists and engineers, after all, are trained in the technical aspects of their fields, not in analyzing the broader social implications of innovation. However, the overarching aim of this proposal is not absolute precision, but to raise consciousness and effectuate cultural change within the innovative community. By tying the award of valuable resources to considerations of social benefits and harms, this proposal aims to cultivate a norm of socially responsive science and technology. As we have seen, government action has modified scientific norms in several ways,<sup>396</sup> and traditional “Mertonian” norms evolve. It may be impossible to determine whether gatekeepers, scientists, and engineers applying this proposal get the social calculus “right” when assessing broader impacts in any given case. However, if this proposal encourages researchers and inventors to consider more deeply the positive, negative, and distributive effects of their work on society, it will have succeeded.

Additionally, technical assistance can help scientists and engineers evaluate the broader impacts of their work (as well as the work of others when they serve as peer reviewers). As noted, NSF has invested considerably in training and technical assistance for researchers, peer reviewers, and program officers.<sup>397</sup> Additionally, universities have a strong incentive to provide similar training to increase the competitiveness of their faculty members applying for grants. As scientific publications and conferences like NeurIPS decide to require applicants (and peer reviewers) to consider the broader social impacts of research, these

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<sup>395</sup> Cf. SEC’Y’S ADVISORY COMM. ON GENETICS, HEALTH, AND SOC’Y, GENE PATENTS AND LICENSING PRACTICES AND THEIR IMPACT ON PATIENT ACCESS TO GENETIC TESTS 391-92 (2010) (indicating disagreement among government-appointed experts regarding the availability of genetic testing and the need for policy interventions to enhance access).

<sup>396</sup> See *supra* Section V.B.

<sup>397</sup> See *supra* notes 240-45 and accompanying text.

institutions should also provide greater guidance and technical assistance to their communities. The PTO already provides significant technical assistance to inventors on navigating the patent system—including how to prepare a patent application<sup>398</sup>—and it could integrate guidance on Broader Impacts Statements in this assistance.

Furthermore, individuals with expertise in assessing the broader impacts of science and technology can and should play a larger role in review processes. NSF should invite greater participation by nonscientists with such technical expertise on merit review panels and Committees of Visitors that evaluate the NSF review process.<sup>399</sup> In similar fashion, NeurIPS employed outside ethics advisors to assist in reviewing conference submissions that had been flagged for ethics review.<sup>400</sup> The perceived technical limitations of PTO examiners in assessing the ethical dimensions of inventions played a role in the demise of the moral utility doctrine.<sup>401</sup> However, the PTO possesses technical expertise to identify inventive areas of high social value, as evidenced by the Patents for Humanity Program, Green Technology Pilot Program, Cancer Moonshot Expedited Examination Pilot Program, and Semiconductor Technology Pilot Program.<sup>402</sup> Furthermore, the PTO bolstered its ability to engage in high-level economic and policy analysis by establishing the Office of the Chief Economist in 2010.<sup>403</sup> While predicting broader impacts *ex ante* is extremely difficult, the Office of the Chief Economist could engage in *ex post*, empirical analysis of the positive, negative, and distributional effects of various inventions. In this fashion, it could offer guidance and economic analysis to inform PTO examiners' consideration of Broader Impacts Statements for patent applications going forward.

Second, some might doubt the willingness of scientists and inventors to disclose harmful impacts that could lead to denials of research funds, publication offers, and presentation opportunities and delayed patents. However, procedural requirements to include thorough broader impacts statements can help alleviate this concern. A scientist or inventor who is not forthright about potential harms risks not getting valuable resources. Furthermore, this distributed model of innovation governance does not rely solely on self-reporting by scientists and inventors. Depending on the context, peer reviewers, program officers, journal and conference staff, and PTO examiners can independently assess the broader social impacts of research and inventions.

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<sup>398</sup> See *Patent Basics*, U.S. PAT. & TRADEMARK OFF., [uspto.gov/patents/basics](https://uspto.gov/patents/basics) [perma.cc/8AR3-7LLC] (last visited Apr. 3, 2024) (providing users with several tools to search for patents, patent attorneys, and educational resources related to patent law).

<sup>399</sup> See *supra* notes 246-47 and accompanying text.

<sup>400</sup> Prunkl et al., *supra* note 323, at 105.

<sup>401</sup> See *Juicy Whip, Inc. v. Orange Bang*, 185 F.3d 1364, 1368 (Fed. Cir. 1999).

<sup>402</sup> See *supra* notes 372-77 and accompanying text.

<sup>403</sup> *Office of the Chief Economist*, U.S. PAT. & TRADEMARK OFF., [uspto.gov/about-us/organizational-offices/office-policy-and-international-affairs/office-chief-economist](https://uspto.gov/about-us/organizational-offices/office-policy-and-international-affairs/office-chief-economist) [perma.cc/DPE2-U37K] (last visited Apr. 3, 2024).

Additionally, history shows that some scientists and inventors are quite willing to disclose the potential harms of their innovations. As noted, scientists agreed to a moratorium on recombinant DNA research precisely to investigate its social risks.<sup>404</sup> While benefitting society, such social reflection was ultimately self-serving. Through researchers' voluntary moratorium on recombinant DNA technology, "[r]estrictive national legislation was avoided, and in the long run, scientists benefitted from their forthrightness and prudent actions in the face of uncertainty."<sup>405</sup> Furthermore, the publicly minded moratorium helped galvanize support for the Asilomar principles that scientists eventually adopted to guide recombinant DNA research.<sup>406</sup> It is also worth emphasizing that it was computer scientists themselves, alarmed by the social risks of AI, who pushed NeurIPS to include broader impacts in its peer review process.<sup>407</sup>

Relatedly, even if a small percentage of scientists and inventors applying for grants, publication and presentation slots, and patents disclosed potential social harms, such disclosures would have significant value. For instance, assume that only 10% of inventors applying for patents on AGI disclosed the social harms of this technology in a robust fashion. While this represents significant undercompliance, patent examiners could use those disclosed harms as the basis for questioning and evaluating the Broader Impacts Statements of the other 90% of patent applications covering AGI. More generally, even infrequent disclosures of social risk by scientists and engineers would eventually create a catalog of harms that NSF staff, peer reviewers, journals and conferences, and PTO examiners could use to evaluate similar research projects and technologies.

A third objection to this proposal is that tying research funds, publication and presentation offers, and patents to broader social impacts may chill valuable scientific and technological work. However, this is precisely the point. In an absolute sense, a line of innovative work that generates significant harms without countervailing benefits is a net social negative that probably does not warrant public support. In less extreme cases, a pause may be useful to discern how to differentiate positive from negative applications of a novel innovation and mitigate risks. Again, this was evident in the moratorium on recombinant DNA technology, which eventually led to the resumption of research under the Asilomar principles. In a relative sense, social resources for innovation are limited, and considerations of positive, negative, and distributional effects are a sensible way to prioritize some projects over others. In a similar fashion, NSF receives more "worthy" proposals than it can fund, and it uses the criteria of intellectual merit and broader impacts to identify proposals that actually receive grants.<sup>408</sup> Relatedly, given the limited resources of the PTO, it seems reasonable

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<sup>404</sup> See *supra* notes 288-96 and accompanying text.

<sup>405</sup> Paul Berg & Maxine F. Singer, *The Recombinant DNA Controversy: Twenty Years Later*, 92 PROC. NAT'L ACAD. SCI. USA 9011, 9012 (1995).

<sup>406</sup> *Id.*

<sup>407</sup> See *supra* Section V.C.

<sup>408</sup> See *supra* notes 189-91 and accompanying text.

to delay the examination of harmful or risky technologies while accelerating those that promise significant social benefit.

B. *The Virtues of Distributed Innovation Governance*

While this distributed model must surmount these (and surely other) objections, it offers several benefits. It bears emphasizing that this Article does not present this model as a panacea. Rather, it suggests combining this approach with traditional, centralized innovation governance, such as mission-based funding and regulation to mitigate technological harms.<sup>409</sup> Indeed, many of the deficiencies of centralized innovation governance define the strengths of this distributed model.

First, this distributed governance model maintains a high level of scientific and inventive autonomy. Recall that Polanyi was deeply skeptical of politically directed science.<sup>410</sup> Recent history has shown that the politicization of federally funded research is a legitimate concern for scientists.<sup>411</sup> However, the day has long passed when publicly funded researchers can expect to receive blank checks from the government without regard to the social benefit of their outputs. As such, relative to mission-based funding or direct regulation, this distributed model maintains a robust degree of scientific and technological autonomy. Under this proposal, researchers and inventors are free to pursue whatever research questions and technologies they like. However, if they seek certain forms of support for their work, public and private gatekeepers are free to consider the broader social impacts of that innovative work when determining whether and how to support it.

Second and relatedly, this approach is sensitive to the threat of overly politicizing innovation policy. As noted, mission-oriented programs, such as Operation Warp Speed, have their place in spending public funds to serve the social good. However, recent controversies spanning Republican and Democratic administrations illustrate Polanyi's fear that politics can threaten the autonomy and robustness of science and technology. Examples include President Trump's hostility to climate science and massive lobbying by technology firms for favorable subsidies and legislation.<sup>412</sup> In a nod to federalism, this Article argues for distributing authority to promote socially responsive innovation among multiple stakeholders. It argues for balancing centralized, top-down regulation with decentralized, bottom-up governance based on peer review and self-disclosure by scientists and inventors.

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<sup>409</sup> See *supra* Section II.A.

<sup>410</sup> See *supra* notes 110-16 and accompanying text.

<sup>411</sup> Ledyard King, *Survey: Many Federal Researchers Say Politics Trump Science and Are Afraid To Speak Up*, USA TODAY (Aug. 14, 2018, 4:49 PM), [usatoday.com/story/news/politics/2018/08/14/survey-federal-researchers-believe-politics-outweighs-science-climate-change/925099002/](https://www.usatoday.com/story/news/politics/2018/08/14/survey-federal-researchers-believe-politics-outweighs-science-climate-change/925099002/) (“Scores of scientists working for the federal government say that under the Trump administration, political concerns outweigh scientific rigor and budget cuts hamper their mission, a new survey shows.”).

<sup>412</sup> See *supra* notes 148-54 and accompanying text.

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To be sure, critics may contend that considering broader impacts simply invites scientists, engineers, and peer reviewers to apply their personal political biases when evaluating innovative work.<sup>413</sup> Put differently, this proposal may simply allow politicization under a different guise. However, science and technology can never be fully divorced from the political context that supports them. More pertinently, this form of “politicization” distributes decision-making power among a wide, decentralized set of largely technical stakeholders. As such, it is qualitatively different from the concentrated political control of science and technology that so concerned Polanyi. Considering broader impacts in federal funding decisions distributes significant authority to far-flung scientific peer reviewers rather than concentrating power in NSF or other government agencies. The move for scientific journals and conferences to consider broader impacts emerged from private ordering and is a far cry from centralized political control. While government bureaucrats—namely patent examiners—would review patent applications for broader social impacts, patent applicants themselves would author the initial disclosures. Additionally, only in rare cases would adverse impacts lead to denying patentability. At most, the results of this analysis would affect the timing of patent examination.

Third, this governance model marshals significant private information distributed among individuals and institutions. Centralized governance, such as mission-based funding or traditional regulation, relies on policymakers identifying priorities to pursue and then implementing policies to achieve them. However, the information upon which policymakers base their decisions may be quite limited. This distributed model relies on legions of scientists and engineers to interpret and apply broad policy objectives related to maximizing social benefit, mitigating social harms, and serving the needs of marginalized communities. Within the vast innovative community, scientists and engineers will produce novel ways to address these objectives that never occurred to central policymakers. After all, AI researchers probably have more ideas for curbing the harms of AI than most politicians.

Relatedly, broad disclosure requirements unlock private information about novel scientific advances and inventions that is immensely useful for policymakers. Researchers are well positioned to anticipate the potential applications, limitations, and risks of their work.<sup>414</sup> This privately generated information can alert policymakers of the need for intervention and inform policy responses. Conditioning research funds, publication and presentation opportunities, and patents on robust disclosure is an “information forcing” mechanism that can enrich formal legislation and agency action.<sup>415</sup> Eliciting this

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<sup>413</sup> Prunkl et al., *supra* note 323, at 107 (acknowledging that incorporating a broader impacts requirement raises the possibility that “scientific articles may become more politicized”).

<sup>414</sup> *Id.* at 106.

<sup>415</sup> Lee, *Externality Asymmetry*, *supra* note 7, at 1993 (discussing how inventors can disclose valuable information regarding their patented inventions that may inform policies and regulations).

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private information can address the typically long lag between the emergence of a potentially disruptive innovation and the development of adequate policy responses.<sup>416</sup> Further enhancing regulatory efficiency, this distributed approach can lead scientists and engineers to nip certain problems in the bud, thus eliminating the need for costly, *ex post* regulation of established technologies.

Ultimately, distributed innovation governance synthesizes the progressive aims of Bernalist science planning with Polanyi's defense of individual and communal autonomy. In the early twentieth century, Bernal influentially argued that governments should actively plan science.<sup>417</sup> Polanyi, however, argued that an autonomous scientific community, governed by communal norms, would produce the most robust science.<sup>418</sup> These days, citizens and states are demanding that massive public investments in science translate to tangible social gains. However, scientific and technological autonomy continues to have much substantive, political, and rhetorical valence.

Accordingly, this distributed model mobilizes the enormous power of norms to promote socially responsive innovation. This model does not impose external, heavy-handed regulations on scientists and engineers. Specifically, it does not legally require or prohibit any type of innovative activity. Rather, this model uses a "softer" approach that links certain resources (research funds, publications, presentations, and patents) to innovations of high social value. We have seen that norms, peer evaluations, and collective authority play a significant role in governing innovative communities. Over time, the proposals of this Article may strengthen a norm in which scientists and engineers routinely consider social impacts—not just technical merit—in assessing the value of their projects and those of others. Among other benefits, leveraging communal norms reduces policing costs, as self-policing by individuals and peer reviewers contribute to high compliance.<sup>419</sup> Such norm-based governance balances collective goals with individual and communal freedom, thus paralleling the Kantian notion that "autonomy means acting according to a law I give myself."<sup>420</sup>

#### CONCLUSION

While society—and the federal government—invests substantially in research and development, resulting innovations do not always address pressing social needs. This Article has argued for a more "socially responsive" approach to

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<sup>416</sup> Prunkl et al., *supra* note 323, at 106 (describing how impact statements encourage anticipation of risks associated with innovations).

<sup>417</sup> *See supra* Section II.B.1.

<sup>418</sup> *See id.*

<sup>419</sup> *Cf.* Drahos, *supra* note 6, at 330 ("But breaches of soft norms can have hard consequences. Once an individual is found guilty of research misconduct, the networks of esteem and funding upon which all scientists rely may fall away, leaving them in an isolated world of shame and regret.").

<sup>420</sup> MICHAEL J. SANDEL, JUSTICE: WHAT'S THE RIGHT THING TO DO? 126 (2009).

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innovation that tackles urgent priorities, mitigates potential harms, and serves the interests of marginalized communities. Centralized approaches to innovation governance, such as mission-based funding and traditional regulation, are valuable mechanisms to increase the social value of innovation, but they exhibit significant deficiencies. Such centralized approaches can undermine scientific autonomy, unduly politicize innovation policy, and rely on an overly narrow information base available to policymakers. Accordingly, this Article has argued for a distributed model of innovation governance to promote socially responsive science and technology. This model would condition the award of valuable resources—such as research funds, publication and presentation opportunities, and patents—in part on the broader social impacts of innovative projects.

This distributed model would enlist various gatekeepers of valuable resources in the typical lifecycle of a research and development project. At the upstream end, this Article argues for bolstering NSF's practice of considering broader impacts when awarding research funds, and it further proposes extending this practice to other federal funding agencies. It also argues that scientific journals and conferences—and the peer reviewers they enlist—should consider the broader impacts of research when screening scientific manuscripts for publication and presentation. While academic journals and conferences are not direct subjects of government regulation, this Article has shown how NSF's policy of considering broader impacts has motivated grassroots efforts to incorporate this norm at private scientific institutions. Finally, at the downstream end of the R&D lifecycle, this Article proposes that the PTO require patent applicants to disclose the social impacts of inventions during patent prosecution. In this manner, the PTO can prioritize the examination of patent applications of high social value. By orienting various gatekeepers to consider the broader social impacts of innovation, this Article seeks to cultivate a norm of socially responsive innovation within scientific and technological communities.